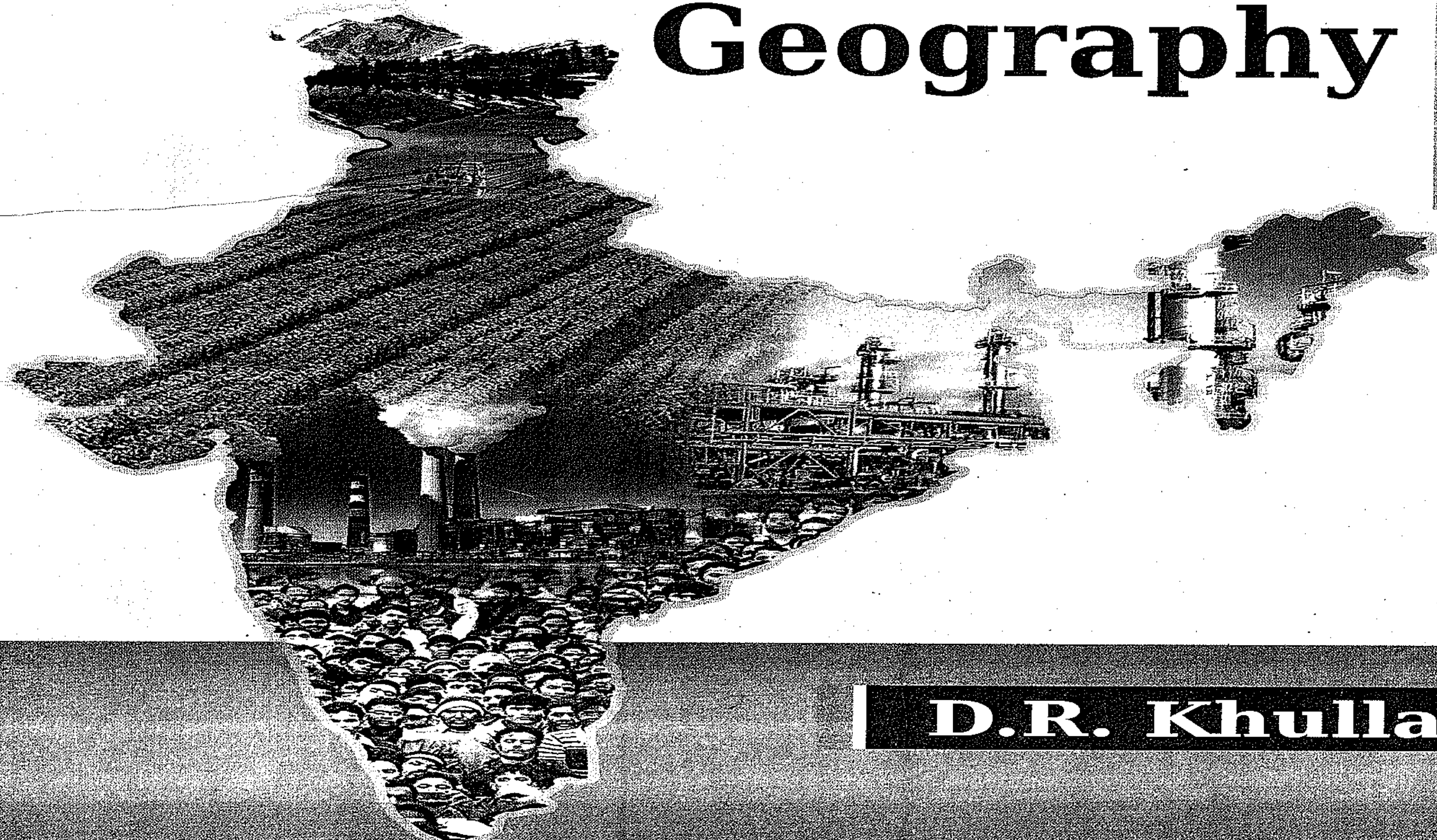
INDIA
A Comprehensive Geography



D.R. Khullar

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CHAPTER 1

Introduction

INDIA AS A GEOGRAPHICAL UNIT

India is a country of great geographical extent. It sprawls from the snowy ranges of the Himalayas in the north to the shores of the Indian Ocean in the south. It belongs to Asia which is the largest continent of the world. It forms a part of south Asia and is separated by the Himalayas from the rest of the continent. It encompasses vast areas of diverse landmasses. In the north are the lofty Himalayas, parts of which are permanently ice-covered. To the south of Himalayas is the Great Indo-Gangetic Plain which is well-known for its fertile soils. The western part of this vast plain is the Thar Desert. South of this plain is the Peninsular India comprising of the uneven plateau which is surrounded by Eastern Coastal Plain in the east and Western Coastal Plain in the west. Indian landmass gets an abundance of sunshine from the tropical sun and splashing rains from the monsoons. These are two most important climatic factors for the Indian people. Due to its vastness and diversities, *India is considered to be a subcontinent* as it possesses all the characteristics of a continent.

India extends from 8° 4′ north to 37° 6′ north latitude and 68° 7′ east to 97° 25′ east longitude. Thus, its latitudinal and longitudinal extent is about thirty degrees. Away from the mainland of India, the southernmost point of the country in the Andaman and Nicobar Islands, the Pygmalion Point or Indira Point is located at 6° 45′ north latitude. Its north-south extent from Indira Col in Kashmir to Kanniyakumari is 3,214 km while its east-west width from the Rann of Kachachh to Arunachal Pradesh is 2,933 km (**Fig. 1.1**). The latitudinal extent of India is about one-third the angular distance between the Equator and the North pole and its longitudinal extent is about one-twelfth of the circumference of the Equator. The longitudinal difference between Saurashtra in the west and Arunachal Pradesh in the east is about 30°. The earth moves around its axis through 360° in 24 hours. Thus, a difference of 1° longitude will make a difference of 4 minutes in time. Therefore the difference of local time between Saurashtra and Arunachal Pradesh is 30 × 4 = 120 minutes or 2 hours. Since Arunachal Pradesh is towards the east, it will have sunrise about two hours before the sunrise at Saurashtra. Thus, the sun is quite high in the sky in Arunachal Pradesh while Saurashtra still waits for the first ray of the sun. Latitudinal extent also has its own impact. Rainfall, temperature and vegetation vary with latitude. The difference between the longest and the shortest day in Kerala is hardly 45 minutes whereas this difference may be as

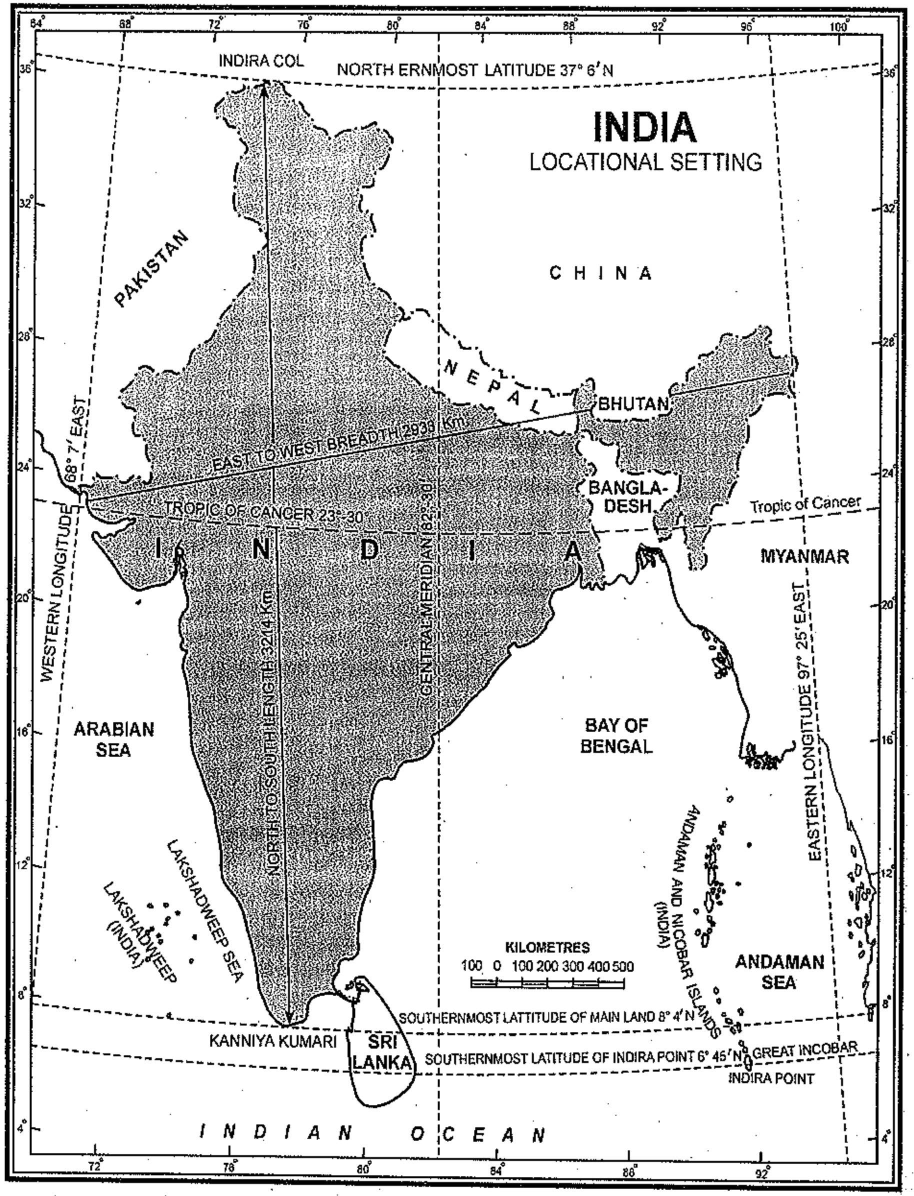

FIG. 1.1. India : Locational Setting

large as 4 hours in Leh and Ladakh. The difference between the longest and the shortest day increases with latitude.

With an area of 32,87,263 sq km, India is the seventh largest country of the world. (**Table 1.1** and **Fig. 1.2**)

TABLE 1.1. Area of seven largest countries of the world

Name of the country		Area in sq km
1.	Russian Federation	17,075,200
2.	Canada	9,984,670
3.	U.S.A.	9,626,091
4.	China	9,596,960
5.	Brazil	8,511,965
6.	Australia	7,686,850
7.	India	3,287,263*

Source **:** Dorling Kindersley World Atlas, 2010, pp. 198-206

* Data for India has been taken from Statistical Abstract, India, 2007, p. 5.

Figures regarding area of India include the area under unlawful occupation of Pakistan and China. This area includes 78,114 sq km under illegal occupation of Pakistan, 5,180 sq km illegally handed over by Pakistan to China and 37,555 sq km under illegal occupation of China.

India accounts for about 2.4 per cent of the total surface area of the world. India is nearly 13 times as large as Great Britain, the country which ruled over us for about two centuries. Many of the Indian states are larger than several countries of the world.

The peninsular tableland juts into the Indian Ocean for a distance of about 1,600 km.

The Tropic of Cancer passes through the middle of the country dividing it into two latitudinal halves being about 15° from either end. But the northern portion is very broad and the area to the north of Tropic of Cancer is nearly twice the area which lies to the south of it. The enormous width of India is often forgotten, being overshadowed by the more popular fact of its length. We are habitual of expressing the dimension of the country as *'from Kashmir to Kanniyakumari'* and not from *'Rann of Kachchh to Arunachal Pradesh'*. The east-west extent of India is almost equal to the combined longitudinal extent of Spain, France, Germany, Belgium, the Netherlands and Poland. South of 22° north latitude, the country tapers off over 800 km into the Indian Ocean as a peninsula and divides this ocean into two arms—the Arabian Sea in the west and the Bay of Bengal in the east.

It is natural to look upon India as being divided into northern temperate and southern tropical lands by the Tropic of Cancer. Thus the temperate part of the country should be twice as much as its tropical part. But India has always been treated as a tropical country for two widely different reasons. The reasons are those of physical and cultural geography. The country is separated from the rest of Asia by a mountain wall forming an insulated compartment. Its climate is dominated by the tropical monsoons and the temperate air masses are restricted by the mountain chain. Further, although the night temperatures in January at several places in Punjab may come down to the level of those prevailing in temperate lands, yet clear skies and intense insolation raise the day temperatures to a tropical level, so that the entire area south of the Himalayas is essentially

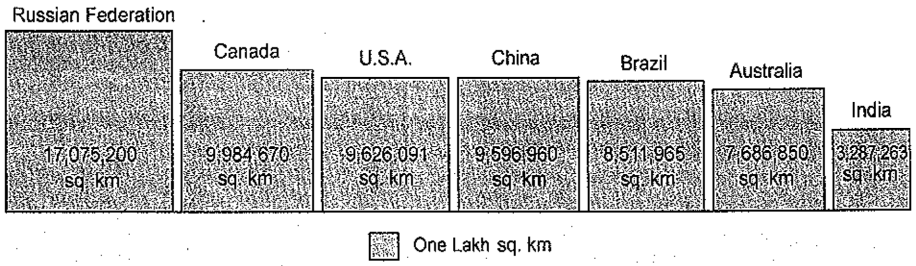

FIG. 1.2. Seven largest countries of the world

tropical from climatic point of view. Outside the Himalayas, almost everywhere agriculture is tropical in type. As per cultural geography, the culture of India is totally different from that of the temperate countries of the western civilisation.

Girdled by the rampart of the young folded mountains in north-west, north and north-east and washed by the Indian Ocean in the south, India along with its neighbouring countries, is a well defined geographical unit. South of the mountain chain, India, Pakistan, Bangladesh, Nepal and Bhutan form a definite realm of South Asia which is often referred to as the ***Indian subcontinent***. India alone accounts for about three-fourths of the total area of the subcontinent. According to **Prof. Chisholm**, 'there is no part of the world better demarcated by nature as a region by itself than the Indian subcontinent'. **G.B. Cressey** strongly advocated that India may be termed as subcontinent because it is a distinct geographical unit with many physical and cultural units. But some Indian geographers are of the view that the use of the term subcontinent for India is a misnomer and is a legacy of the British rule which tended to divide the area on the basis of region and religion. These geographers contend that this expression has never been used for much vaster and more diverse geographical units like China and Russia. It is worth mentioning that the subcontinental theory of the Britishers worked very well in dividing the area into different nations giving credibility to their basic policy of ***'divide and rule'***. Total area of the country before partition was 42,27,378 sq km. The partition of the country on 15th August, 1947 gave birth to a new country of Pakistan. This led to a loss of 7,96,095 sq km area of West Pakistan (now called Pakistan) and 1,44,020 sq km of East Pakistan (the present Bangladesh). Thus the present extent of the country is reduced to about three-fourths of its original size. Consequently, some scholars tend to replace the term Indian subcontinent by South Asia which includes, India, Pakistan, Bangladesh, Nepal, Bhutan, Sri Lanka and sometimes even Afghanistan.

Nomenclature of the Country

This country has been variously named as ***India***, ***Hindustan***, ***Bharat*** and ***Aryavarta***. The word India has its origin in the Greek literature meaning the land of '*Indoi*', the people living near the *Indos* (latin Indus). Persians and Greeks extended the name ***Sindhu***—'the river' from the Indus. Thus it was called ***Hindustan***—the land of Hindus in Persian and other West Asian languages. The term Hindu is derived from Sindhu. The Persians pronounce 'S' as 'H' and thus they called Sindhu as Hindu. The land to the east of the Sindhu was called Hindustan. In the Hindu literature the subcontinent as a whole is styled as *Bharat* or *Bharat-Varsha*, the land of the legendary King Bharata who visualised the fundamental unity of the country. However, some scholars believe that the name has been derived from the Bharath tribe, who among others inhabited the area. In the European languages it is popularly known as ***India***. The name *Aryavarta* refers to the land of the Aryan race. At present only *India* and *Bharat* are officially recognised, although *Hindustan* is also in common use.

INDIA'S FRONTIERS

Encompassed between the Himalayas in the north, north-west and north-east, the Indian Ocean in the south and marshy Rann of Kachchh, vast desert of Rajasthan and fertile plain of Punjab in the west, India has both land and water frontiers.

Land Frontiers

India shares her 15,200 long land frontier with Pakistan, in the west and north-west. Afghanistan in the north-west, China, Nepal and Bhutan in the north, and Bangladesh and Myanmar in the east. India's longest border is with Bangladesh while the shortest border is with Afghanistan as is indicated in **Table 1.2. Figure 1.2** shows land frontiers of India.

1. Border with China

India shares 3,917 km long border with China which is over one-fourth of the total land border of the country. This is the second longest border of India, next only to its border with Bangladesh. Five Indian states, namely Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh touch the Indian boundary with China. This border is the product of Manchu policy, Chinese Republican policy and the British policy. It is difficult to demarcate this boundary on the ground due to rugged terrain and harsh environment. Therefore, it was

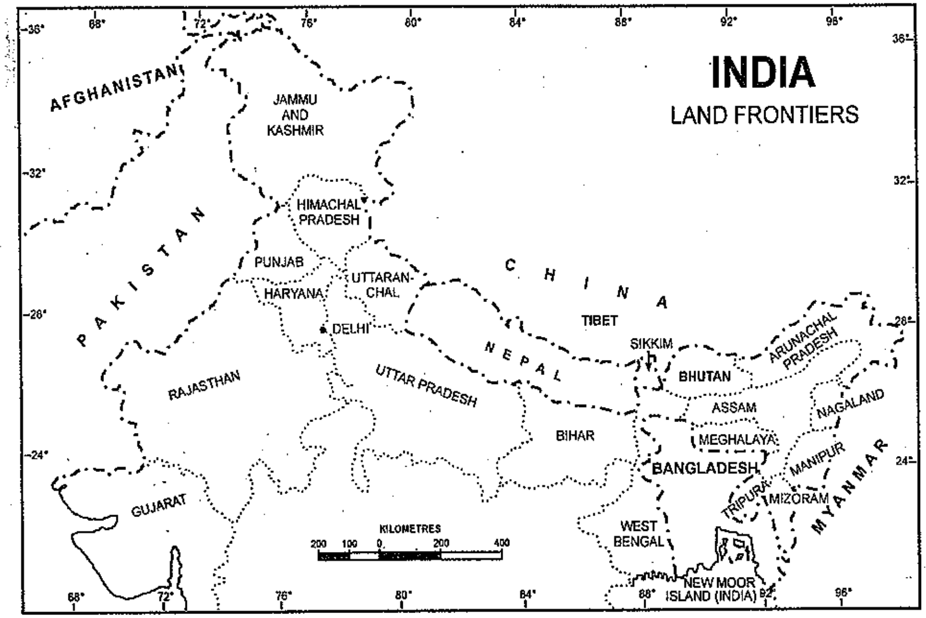

FIG. 1.3. India : Land Frontiers

delimited on the maps in a rather imprecise form, between British India and independent Tibet. China never accepted this boundary legally but ignored the issue during the British rule in India. Since Independence of India on August 15, 1947 and the Communist takeover of China on October 1, 1949, a goodwill gesture developed between these two countries and in 1954 a general agreement containing the principle *Panch Sheel* was announced. These five principles were (*i*) mutual respect for each others territorial integrity and sovereignty, (*ii*) mutual non-aggression, (*iii*) mutual non-interference in each others internal affairs, (*iv*) equality and mutual benefit, and (*v*) peaceful co-existence. In the same year, India recognised the Chinese sovereignty over Tibet and it was brought under the direct control of China. Thus, the buffer character of Tibet ceased to function and a razor-thin boundary between India and China became operative. However, China attacked India in 1962 to take revenge of the so called Indian interference in Tibetan affairs.

The Sino-Indian border is generally divided into three sectors namely : (*i*) the Western sector, (*ii*) the Middle sector, and (*iii*) the Eastern sector.

(*i*) The Western Sector. This 2,152 km long sector of the Sino-Indian border separates Jammu and Kashmir state of India from the Sinkiang province of China. The frontier between Sinkiang and Pakistan occupied Kashmir (PoK) is about 480 km long. The rest is boundary between Ladakh and Tibet. The boundary in the western sector runs along the Muztaghata Range and the Aghil Mountain across the

TABLE 1.2. Length of India's Border with the Neighbouring Countries

Name of the country	Length of border (in kilometres)	Percentage of total length of border
1. Bangladesh	4,096	26.95
2. China	3,917	25.77
3. Pakistan	3,310	21.78
4. Nepal	1,752	11.53
5. Myanmar	1,458	9.59
6. Bhutan	587	3.86
7. Afghanistan	80	0.52
Total	**15,200**	**100.00**

Karakoram Pass via Quara Tagh pass and along the main Kunlun Range to a point east of 80°E longitude and 40 km north of Hajit Langer. It forms a physical boundary between Gilgit area and Sinkiang following the main Karakoram watershed separating the streams flowing into the Indus basin from those flowing into the Tarim basin. Farther south-east the boundary runs along the watershed across Lanak La, Kone La and Kepsang La, then follows the Chemesang river across Pergyon Lake and the Kailash Range. Here the boundary constitutes the watershed between the Indus system in India and the Khotan system in China.

The western sector boundary is largely the outcome of the British policy towards the state of Jammu and Kashmir. These boundaries were defined by the treaties of 1665 and 1686 (known as ***Ladakh-Tibet*** agreements) and were confirmed by 1842 Dogra-Ladakh agreement among Kashmir, Tibet and China. However, this boundary was never delimited precisely on maps and has led to several boundary disputes between China and India. The Chinese claim rests mainly on ethnic grounds, and on the assertion that the wastelands of the Aksai Chin in disputed territory were always linked more with Tibet and Sinkiang. The Chinese claim that Aksai Chin is just an extension of Tibet with regard to language, religion and culture. But in Chinese documentation regarding the actual occupation of the area by Tibet is inconclusive. The Indians, on the other hand, claim that the area has been historically administered by the state of Jammu and Kashmir since 1849, and that the Indo-Tibet Treaties of 1665, 1686 and 1842 confirmed the boundary between Tibet and Ladakh. China claims the Aksai Chin district, the Changmo valley, Pangong Tso and the Sponggar Tso area of north-east Ladakh as well as a strip of about 5,000 sq km down the entire length of eastern Ladakh. China also claims a part of Huza-Gilgit area in North Kashmir (ceded to it in 1963 by Pakistan), although the whole territory has been effectively under the British sovereignty since 1895.

Since 1954, the Chinese have repeatedly violated the international border between India and China and penetrated deep into the Indian territory in the western sector. China renewed aggression in 1959 and the Line of Actual Control (LoAC) became a series of positions occupied by the Chinese forces rather than a well defined border between the two countries. In 1962, China waged a full scale war and its forces intruded far deeper into the Indian territory. Currently the Chinese occupation line runs 16 to 240 km west of traditional line. China is in actual possession of about 54,000 sq km of the Indian territory of which 37,555 sq km is in Ladakh area alone.

(*ii*) **The Middle Sector.** The middle sector boundary between China and India is 625 km long and runs along the watershed from Ladakh to Nepal. Two Indian states of Himachal Pradesh and Uttarakhand touch this border. The boundary of Himachal Pradesh follows the water parting between the Spiti and Para Chu rivers and continues along the watershed between the eastern and western tributaries of the Satluj. The Uttarakhand boundary is demarcated by the watershed between the Satluj on one hand and the Kali, the Alaknanda, and the Bhagirathi on the other. This boundary crosses the Satluj near the Shipki La on the Himachal-Tibet border. Thereafter, it runs along the watershed passes of Mana, Niti, Kungri-Bingri, Dharma and Lipu Ladakh. It finally joins trijunction of China, India and Nepal. This part of the border was approved by the Tibetan and the British governments under the 1890 and 1919 treaties. Although there are not much serious territorial problems between the two countries, the Chinese lay claim on nearly 2,000 sq km area in this sector.

(*iii*) **The Eastern Sector.** The 1,140 km long boundary between India and China runs from the eastern limit of Bhutan to a point near Talu-Pass at the trijunction of India, Tibet and Myanmar. This line is usually referred to as the Mc Mahon Line after Sir Henry Mc Mahon, then foreign secretary of British India, who negotiated the boundary agreement between Great Britain and Tibet at Shimla accord in 1913-14. This line normally runs along the crest of the Himalayas between Bhutan in the west and Myanmar in the east. India has stressed that the Mc Mahon Line is the international boundary between Tibet and India as was agreed to between the governments of India, China and Tibet. On the other hand China considers the Mc Mahon line as illegal and unacceptable, claiming that Tibet had no right to sign the 1913-14 convention held in Shimla which delineated the Mc Mahon Line on the map. India challenges such a position, maintaining that Tibet was

independent and in fact concluded several independent treaties which were considered valid by all parties, and were in operation for decades.

China declined the validity of the Mc Mahon Line as an international boundary and laid claims to areas south of this line up to the foot of the Himalayan range in the Brahmaputra valley. The whole of Arunachal Pradesh, measuring over 88 thousand sq km has been claimed by China as the Chinese territory—calling it ***"South Tibet"***. This area has been administered by India since 1947.

Chinese government never formally questioned the validity of 1913-14 Shimla convention until 1959. India has been striking at the two crucial points. First, Britain and India had been exercising jurisdiction over the area since 1914 and 1947 respectively and second China never disputed the Indian control over the area until 1959. Even in 1956 when the Chinese attention was drawn to certain maps drawn by China which showed these areas to be parts of China, the Chinese government promised to look into the 'cartographic errors' in their maps.

China's relations with India started taking a bad turn in 1950s when China started consolidating its position in Tibet and then in Ladakh. By 1956, China started intensifying its intrusions into the Indian territory. India wishfully hoped that the insurmountable barrier of the Himalayas would prevent Chinese to attack Indian territory. Indian apprehensions grew in 1956 when China built a road through Ladakh linking West Tibet with Sinkiang and quickly moved into Aksai Chin and eastern Ladakh. China also moved its forces into the North-East Frontier Agency (NEFA), the present Arunachal Pradesh. Reported small-scale armed clashes between 1959 and 1962 escalated into a full-scale war in October, 1962 when China launched a major offensive in Ladakh in the western sector and NEFA in the eastern sector. Indian armed forces were not well trained to fight a modern war in a rough and rugged mountainous terrain. They were outnumbered and outgunned by the Chinese forces.

Following lessons have been learnt from Chinese aggression over India :

(*i*) The myth that the Himalayas was an effective defense barrier was exploded.

(*ii*) India's naive confidence in China's friendliness had dulled its perception regarding effective security measures in the Indo-China borderlands.

(*iii*) The prompt and positive response of western countries in rushing military supplies to the war zone helped improve the image of the West in Indian eyes.

(*iv*) India realised that posture of "non-alignment" was no substitute for defense preparedness.

Surprisingly, Chinese forces pulled back without annexing the disputed territory in the eastern sector. In the western sector, however, they did not pull out of most of Aksai Chin. Perhaps they did so due to the fear that their advance troops would have been cut off from supply bases in Tibet in winter of 1962 when the high passes in the Himalayas would have been closed by snow. The Chinese justified their withdrawal by stating that they had no further territorial ambitions.

The primary aim of Chinese invasion was to deprive India of its moral leadership in the world especially among the Afro-Asian countries, and to put pressure on it to join the socialist camp. China's collusion with Pakistan is a clear indication of this political ambition. Perhaps China miscalculated its political power strategy. The support of the Western countries to India compelled China to rethink its strategy. India's unity in the face of Chinese aggression was another deterrent for China to achieve political mileage.

An uneasy truce had been prevailing for a long time since the October, 1962 war. Neither side made a serious effort to normalise the situation on the border. The Colombo powers, spearheaded by Ceylon (now Sri Lanka) and the erstwhile Soviet Union failed to bring about a respectable agreement between the two countries. Several countries condemned China as an aggressor. However, Cuba, Albania and Portugal supported the Chinese.

Of late, leaders of both the countries have engaged themselves in improving bilateral relations. Several meetings have been held to resolve the problem of border issues. The first important step to resolve dispute was the signing of Border Peace and Tranquillity Agreement at Beijing on September 7,

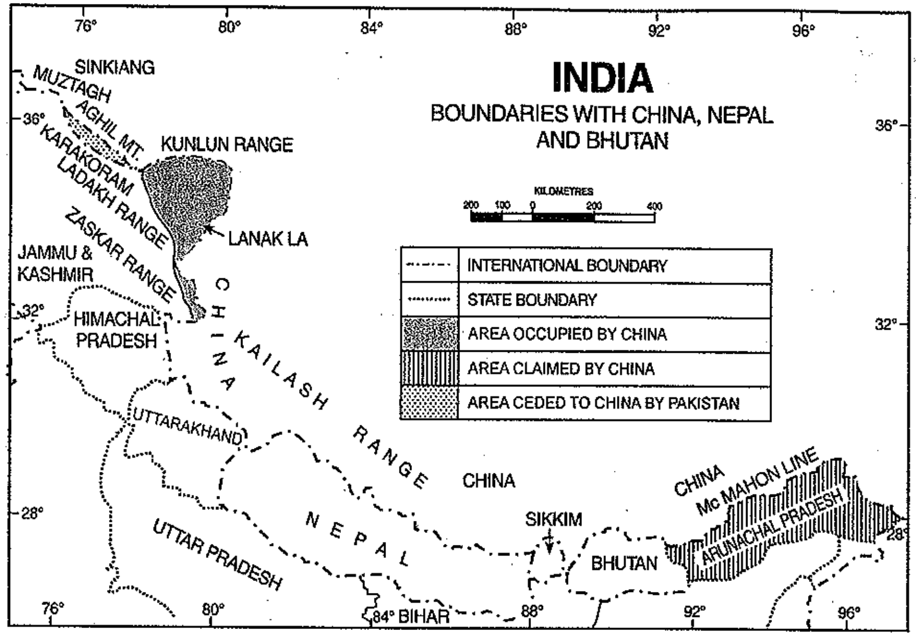

FIG. 1.4. India : Boundaries with China, Nepal and Bhutan

1993. The pact consists of confidence-building measures (CBMS). An agreement on CBMS and the military field along the line of Actual Control (LAC) was signed between the two sides on November 29, 1996. A major development took place in October, 2003 when China made a significant change in its official website. It removed the mention of Sikkim from its list of nations. In May, 2004, China recognised Sikkim as a part of India for the first time. The world map in World Affairs Year Book 2003/2004 does not show Sikkim as a separate country in Asia. It also does not mention Sikkim in its index of countries. The move was significant since it involves recognition of Sikkim-China border which is a part of the Mc Mahon Line. A protocol on modalities for implementing military CBMS was signed on April 11, 2005. If things go as planned, the two nations should be able to work out the guidelines for transforming the Line of Actual Control (LoAC) into a mutually acceptable and internationally recognised boundary. However, China still insists that Arunachal Pradesh is a disputed territory. China has also suggested a 'package deal'. It asked India to accept Chinese domination over Aksai Chin in return of China's acceptance of Mc Mahon Line as the international boundary. India, however, has advocated 'sector-by-sector' approach. Indian side is hopeful because China has settled border disputes with Russia and Vietnam.

China's Aggressive Postures

China has been adopting aggressive postures against India and some other neighbouring countries even since the Indo-China wars of 1962. With its fast growing economy, China is dreaming of becoming a super power like the U.S.A. and one of the main devices to realise this dream is to dominate over its main rivals. From this point of view, India is the main target because India is also progressing rapidly. Some of the recent developments are pointers towards the unwanted intentions of China, so far as India is concerned.

1. China Water Strategy. China has prepared an ambitious plan to harness the huge water potential of the upper Brahmaputra river course in Tibet. The plan includes construction of gigantic 38,000 MW. Motuo dam along the Brahmaputra's ***'great bend'*** when the river curves to flow south into Arunachal Pradesh of India. China considers it to be the word's biggest hydroelectric project which would supply clean energy and would save 200 million tons of carbon emissions per year. It would involve 15-25 km long tunnels attached to downstream pipes. China claims that this dam would be 1.5 times the size of Three Gorges dam—currently world's biggest. In all 28 dams are proposed to constructed across the main Brahmaputra river and its tributaries in Tibet. Of these 28 dams, ten dams have been completed, three are under construction, seven under active consideration and eight more are proposed. Some of the important dams are shown in **Fig. 1.5**. These dams are primarily motivated by Beijing's desire to develop larger hydropower projects to power resource extraction, infrastructure development and ultimately for supply to coastal Chinese cities where demands are the highest.

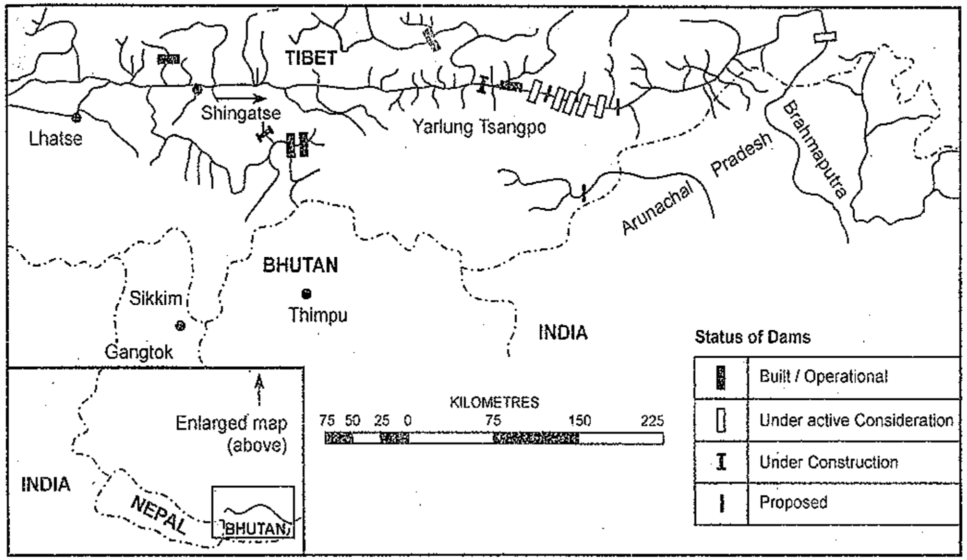

FIG. 1.5. China's water strategy includes construction of 28 Tibetan dams which will put India at a greater risk as the free flow of the Brahmaputra river water will be controlled by China.

The construction of these 28 dams will put India at a greater risk, because China will gain significant capacity to control the Brahmaputra's flow. China will be able to hold back water in the river when it is most needed in India during spring and summer, and release more water during the monsoon when there is fear of flood in large tracts of Assam and Arunachal Pradesh in the middle course of the river. Thus India will become dependent on China for flow of what is now a ***"free-flowing international river."*** Further, the proposed projects pose greatest risk for India because of seismic activity in the region. Thus water dispute has added a new dimension to the already complex relations between India and China. Limited water resources and rapidly growing demand for water resources on both sides of McMohan line is bothering our security planners. Since India is the lower riparian country, she is likely to suffer severely due to the Chinese plans and a conflict between the two giants of Asia can break at any time. Some defence experts on the Indian side have gone to the extent of calling this plan of China as ***'Chinese Water Bomb.'*** It may be pointed out that the turbulent Tibetan plateau is the source of most of China's water. According to an estimate, the existing water resources in Tibet are about 40,000 times higher than in China. Of that about 354 billion cubic metres (BCM) flows into India with 131 BCM being accounted for by the Brahmaputra alone.

According to a report published by Institute for Defence Studies and Analyses (IDSA), Beijing has plans of damming the Yarlung-Trangpo (Brahmaputra) and controlling the flow the river water to China's advantage. The IDSA report, "Water Security for India : The External Dynamics", states, "Harnessing the potential of the Yarlung-Tsangpo is critical to China's overall development" plans and is part of its grand design to divert waters from the south to the north. As a lower riparian state, India will be vulnerable to any major storage projects planned on the Yarlung-Tsangpo. The report also held that, "Given the political situation between the two countries it is hard to imagine China playing the role of a responsible upper riparian country by releasing *re-regulated* flows from power houses immediately back into the river." In fact China has advantage of using water resources as a ***military tool.*** Thus there is an urgent need for a regional basin approach by which China, India and Bangladesh decide to treat the water of the river systems of Tibet as a common resource and develop a formula to reasonably distribute it among themselves.

China's rail and road projects. Realising the strategic significances of railways and roads from the defence point of view, China has drawn a gigantic plan to construct railways and roads in the border areas. China has already completed its 3,900 km long Beijing-Lhasa rail link. This is considered as a great achievement by China because of the rough and rocky terrain and adverse climatic conditions prevailing in the Tibet plateau. China is also pushing ahead with several other railroad projects adjoining the Indian border. Two major projects are to connect Lhasa with Shigatse near Sikkim border and Nijingchi near Arunachal Pradesh border.

China has also announced plans to extend rail connectivity to its outpost at Rulli, adjoining its border with Myanmar. Proposals are also afoot to build 5,000 km of rail links, with emphasis on establishing connectivity in the Tibetan autonomous Region. Further, China has also proposed to build a rail network in Nepal.

In contrast, India is very poorly prepared so far as railway construction in border areas is concerned. There is practically no rail service in the whole of the Himalayan region except Jammu-Baramula rail link. Another plan has been drawn to construct 497 km Bilaspur-Manali-Leh rail link stretching from Himachal Pradesh to Jammu and Kashmir.

China is showing considerable interest in railway development in Pakistan also. Pakistan happens to be China's close allie so far as economic and defence ties are concerned. That country is helping Pakistan to build railway infrastructure very close to Indo-Pak border along the six km long Munabao (in Rajasthan) and Khakrapur (in Pakistan) making India vulnerable to Pakistani attack. Another 1,800 km long railway line has been planned by China. It will connect Keshgar in Xinjiang in China to Gwadar Port of Pakistan, passing through PoK, Islamabad and Karachi. Preliminary research study has already been conducted. India has objected to this project. China is also building Karakoram highway, a road of great strategic significance in the Pakistan occupied Kashmir (PoK) (**Fig. 1.8**).

All the above mentioned developments put India to a great risk because India will find herself at a great disadvantage as compared to China and Pakistan regarding the movement of men and materials in the event of a war.

Chinas Increasing Influence in the Indian Ocean. Although China has its coast on the Pacific Ocean only, that country is increasing its influence in the Indian Ocean also. As part of a new strategy called ***'far sea defence'***, the Chinese military is seeking to project naval power well beyond the Chinese coast, from the oil ports of West Asia to the shipping lanes of the Pacific. According to the Chinese admirals, Chinese warships will escort and defend tankers and other ships from as far as Persian Gulf and Gulf of Aden, sailing across the Indian Ocean to the Strait of Malacca carrying commercially important cargo. China imports most of its mineral oil requirements through this ocean router. According to the U.S. sources, China aims to have a formidable naval presence in the Indian Ocean. According Robert Kaplan of the centre for a New American security, "The rise of China as a sea power is one of the biggest development of the last one decade. China's ambition of becoming a big power in the Indian ocean is reflected in the plan to build ports at Chittagong in Bangladesh, Hambantota in Sri Lanka and Kyaukpyu in Myanmar." He further remarked that China becoming sea power across the Indian Ocean and India too, is raising and becoming a sea power—

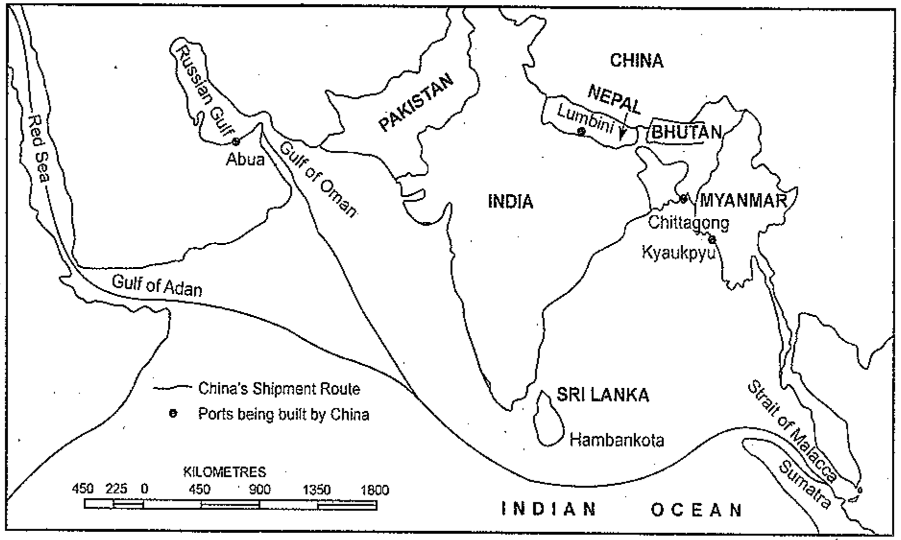

FIG. 1.6. China's increasing influence in the Indian Ocean

brings China and India into competition for the first time in their histories.

Apart from China's efforts to increase its influence in the Indian Ocean, that country is also trying to influence Nepal by providing facilitates for infrastructural development such as railways and roads and some industries. The latest venture is to develop Lumbini, the birth place of Lord Buddha as Mecca for Buddhists (**Fig. 1.6**). A Chinese government backed NGO, has signed a deal to develop Lumbini, a UN world heritage site, with funds worth $ 3 billion. The project is aimed at creating a 'special development zone' in the sleepy town by building airports, convention centres and infrastructural network. The project could be a major security concern for India due to long-term presence of Chinese personnel in the area.

2. The India-Nepal Boundary

India has common border with Nepal which stretches for 1,752 km from the trijunction of Nepal, Tibet and Uttarakhand state of India in the west to Sikkim state of India in the east. Five states of India, namely Uttarakhand, Uttar Pradesh, Bihar, West Bengal and Sikkim touch the Nepalese border with India. Major portion of Indo-Nepalese border runs in the east-west direction almost along the foothill of the Shiwalik Range. Although there had been numerous border conflicts between British India and Nepal since 1769, the present Indo-Nepal boundary is peaceful and there is no boundary dispute between the two countries.

Nepal is a landlocked country which is sandwiched between two giant countries of China and India. Consequently, Nepal has pursued its foreign policy very carefully and has allowed both India and China to construct roads linking its capital city of Kathmandu with its two big neighbours. Nepal has close contacts with India by treaties of friendship and protection from external aggression.

3. The India-Bhutan Boundary

Bhutan is a 'buffer' state between India and China and shares 587 km long border with India. Bhutan is protected from external invasion, although it became a fully sovereign nation and became a member of the United Nations in 1971. India's border with Bhutan is quite peaceful and there is no boundary dispute between the two countries.

Bhutan's border with China follows the crest of the Great Himalayas—the watershed for the north part. China rejected the watershed principle and claimed nearly 775 sq km of the northern Bhutan as its own territory. Bhutan has friendly relations with

India which are based on 1949 treaty. This treaty provides a sound framework to ensure 'perpetual peace and friendship'. Under this treaty, India has got the rights to protect Bhutan's sovereignty and defend its border. Accordingly, India formally protested in 1959 against China's claim over Bhutanese territory. China denounced India's rights of protection of Bhutan, and asserted that any border dispute with Bhutan could be settled with Bhutan without Indian interference. India maintained its right to defend Bhutanese borders as per provisions of the 1949 treaty. India has been closely helping Bhutan in its defense efforts. Indian army units are permanently stationed all along the Bhutan-China border.

4. The Indo-Pakistan Boundary

The Indo-Pakistan boundary is the result of partition of the country in 1947 under the Radcliffe award of which Sir Cyril Radcliffe was the chairman. This boundary runs through varied relief features and is marked by a large number of incongruities, anomalies and irrationalities. It starts from the marshy Rann of Kachchh in Gujarat, and traverses through the sandy deserts of Rajasthan, fertile plain of Punjab, hills and mountains of Jammu and Kashmir and reaches right upto the Karakoram Range in its northernmost reach (**Fig. 1.7**).

This boundary has created several problems by dividing the fertile erstwhile Punjab, the eastern part remaining with India and the western-part going to Pakistan in the form of West Punjab. Here the boundary line cuts across the canals, roads, railways, towns, villages, fields and even the places of worship. Thus, it is a purely unnatural boundary created by man as a result of partition of the country which is based entirely on communal considerations.

Consequently boundary has been marred by a number of disputes and hostile activities from both the countries ever since it came into being. Following disputes are worth mentioning.

(i) The Rann of Kachchh Dispute. Rann of Kachchh boundary was well defined according to the Radcliffe award but Pakistan advocated that it was not properly delineated. That country argued that the Rann was not a marsh but a land-locked sea or lake and as such it should be equally divided between India and Pakistan. India countered Pakistani claim

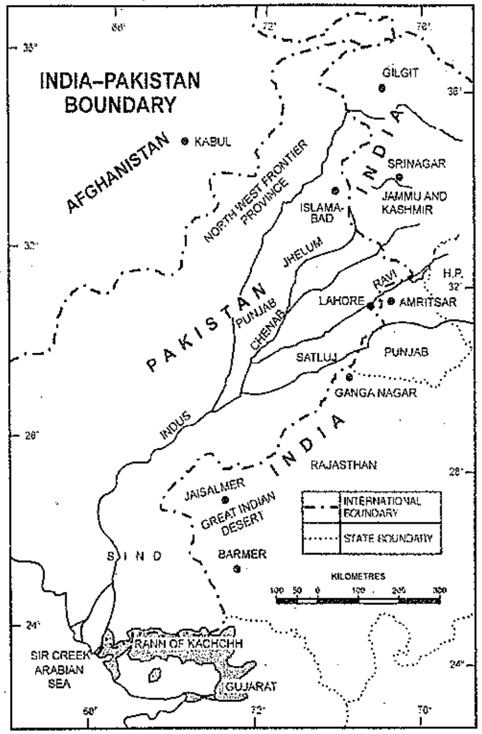

FIG. 1.7. India-Pakistan Boundary

by presenting documentary proof that the Rann was a marsh which always remained a part of the Kachchh state. As this state merged with India after independence, the entire Rann of Kachchh should be given to India. Pakistan claimed about 9,065 sq km out of a total area of 20,720 sq km of the Rann of Kachchh. During the 1965 Indo-Pakistan war, the Pakistani troops invaded this area and reached inside the Indian territory. The matter was referred to a boundary tribunal constituted by the International Court of Justice which awarded 906.5 sq km area of the Kachchh to Pakistan. After a number of protests and representations both India and Pakistan accepted the award and the demarcation of the boundary was completed in June 1969.

***(ii)* The Kashmir Problem.** The former princely state (more precisely the state of Jammu and Kashmir), is undoubtedly the most complex and serious problem between India and Pakistan and is the major stumbling block in normalising the relations

between the two countries. The Kashmir problem has led to bloody wars between the two countries in 1948, 1965, 1971 and 1999. There had been large scale violations of LoC by Pakistan in 2014. From defence point of view these violations are serious and can be compared to the 1971 war. Besides there had been skirmishes adding to bitterness between the two countries. Both countries have large political, economic and strategic stakes in Kashmir and this state has become a symbol of national prestige and honour for either of the two countries.

With an area of 2,22,236 sq km Jammu and Kashmir is the sixth largest state of India and represents heterogenetic character with regard to geographic, economic, cultural and linguistic elements. The whole state of Jammu and Kashmir can be treated as conglomeration of six distinctive regions. These regions (excepting for Hunza-Gilgit and Nagar) were brought together as a united political unit by Maharaja Gulab Singh, who entered into a subsidiary alliance with the British within the Indian empire in 1849. The *first* is the beautiful **Kashmir Valley.** It is the most important centre of tourist attraction and politically the seat of central authority. Until recent time, it was accessible from India by a single road. This road remained snowbound until the introduction of snowplows in 1948. A few roads connect it with Pakistan. The nucleus of dispute in this valley is its overwhelmingly Muslim population. The minority of Kashmiri Brahmans have been holding high positions of economic, social and political significance, whereas the Muslim peasantry remained very poor. The *second* is the **Jammu** region which lies in the southern part of the state. It covers only one-seventh of the total area of the state and is predominantly a Hindu majority region. More than half of the population of this region consists of Hindus. Jammu is the winter capital of the state and home of state's former rulers—the Dogra Rajputs. The *Third* region is **Gilgit.** It lies in the northern part of the state. This region is marked by high mountains and is almost entirely inhabited by Muslims. Previously it used to be reached from Srinagar by crossing high mountains, plateaus and glaciers. Now it is well linked to Pakistan through Karakoram highway built by China-Pakistan in 1970. The *fourth* region is that of **Baltistan** which lies in the extreme northern part of the state. Like Gilgit, it contains high mountains and is not easily accessible. It is reached by road along the Indus river in Pakistan. It is an overwhelmingly Muslim area. The *fifth* region is that of **Punch** which lies to the north of the Jammu region and in the west of the Kashmir valley. It is near the Pakistan border and is inhabited by Muslims. Pakistan has easy access to this region. The *sixth* is the **Ladakh** region which is also known as 'Little Tibet'. It lies in eastern part of the state and covers about one-third territory of the state. It is a vast, barren, high plateau which resembles Tibet in many respects.

As mentioned earlier, the state was ruled by a Hindu whereas about 77 per cent of the population of the consisted of Muslims before partition of the country. It is an extremely important state from the strategic point of view because of its contiguity to Pakistan, China and Afghanistan and proximity to Tajikistan (formerly a part of the U.S.S.R.). The state was sought by Pakistan on the basis of its Muslim majority status. Moreover, major rivers of Pakistan namely Ravi, Chenab, Jhelum and Indus flow through Kashmir. Unlike most of the rulers of princely states who had acceded to either India or Pakistan before August 15, 1947, ruler of Kashmir did not make up his mind. The Maharaja thought that any decision to accede to India or Pakistan may spark off chain reactions and disturb the peace of the state. Pakistan cut off the communications and stopped the supply of essentials to coerce Kashmir to accede to Pakistan. On October 22, 1947, fully armed tribesmen, supported by Pakistani armed forces, invaded Kashmir. They indulged in large scale killing of Hindus and Muslims and committed large scale looting and arson. This forced the ruler to make a desperate appeal to the Indian government for military help. India promised to help the ruler but only after he decided to accede to the Indian Union. The ruler agreed to this condition and the instrument of accession of Kashmir was signed by Maharaja Hari Singh on October 26, 1947. The accession was accepted by the Governor General of India on October 27, 1947. Thus, Kashmir became legally and constitutionally an integral part of the Indian Union. Pakistan described the Maharaja's accession to India as based upon "fraud, deceit and violence", and maintained that it was totally against the wishes of its long oppressed Muslim subjects. Soon after, Pakistan rushed its own troops to support the invading tribesmen. India quickly moved its troops to halt the invaders and Indo-Pakistan war broke out in 1948.

India could have done much better, had it flushed out the invaders from the entire state. Instead, India took the case of aggression from Pakistan to the United Nations which immediately appointed a commission to investigate the dispute. The United Nations Commission on India and Pakistan (UNCIP) proposed a plebiscite to ascertain the wishes of the people of the state. It also called on India and Pakistan to agree on a cease-fire line. A cease-fire line was delimited with areas of high altitude left undelimited. The line was accepted by both India and Pakistan on January 1, 1949. The cease-fire line left India in possession of two-thirds of the state including the Kashmir valley, lying south-east of the line, and one-third area in the north and west of the line remained under Pakistan's control. The area is administered through the so-called *Azad Kashmir* government. The cease-fire line (adjusted under Shimla Agreement as Line of Actual Control) has crystallized into de facto boundary between areas controlled by India and Pakistan respectively.

Right from the beginning Pakistan has been insisting on plebiscite in the entire state in the hope that such an exercise will give clear mandate in its favour. That country argues that plebiscite has been recommended by the United Nations. India, on the other hand, held the position that Kashmir's accession had given India sovereignty over Kashmir. Initially agreeing to the proposal of plebiscite, India rejected it on the ground that Pakistan had not withdrawn its

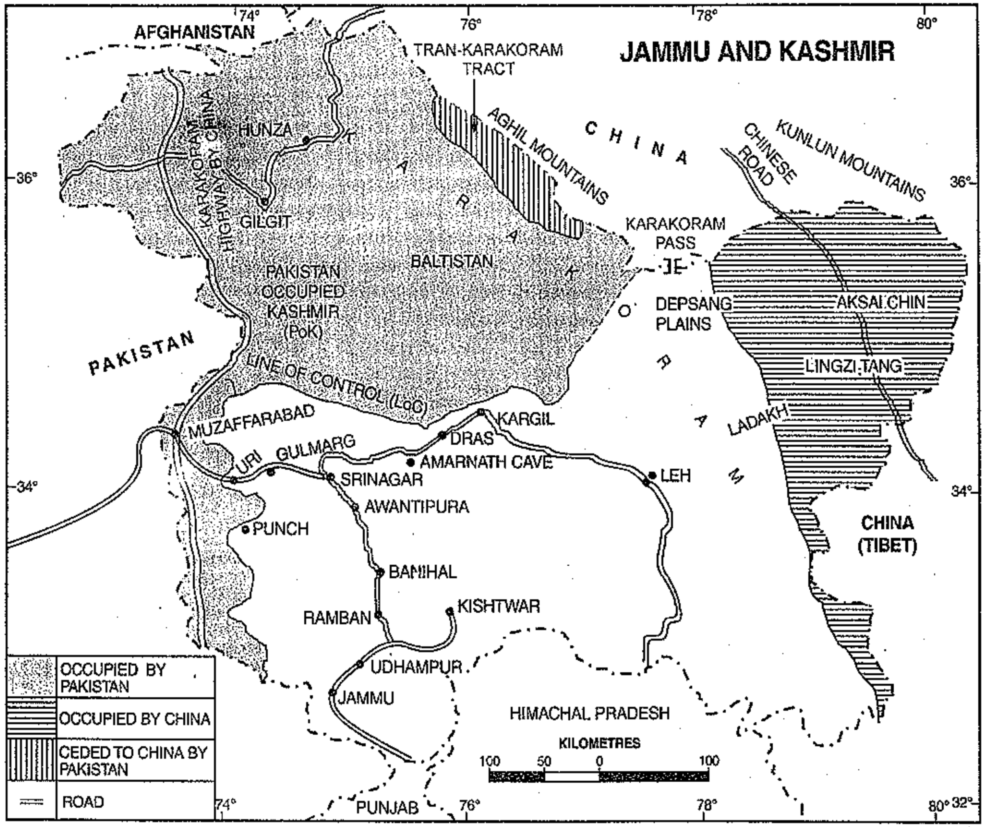

FIG. 1.8. Jammu and Kashmir

invading forces from Kashmir. This condition was stipulated by the United Nations resolution, but had never been realised on the ground. India has been regularly stressing upon the illegality of Pakistani support of the raiders and the *Azad Kashmir* government. Pakistan blames India for failing to withdraw its forces from the Indian-controlled territory, and for supporting a regime prejudicial to holding of a plebiscite. Since then the issue has been getting listed in the U.N. Security Council and the Cease Fire line or Line of Actual Control divides Kashmir between Indian and Pakistani occupied areas.

Ever since Kashmir's accession to India, the Kashmir government in Srinagar has maintained a close relationship with the Indian Union, and in 1952, negotiated a pact which has given it a special status within India. In 1956, arrangements were made for establishing an elected constituent assembly for Kashmir which voted to make it a regular state within India. Since then, India has treated Kashmir as a constituent unit of the country and the state is no longer open to a plebiscite.

Two major considerations have guided India's policy about Kashmir problem. *First*, India is secular state and surrender of Kashmir to Pakistan on religious grounds would amount to denial of the nation's essential principles. *Second*, the strategic location of Kashmir is of great importance to India. China's occupation of Tibet and part of Ladakh and building a road through Aksai Chin to serve Tibet and Sinkiang, and full scale aggression on India in 1962 further lent urgency to the strategic aspect of Kashmir's location. China helped Pakistan in building a new road across its occupied area to Sinkiang and Pakistan, in turn, ceded a large territory of 5,180 sq km to China. This move by Pakistan has been termed as illegal; because India claimed that the entire state including the territory controlled by Pakistan, annexed by China and ceded by Pakistan to China belonged to India. Thus, out of a total area of 2,22,236, a territory of 78,114 sq km is under illegal occupation of Pakistan, and 5,180 sq km illegally handed over by Pakistan to China and 37,555 sq km under illegal occupation of China in Ladakh district.

Pakistan has so far made four abortive attempts to conquer Kashmir. Its forces had to trace back in 1947-48 war when Kashmir was legally acceded to India. Pakistan again invaded in 1965 and it was badly mauled by the Indian forces. The 1971 India-Pakistan conflict led to the liberation of East Pakistan and emergence of a new country by the name of Bangladesh. This left Pakistan a truncated country and added much to the already increasing bitterness between India and Pakistan. In 1999, Pakistani troops stealthily occupied certain positions in the Kargil sector for which India had to use strong force. Unable to beat India in regular warfare, its forces are launching proxy war in Kashmir and sending foreign mercenaries and terrorists to disturb law and order in and incite communal tension in the state. Due to its link with Islamic terrorist organisations and ISI, Pakistan has become the hot-bed of international terrorism and is posing a serious threat to world peace. Even after more than six decades of Kashmir's accession to India, there seems no sign of resolving the Kashmir problem as both sides stick to their respective positions. India is taking no chance to safeguard the integrity and sovereignty of the country, particularly of Jammu and Kashmir. There are an estimated 1,00,000 Indian troops ranged along 188 km long International Border, the 788 km Line of Control (LoC) and 150 km Actual Ground Position Line (AGPL) in Jammu and Kashmir.

(*iii*) The Siachin Glacier Dispute. Siachin glacier is about 75 km long and 2 to 8 km wide. This glacier has the distinction of being the largest glacier outside the Polar or sub-Polar regions. It covers an area of about 450 sq km at an altitude of about 5,800 metre above sea level in Ladakh region near Karakoram range. The Karakoram highway between China and Pakistan is very close which enhances its strategic value. India occupies about two-third area of the glacier in its south-eastern part. Here Nubra river emerges from Karakoram glacier and meets the Shyok river which is a tributary of the Indus river. Indian troops use the Nubra valley to reach the glacier. The glacier has four passes. Of these Gasherbrum, Saltoro and Vilafondala are in India and Gyongla is under Pak occupied Kashmir.

It is worth mentioning that LoC demarcated in 1972 after the Shimla agreement stopped dead at the grid reference N.J. 9842, with no indication as to how it would run along the 70-odd km left to the Chinese border in the north. While Pakistan decided to extend this line eastward to Karakoram Pass, thus claiming an area two-thirds the size of Sikkim, India's decision

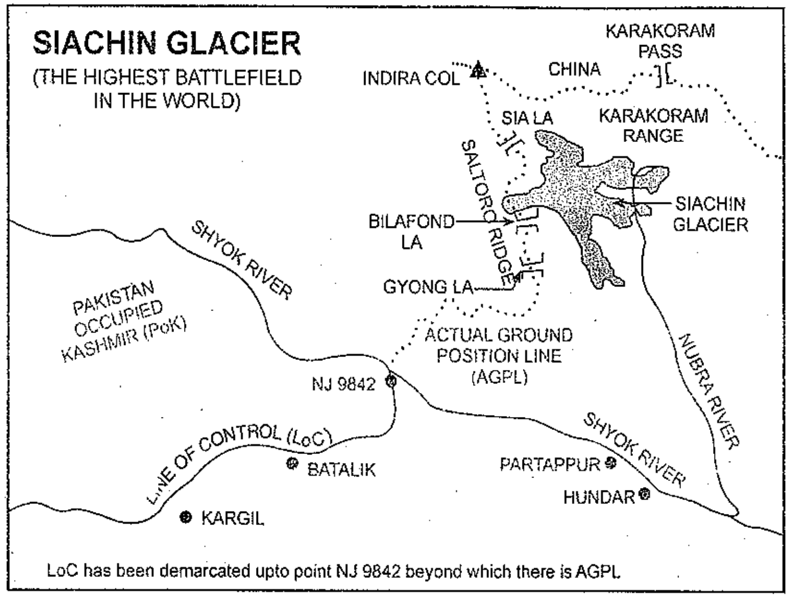

FIG. 1.9. The Siachin Glacier : The Highest Battlefield in the world.

was to go by the wording of 1949 Karachi agreement that was superseded by LoC of 1972 which spoke of line "thence northwards joining the glaciers". Further, India wants Pakistan to officially recognise the Actual Ground Position Line (AGPL) begin N.J. 9892 grid point as a pre-requisite to de-militarisation of the Siachin glacier.

Pakistani troops established an observation post on Saltoro range. To counter this, India launched Operation Meghdoot on April 13, 1984. Since then both the countries are maintaining troops in this inhospitable environment at a very high altitude. A number of skirmishes have taken place making it the highest battlefield in the world (**Fig. 1.9**). Sending men and material in such an area is a very expensive affair. On an average India spends about ₹ 5 crore per day for maintaining troops in this hostile area. Pakistan also spends about ₹ 2 crore for the same purpose. Casualties on both sides of the border are also very high. Even in normal circumstances, Indian troops suffer one casualty every second day while Pakistani troops suffer one casualty every fourth day. Besides there are psychological desorders, frostbite, high altitude pulmonary and cerebral edema and snow blindness. Such heavy losses can be avoided if both the countries start living in peace as friendly neighbouring countries.

(iv) **Sir Creek.** Sir Creek forms the boundary between Gujarat state of India and Sind Province of Pakistan. This creek is extremely rich in oil and marine life and both the countries desire to include it in their respective territories (**Fig. 1.10**). Sir Creek has become a contentious issue between the two countries as Pakistan has been claiming a 40 km region inside India's territory. The Sir Creek dispute goes back to pre-independence India and involves the last portion of our western land border that is in the form of a 100-km estuary that empties into the sea. Pakistan claims that the border runs along is eastern shore, while India invokes the "Thalweg principle" in international law to say that it lies in the middle of the channel.

Pakistan has responded positively to the goodwill gesture initiated by India since early 2004 to ease tension on the border. This can lead to friendly relations between the two countries if the concerned countries take necessary positive steps for normalisation of relations.

Some of the steps taken/proposed are :

- Srinagar-Muzaffrabad bus service.
- Kargil-Skardu bus link and routes into Poonch-Rajouri sector.
- Amritsar-Lahore bus and rail link.
- Meeting points for divided families across LoC at Poonch, Mendhar, Suchetgarh, Uri, Tangdar and Kargil.
- Rail link between Munnabao (Rajasthan) and Khokrapar (Sind).
- Link between Ferozpur and Sahiwal.
- Trade across the LoC/border.
- Mechanisms to permit two-way religious pilgrims.
- Promotion of cultural interaction and cooperation.
- Joint efforts to promote tourism.

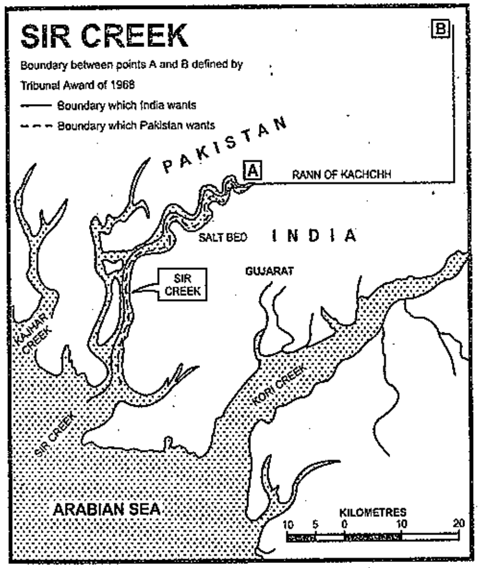

FIG. 1.10. Sir Creek

5. The India-Bangladesh Border

Of all the neighbouring countries, India's 4,096 km long border with Bangladesh is the longest and accounts for nearly 27 per cent of the total land border of India (**Table 1.2**). As many as five Indian states share the international boundary with Bangladesh. They are West Bengal, Assam, Maghalaya, Tripura and Mizoram. The boundary line between India and Bangladesh criss-crosses the vast Ganga-Brahmaputra delta. This boundary runs through an entirely flat country, in which there is not even a small mound or hill which could be used for demarcating the boundary between the two countries. It is, therefore, a very unsatisfactory border because it fails to separate the people living on either side of the frontier. This boundary has been determined under the Radcliffe Award which divided the erstwhile province of Bengal into two parts. The eastern part went to the then East Pakistan which became an independent country, Bangladesh in 1971, and western part remained with India as the state of West Bengal. West Bengal has 2,272 km long border with Bangladesh which is the longest border shared by any Indian state with Bangladesh. Although Indo-Bangladesh border has remained more or less peaceful and there are no serious border problems between the two countries, yet there were four overlapping claims which were referred to the tribunal. The first was between Rajshahi district of Bangladesh and Murshidabad district of West Bengal (India). Here the channel of the Ganga fluctuates rather frequently as a result of which the boundary has shifted several times. The northern portion of the district was confirmed as the international boundary. The *second* dispute was between Karimpur district (India) and Daulatpur district (Bangladesh). In this

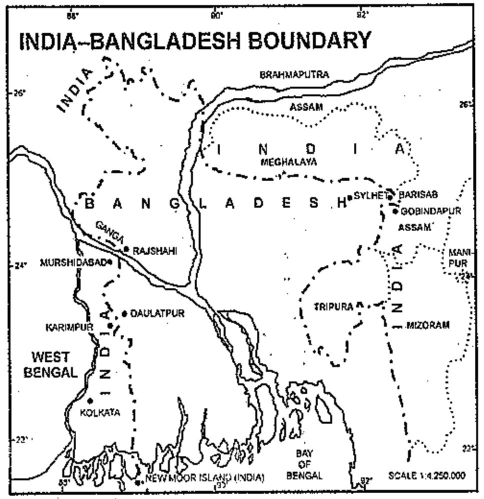

FIG. 1.11. India-Bangladesh Boundary

case, Redcliff award was amended and half way line in the Matabhanga River was treated as the international boundary. Bangladesh gained about 13 sq km as a result of this amendment. The *third* dispute was in Sylhet district of Bangladesh and Garo, Khasi, and Jaintia Hills districts of Meghalaya in India. This is a densely forested area where demarcation is difficult. Here Radcliffe Award was confirmed and India's claim was sustained. The *fourth* dispute existed between Barisari district (Bangladesh) and Gobindpur district (Assam).

Farakka barrage was another major issue between India and the then East Pakistan (now Bangladesh). Immediately after the Indus Water Treaty between India and Pakistan, a dispute arose over the use of the Ganga river water. India planned the construction of a barrage across the Ganga at Farakka. This barrage aimed at rejuvenating the river system of West Bengal, flood control, efficient distribution of water between the northern and southern parts of West Bengal and for desilting the Kolkata harbour. Pakistan feared that construction of Farakka barrage would seriously reduce water supply to East Pakistan. Negotiations failed to produce a settled agreement and the work on the construction of Farakka barrage started in mid 1960s.

During the 1980s a refugee influx of Bangladeshis in Tripura and Assam created problems for India. By 1989 more than six lakh refugees from Bangladesh had entered India. The refugee influx continues even today, creating economic, social and political problems for India. Currently, almost all the Indian states touching the Bangladesh border are infested by refugees from Bangladesh. India's plan to erect barbed-wire fence along the Bangladesh border to check the illegal migration of refugees from Bangladesh has not been welcomed by that country.

In the beginning, the emergence of an independent and generally friendly country of Bangladesh in place of the initial East Pakistan was viewed positively by India. But the recent growth of anti-India elements backed by ISI of Pakistan is likely to create problems between the two countries.

However, things have slightly changed in the positive direction as India and Bangladesh agreed on 6th September, 2011 to exchange 166 enclaves in each other's territory, settle all issues related to adverse possessions and demarcate the lost stretch of 6.5 km of the 4906 km border. According to the deal, India will get back 111 enclaves and 55 will go to Bangladesh. But there is strong resentment in Assam as that state is likely to lose 665 acres of land across Dhubri and Karimganj districts to Bangladesh. Bangladesh initially wanted 793 acres of land from India but was given only 267.5 acres according to the agreement signed by the countries on 6th September, 2011. Indian states bordering Bangladesh are also sour about the illegal Bangladeshi immigrants to their states. It is estimated that there are over 40 lakh illegal Bangladeshis in Assam alone. Sharing of waters of the river Teesla—including those of Feni, Manu, Muhuri, Khowai, Gumti, Dharla and Dudhkumar still remain the main irritant.

Another major problem between India and Bangladesh is the refusal of transit facility to India by that country. **Figure 1.12** shows that a narrow stretch of land in the northern part of West Bengal—referred to as the **Siliguri Corridor** or **Chicken's Neck**—is north east's only gateway to the rest of the country. This not only puts extraordinary pressure on this route but gave Dhaka a diplomatic edge over India due to the economic and strategic significance attached to the transit facility requested by New Delhi. India has entered into an agreement with Myanmar to execute the Kaladan Multi-Modal Transit Transport Project through which goods can be easily shipped from ports in eastern India, loaded into small vessels to be transported trough Kaladan river in Myanmar and then transhipped onto trucks that would drive through Myanmar into Mizoram state of India. India will bear the cost of upgradation of Sittiwe Port and Kaladar waterway and construction of road from Setypitpyin (Kaletwa) to Indo-Myanmar border. The plan includes construction and improvement of the 117 km road on the Indian side from the border up to National Highway 54. The Kaladan river is navigable from the Sittwe port to Setpyitpyin (Kaletwa) beyond which navigation is not possible due to shallow water and frequent rapids across the river.

SALIENT FEATURES

- Alternate route to Chicken's Neck from Kolkata to Mizoram.
- Kolkata (India) to Sittwe (Myanmar) sea route.
- 225 km journey from Sittwe post to Setpyispyin (Kaletwa) transport on River Kaladan.
- 62 km road journey from Setpyipsyin to Mizoram border.
- Mylikwa will be handling port in Myanmar.
- Hmawngbu will be the handling port in Mizoram.

BENEFITS FROM THE PROJECT

- An alternative access route from any part of India to landlocked north-eastern region.
- Net saving of time and cost involved in the movement of goods.
- The route will lead to economic development of the entire north-east region and motivate youth to stay away from insurgency.
- A strong message to Dhaka that withholding transit did not imply that India did not have alternatives.

6. India-Myanmar Boundary

The boundary between India and Myanmar is 1,458 km long and runs from India-China-Myanmar trijunction in the north to the southern tip of Mizoram. This boundary runs roughly along the watershed between the Brahmaputra and Ayeyarwady. It passes through thickly forested hill country, with Mizo Hills, Manipur and Nagaland on the Indian side and Chin Hills, Naga Hills and Kachin state on the Myanmar side. Although defined under the treaty of Yundaboo in 1926, this boundary was determined precisely by bilateral treaty signed on March 10, 1967. Barring a few minor incidents, the Indo-Myanmar-border has remained peaceful due to the goodwill gesture of give and take on both sides.

In May, 2012, India and Myanmar signed several agreements in Naypyidaw (new capital of Myanmar, over 300 km north of old capital Yaugon) to strengthen relations between two neighbouring countries. Some of the important agreements are briefly described as under :

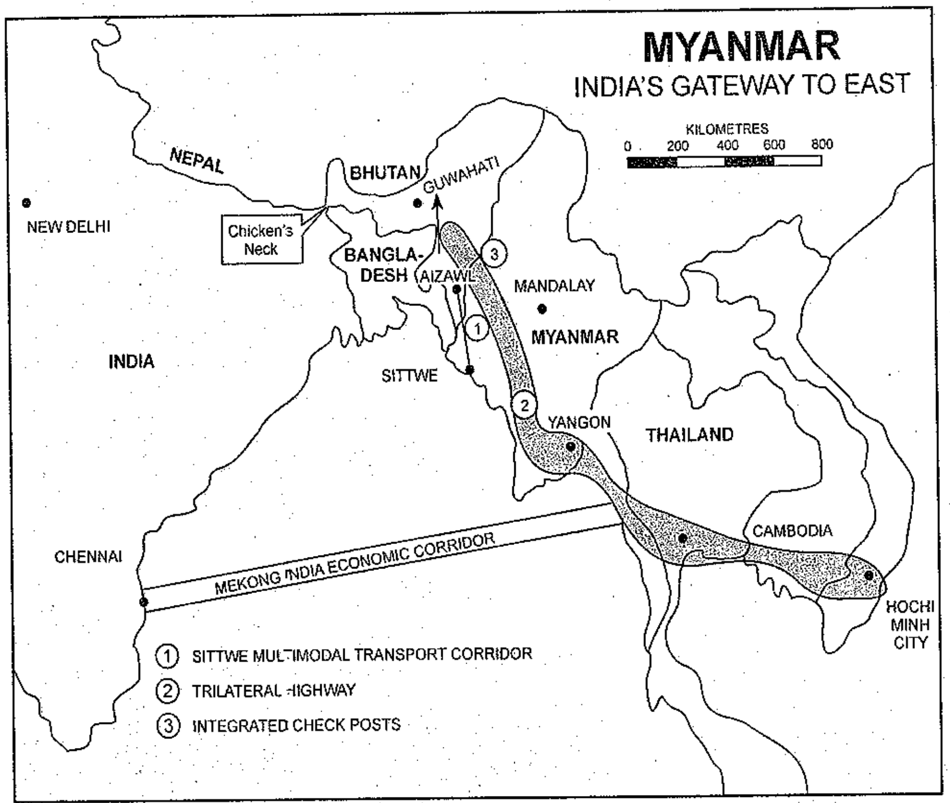

FIG. 1.12. Myanmar : India's Gateway to East

1. Sittwe Multimodal Transport Corridor. This a road and river corridor which will run from Sittwe port (Myanmar) to Aizawl in Mizoram. It will provide India an alternate access to Mizoram and Manipur in case northeast insurgents block National Highway 45 again. It will also strengthen trade between India and Myanmar.

2. Trilateral Highway. This highway from India to Vietnam is the most ambitious and geopolitically the most significant project. Concerned as a three nation project by India under the Ganga-Mekong cooperation agreement in 2004, it now includes Combodia and Vietnam. However, it is facing difficulties due to poor infrastructure in India and Myanmar.

3. Integrated Check Posts. India is building a check post on the Myanmar border in Moreh like the one at Wegah with Pakistan border near Amritsar. The difficulty lies in the fact that the trade agreement covers only 40 items, compared to thousands in most such deals.

4. Mekong India Corridor. There is plan to developed Dawei port of Myanmar which will allow shipments from the Indian Ocean to find easy access to Thailand and South-east Asia avoiding much longer route via Malacca Straits.

Water Frontiers

About 6,100 km long coastline of mainland of India is washed on three sides of the country by the Indian Ocean and its two arms namely the Arabian Sea in the west and the Bay of Bengal in the east. If we add to this the coastlines of Andaman and Nicobar Islands in the Bay of Bengal and Lakshadweep Islands in the Arabian Sea, the total coastline stretches to 7,517 km. Next to the Himalayas, the Indian Ocean is the most dominant factor which has influenced the destiny of India. It is through the waters of the Indian Ocean that India could establish her trade contacts with the neighbouring countries in the historic past. One of the greatest climatological phenomena, the Monsoon winds, have their origin in the Indian Ocean. Our water frontiers had been considered to be safe in the past. But the recent technological advancements in naval warfare have made these frontiers vulnerable to attack by the enemy forces and this has necessitated greater defence preparedness. "To be secure on land, we must be secure at sea."

7. India-Sri Lanka Boundary

India and Sri Lanka are separated from each other by a narrow and shallow sea called Palk Strait. Dhanushkodi on the Tamil Nadu coast in India is only 32 km away from Talaimanar in Jaffna peninsula in Sri Lanka. These two points are joined by a group of islets forming Adam's Bridge. There have been close and cordial relations between the two countries in the historical times. Every phase of Peninsular Indian culture found its way into the island. Consequently more than half of the island had remained under the peninsular influences. The northern and north-eastern parts of the island have large number of Tamilians who migrated from Tamil Nadu to that country.

The maritime boundary between India and Sri Lanka passes through Palk Strait as Palk Bay touching Dhanushkodi (**Fig. 1.13**). This boundary has remained peaceful barring a few minor clashes between the fishermen of the two countries over the fishing rights. Some bitterness was created over the ownership of Kachchitevu Island (area 1.92 sq km) in the Palk Strait about 16 km from the Tamil Nadu coast. The problem was resolved with the demarcation of India, Sri Lanka boundary along the median line. This island was given to Sri Lanka as a result of agreement of 1974. The maritime boundary between India and Sri Lanka became lively in 1980s with the insurgent activity of L.T.T.E. which is demanding a separate homeland for Sri Lankan Tamils within the island.

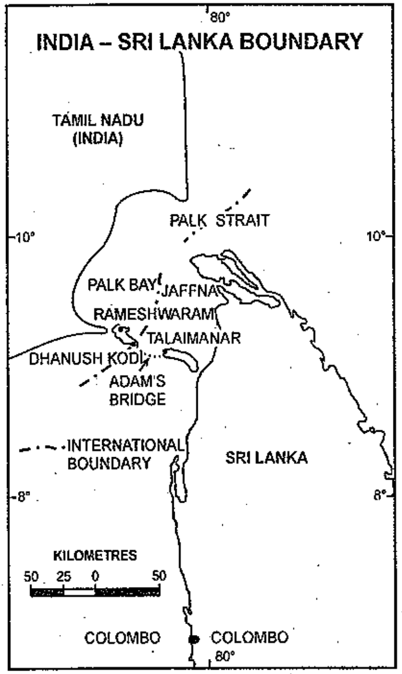

FIG. 1.13. India-Sri Lanka Boundary

GEOPOLITICS OF THE INDIAN OCEAN

With an estimated area of about 73,442,700 sq km the Indian ocean is the third largest ocean in the world after the Pacific Ocean and the Atlantic Ocean. Although the Indian Ocean is much smaller in size than the Pacific and the Atlantic Oceans, yet it is of immense importance for us because it is located to the south of India. This is the only ocean in the world to be named after the name of a country, *i.e.*, Indian Ocean after India. In a way, it is just half an ocean because it does not open out northwards in the Arctic Ocean. It is bounded by South Asia in the north, Indonesian islands and Australia in the east and by Africa in the west. The meridian of Cape of Tasmania (147°E) forms the boundary line between the Indian and the Pacific Oceans while the meridian of Cape Town (18° 22'E) forms the dividing line between the Atlantic Ocean and the Indian Ocean. In the south, it extends to the Antarctic continent from where it merges with the Atlantic and the Pacific. The International Hydrographic Organisation has recognised the coast of Antarctica as the southern extreme of the Indian Ocean. Tropic of Cancer forms its northernmost limit.

The Indian Ocean has great strategic importance for India. The "landlocked" nature of the Indian Ocean has given India a commanding position. From the eastern coast of Africa and the shores of the Persian Gulf to the Strait of Malacca, no other country rivals India's dominant location in the Indian Ocean. The strategic importance of this ocean is further enhanced by the fact that it is accessible from the west and the east through narrow straits only. The Red Sea and the Persian Gulf are the narrow outlets in the west while in the east, there are the Strait of Malacca and the Timore and Arafura sea.

The Indian Ocean has limited outlets. Before the opening of the Suez Canal in 1869, the only contact of littoral states of the Indian Ocean with the western countries was via Cape of Good Hope by circum-navigating the whole continent of Africa. On the eastern side there are two outlets—one through the islands of Indonesia and the second is to the south of Australia. The Indian Ocean can be choked any time by controlling these outlets. Since the Indian Ocean and the countries surrounding it are very rich in natural resources, such a possibility has considerably enhanced the geopolitical strategy of this ocean.

In spite of above mentioned geopolitical limitations, the Indian Ocean has never been a barrier between the countries. On the contrary it has served as a great linkage between the countries lying on its coasts and even further beyond. We can reach West Asia, Africa and Europe from the west coast and South East Asia, Far East and Oceania from the eastern coast. The Indian Ocean, thus, bridges a gap between east and west. This ocean is encircled by 46 countries (27 littoral including Australia, 7 island countries and 12 landlocked countries as recognised by the U.N.), with great diversity in almost every respect; shape, size, people, resources, economy, polity, culture, etc. (**Fig. 1.14**)

The Indian Ocean is endowed with rich variety of natural resources of which mineral and power resources as well as food resources are very important. Some of the resources are briefly described as under :

Aggregates

Marine aggregates comprise sand, gravel or shell deposits and are used primarily in construction industry. They are, at present the most important commodities mined offshore, both quantitatively and by value. They are mainly found on the continental shelves. Offshore calcareous deposits are formed by fragmentation of shells by waves and currents. These are used for manufacturing cement.

Placers

Placer deposits are concentrations of heavy, resilient, and chemically resistant minerals eroded

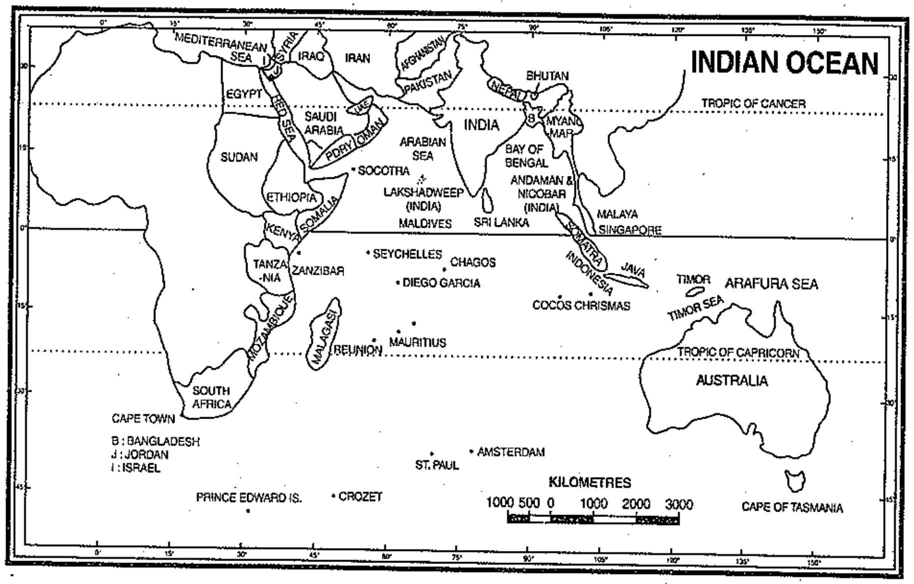

FIG. 1.14. Indian Ocean

from existing ore bodies by mechanical weathering. Such deposits include native gold, native platinum, tin, titanium, magnetite (iron), zirconium, monozite (thorium) and gemstones. In the Indian ocean, such placers are found along the coasts of Sri Lanka, India, Australia, Malaysia and Indonesia. Sri Lanka, India and Australia have titanium sands, whereas Malaysia and Indonesia have tin deposits. Indonesia is one of the main areas in the world where offshore placers are mined. Primary tin deposits occur in granitic rocks onshore and heavy minerals extend offshore.

Polymetallic Nodules

Polymetallic nodules are those which contain several metals, the important metals being manganese, copper, nickel, cobalt, etc. They occur in many shapes, sizes and forms and are generally friable.

Manganese nodules were first discovered on the 1872-76 scientific voyage of *Challenger*, but systematic exploration and detailed studies only started in late 1950s when it was realised that nodules might be a source of nickel, copper and cobalt. Several investigations in the mid 1960s reported finding enrichment of manganese and iron in the sediments of wide areas of the ocean floor on the East Pacific Rise axis, and since then similar enrichments have been found in Indian ocean also, especially along the mid-Indian rise. India has obtained the technology of exploiting these mineral nodules from the ocean beds. The United Nations has granted permission to India to exploit the polymetallic nodules over an area of 1,50,000 sq km in the Indian Ocean. India is the first country to obtain such a right. The National Insititute of Oceanography, Goa has played a leading role in the research and development of this mining technique.

Metalliferous nodules containing zinc, copper and silver have been discovered in Red Sea. *Seafloor phosphorite* contains phosphate mineral which is used for the manufacture of phosphate fertilizers and certains phosphate based chemicals. Seafloor phosphorite was first discovered as nodules in dredge samples obtained from the Agulhas Bank off South Africa during the *Challenger* Expedition of 1872-76 and have since been found elsewhere. They occur mostly on the continental margins and upper parts of the continental slopes at depths of less than 500 metres. They are normally confined to the zone between 40°N and 40°S latitudes. In the Indian ocean phosphorite deposits occur along the coast of Arabian

Peninsula, east coast of India in the Bay of Bengal, near Andaman and Nicobar Islands and in the south of Sri Lanka. Phosphorites occur widely on Agulhas Bank off South Africa. It has become one of the most intensely studied areas of the world. The total reserves are estimated at 450 million tonnes.

Estimates of reserves suggest that recoverable *nickel* and *copper* are of the same order as known land economic resources. But the current level of technology is not competent enough to exploit these resources. Specialised mining systems have to be developed to recover the nodules without lifting the underlying sediment from depths in excess of 4000 metres. The environmental conditions of potential mine sites and possibilities of mineral extraction have been ascertained.

Oil and Gas

Oil and gas are the most valuable of all the minerals extracted from the sea bed. Most of the oil and gas producing areas of the oceans are confined to the *continental shelf*, but oil wells in much deeper seas have been dug in the recent past. At present half of the world's total output of oil and gas comes from offshore wells and over 80 countries of the world are engaged in offshore drilling.

In the Indian ocean, the major players in offshore oil and gas exploration, drilling and production are India, countries surrounding the Persian Gulf and the south-east Asian countries like Indonesia and Malaysia. Coastal areas of Australia (western Australia) also have offshore oil reserves.

India has 3.2 lakh sq km offshore area of sedimentary deposits on the continental shelf upto a depth of 200 metres. The Indus cone formed by the deposition of sediments by the Indus river encompasses the Kachchh Shelf, Gulf of Khambhat and Mumbai High. Mumbai High is the largest oil producer of India. Huge gas reserves have been found in the Krishna-Godavari basin off the coast of Andhra Pradesh.

Oil and gas reserves of the Persian Gulf are simply amazing. But these reserves remained unexploitated for a pretty long time because this gulf has land based reserves also and those reserves were to be exploited first. The offshore potential is very important, especially for smaller states which have restricted land areas. The Persian Gulf has the advantage of being sheltered from the open ocean, is shallow and relatively free of hazards. It is the most rapidly developing part of the industrialising world as its onshore and offshore wealth is re-invested in industry. Kuwait, Saudi Arabia, Bahrain, Qatar, United Arab Emirates, Iran and Iraq are the likely beneficiary states.

In South-east Asian waters, offshore, oil is becoming increasingly significant for a number of countries in this vast archipelagic area. There is increasing shift from exploitation of land resources to offshore resources. This phenomena is particularly seen in Indonesia and Malaysia where the main producing areas are off southern Sumatra. The South-east Asian waters are considered as one of the most promising for immediate exploitation.

Off the coast of Western Australia there are substantial reserves of oil and gas. These reserves experienced rapid development in the 1970s.

Besides there is great scope for harnessing the non-conventional energy resources in this ocean.

The above mentioned and some other natural resources of this ocean can be a great cause of rivalry among the nations of the world.

India has used the Indian Ocean for thousands of years. This ocean had been a powerful medium of trade, defence, colonization and diffusion of Indian culture particularly in Southeast Asia. The Mauryan kings had established ports on the Bay of Bengal in the fourth century B.C. Kautilya made a mention of a separate administrative division of overseas maritime activities in his famous *Arthsastra*. Large naval kingdoms of the Cholas and Chalukyas were set up in South India. Sri Vijaya empire, set up by the Indian rulers in South-east Asia from eighth to eleven centuries, maintained strong cultural and commercial ties with south India through the Indian Ocean. The Arab explorers and traders increased their activities in the Arabian Sea from the middle of the 13th century to the beginning of the 16th century. However, they could not exercise much control on this ocean. The European influence in the Indian Ocean started after the landing of Vasco da Gama at Calicut on the western coast of India in 1498. Major European powers were eventually drawn into a long and bloody struggle for power in the Indian Ocean. Out of all the

European powers, Britain had the best naval force and gained supremacy over the Indian Ocean and the Indian subcontinent.

During the 18th and 19th centuries, sea ports like Mumbai, Kolkata and Chennai were developed to boost up sea trade and maritime activities. The British became a super power by dint of its naval superiority. According to an Indian historian and diplomat, K.M. Panikkar (1945), the history of British control in Indian Ocean illustrates the basic geopolitical principle that *the power which rules the sea eventually rules the adjoining land*. He observed that the pre-British invasions and land directed conquests of India led to the founding of political dynasties, which in a short period were Indianised. Only the British rulers could remain unassimilated as they could draw their strength from England through the naval supply lines. It is worth noting that although a large portion of north India was conquered many times by foreigners, India was never ruled by a monarch who did not have his capital in India except whom it was under the naval power of the British (Panikkar, 1951). Japanese effort to capture Singapore and Andaman Islands during the World War II also corroborated the above statement.

Most of the former British colonies became independent countries after the World War II. This resulted in shrinking of the British empire and reducing of the British influence in the Indian Ocean. By mid 1960s, it lost almost all the colonies and serious economic strains were experienced in Britain. Consequently Britain started withdrawing its military forces from the Indian Ocean region. This withdrawal created "*a power vacuum*" which gave birth to super power rivalry in the Indian Ocean region. The USA immediately jumped into the fray and made efforts to fill the '*power vacuum*' created by the withdrawal of the British forces. The USA purchased Diego Garcia island from Britain to build a military base there. The base is fully equipped with nuclear weapons and provides decisive advantage to the USA to command the areas of the Middle East, South Asia, Central Asia, Russia and China. In addition to Diego Garcia, the USA has set up military bases near Asmara (Ethiopia), Woomera and Harsld E. Holt (Australia) as well as in Bahrain and Mahe. The military bases at Vacaaos (Mauritius), Gan Island, Masirah Island, Simonstown (South Africa) and Port Louis (Seychelles) are jointly owned by the US and the UK. France has also set up bases in Diego Suareg and Reunion Island.

The Russian interest in the Indian Ocean region is as intense as that of the USA. The individuality of the ocean makes it possible for both the countries to exercise their power even though they may be far removed from the Indian Ocean. In order to counter the US influence, Russia sent its fleet in 1968. Since 1970, Russia has been steadily building trade and economic connections with India and the countries bordering the Indian Ocean. That country has entered into bilateral treaties with several countries of the region such as India, Sri Lanka, Bangladesh, Iraq, Egypt, Mauritius, Somalia, Seychelles, etc. Russia maintains military bases at Berbera, Masira, Umakas, Dahalak and Socotra islands. It constructed naval radio stations and ammunition depots too at the north of the Red Sea. It has also obtained access to port facilities in Somalia, Mauritius and Singapore. Russia is trying to gain a foothold in the oil rich countries of the Middle East also.

In the recent past, China has also shown keen interest in the Indian Ocean. With the former U.S.S.R. having lost its super-power status, China wants to take full advantage of the situation and is trying hard to fill in the vacuum, and ultimately assume the leadership of the Afro-Asian world. One of the major aims of the Russian push in the Indian Ocean is to contain Chinese influence in the African and Arab countries and in Southeast Asia. Since Indian and Australian naval capabilities are not significant, the western countries are deeply concerned over expanding influence of Russia in the Indian Ocean. India is currently preoccupied with economic development programmes. With her modest financial resources, India finds it difficult to develop a strong naval capability to deter encroachment by other major powers on India's role in the Indian Ocean.

India could establish her supremacy in the Indian Ocean in 1988 when Sri Lankan mercenaries invaded Maldives and Indian forces had come to its rescue. Maldives has been consistently turning down lucrative offers by big powers to provide facilities for establishing military bases on its soil in order to make the Indian Ocean a zone of peace.

The littoral countries encroaching the Indian

Ocean are closely associated with this ocean traditionally, culturally and economically. These countries are awfully worried about the geopolitical affairs of the ocean. The concerned countries want to keep the Indian Ocean a zone of peace rather than an area of cold war, great power rivalry, super power confrontation and a battle-field.

Maintaining the environment of peace in the Indian Ocean is very important for the littoral states because almost all the countries surrounding this ocean are at the developing stage. They are in the process of economic reconstruction and development, social change towards modernization and building the democratic political system. As such these countries cannot afford confrontation and war and they want to maintain peace in the Indian Ocean at any cost. Majority of these countries are members of the Non-aligned movement and do not want any external interference in the affairs concerning Indian Ocean. The member countries of the Non-aligned group strongly feel that the socio-economic prosperity in the region will only be possible when there is an atmosphere of economic co-operation and co-ordination among the richly endowed littoral states. This can happen only if the external powers are not allowed to show their presence in the Indian Ocean and are deterred from influencing the littoral states. The conference of the Heads of Non-aligned nations held at Lusaka in 1970 called upon all states to identify the Indian Ocean as a zone of peace and should also be free of nuclear weapons. The UN General Assembly has also passed a resolution to keep the Indian Ocean zone as a '*zone of peace*.'

However, there are several obstacles in maintaining peace in the Indian Ocean. A large number of the littoral states are small, economically poor and politically immature. Some of the littoral states such as India, Australia, Republic of South Africa, Iran and Indonesia are strong enough to influence the political events at the regional and international levels. Environment of politically strained relations between some of the neighbouring countries is also a great hindrance in the way of peaceful co-existence. The situation has become rather complicated with the growing interference of China and Japan. China wants to establish itself as a major power in the Afro-Asian region. Similarly, Japan wants to increase its influence because nearly 50 per cent of the Japanese international trade is carried through the Indian Ocean. The Gulf War made the Indian Ocean the focal point of the world geopolitics. The growing terrorism in the Muslim world has also assumed dangerous posture for the world in general and for the Indian Ocean in particular.

Thus, peace in the Indian Ocean is very fragile and it can be maintained only by the cooperation of the littoral states. Only such cooperation can save this ocean from exploitation by the developed countries and the erstwhile colonial powers.

ROUTES INTO INDIA

It has already been mentioned that India is separated from the rest of Asia by a broad *no-man's land* of mountains, from the north, north-west and north-east. Most of the Himalayan ranges are either ice bound or covered by thick vegetation and offer an almost an impenetrable wall. This makes India an intelligible isolate. However, there are a few passes which provide routes into India.

Three high passes *viz. Muztagh* (Snowy mountain), the *Karakoram* and the *Changchemo* are all over 6,000 metres above sea level and offer little scope for interaction between the two sides of the mountain ranges. Some passes in the high Himalayas such as *Burzil* and *Zoji La* in Jammu and Kashmir; *Bara Lacha La* and *Shipki La* in Himachal Pradesh; *Thagla La*, *K-Lang*, *Niti and Lipu Lekh* in Uttarakhand; *Nathu La* and *Jelep La* in Sikkim are used for crossing the main Himalayan range.

Towards the north-west, the frontier formed by the Himalayas is continued by the *Karakoram* range and the *Hindukush*. Further south lie the *Safed Koh*, *Sulaiman* range and the *Kirthar range*, which separate India from Afghanistan and Baluchistan. Thus the real natural frontier of India lies far away from the present man-made and artificial frontier between India and Pakistan which is the creation of partition of the country in 1947. The mountain ranges here become shallow and narrow down to less than 500 km between Turkestan and the Punjab (undivided) Plains. The *Hindukush* is pierced by numerous passes which are snow covered in winter but can easily be crossed in other seasons. There are a few passes which are less than 1,600 metres above sea level and offer easy access into India. The passes of *Khyber*, *Malakand*, *Tochi*, *Gomal* and *Kohat* have their base in *Badakhshan* province of Afghanistan and provide passage from Afghanistan to the Indian subcontinent. Towards the south, the highways of *Herat* and *Seistan* converge at Quetta. It is worth noting that Quetta lies at the head of the *Bolan pass* and provides one of the most significant gateways into the Indian subcontinent. History reveals that the barrier was at no time an insuperable one, and at all periods, invaders, settlers and traders have found their way over the high and desolate passes into India, while Indians have carried their commerce and culture beyond her frontiers by the same routes. India's isolation has never been complete, and the effect of the mountain wall in developing her unique civilisation has been over emphasised. People after people, literally nations have pressed into the Indian subcontinent through these passes and changed the fate of various dynasties in India. Hordes of invaders have attacked and conquered India through these passes.

Perhaps the earliest immigrants of civilised man into India were the *Dravidians* about whom little evidence is available. It is believed that they migrated into India from the *Tigris Valley* along the *Makran Coast* of present Pakistan. This was followed by many others in the pre-historic times, the most prominent being the *Aryans* who migrated by the Kabul approaches. Later in the historic times, several other people such as *Greeks*, *Parsees*, *Huns*, *Mughals* and *Mohammadans* entered India mostly through these passes.

In the east, the hills forming the boundary between India and Myanmar are comparatively low and rarely exceed 3,000 metres in elevation. But the dense forests, heavy rainfall for half the year, difficult terrain and a large number of swift flowing rivers have acted as effective barriers between the two countries. The only passages are along the courses of rivers Brahmaputra, Mekong, Salween and Ayeyarwadi—the main gaps being the *Ann*, *Teju*, *Manipur*, *Tulu*, *Tongap*, etc. Therefore, not many foreigners have crossed through this frontier into India. In fact, reaching Ayeyarwadi valley in Myanmar from India is much easier by sea than by land. The opening of a new trade route in 1995 connecting *More* in Manipur with *Tamu* in *Myanmar* may help in developing trade and cultural relations between the two countries. The bus service proposed in June 2014 between Imphal (Manipur) and Mandalay covering a distance of 579 km may further strengthen ties between India and Myanmar.

It is surprising that until the coming of European seamen, no considerable power was founded in India from the sea; but some were from India. Initiative to the east really came from India. Hindu traders and colonisers took their civilisation by sea to the south-east Asian countries. Buddhism originated in India and spread to the whole of eastern Asia. The Cholas had an empire in the East Indies. Several other Hindu cultural traits are still found in large parts of the Far East.

LAND OF DIVERSITIES

India is a land of great diversities and contrasts. It is but natural that an area as vast as the Indian subcontinent should have considerable physical diversity. *The extremes of physical and human geography of India are extreme indeed.* In the south is the Plateau which is one of the oldest and least disturbed land masses on the earth's surface. Its rocks have never been extensively covered by sea since their formation in the pre-cambrian period over 3,000 million years ago. In contrast to this, the Himalayan mountain ranges and the Great Plains represent the most recent formations. The denudational processes have made these contrasts still sharper. While the mountain ranges in the north have very youthful topography with sharp peaks and steep-sided valleys, the Peninsular plateau shows old and senile topography with gently rising ridges and wide valleys. The Aravalis and the Himalayas are perhaps the oldest and the youngest ranges on the earth's surface. The differences are most striking even in the landforms of recent origin. Within a distance of a few hundred kilometres from north to south, one can reach from the highest peak of the world to the flat, featureless and monotonous plain.

Even the rivers of the Himalayan and the Peninsular regions have contrasting characteristics. The Himalayan rivers have their origin in the snow covered areas. As such, they receive water even in dry season due to snow melt and are perennial. On the other hand, rivers of the Peninsular plateau carry only

rain water and the quantity of water carried by them decreases considerably in dry season. They are, therefore, termed as seasonal rivers. Moreover, the rivers of the Peninsular plateau have reached maturity whereas the Himalayan rivers are still in their youthful stage. Most of the Himalayan region is made of sedimentary rocks while the Peninsular plateau has mostly igneous and metamorphic rocks. Hemmed between the Himalayas in the north and the Peninsular plateau in the south, lies one of the largest alluvial plains of the world. This vast plain stretching in a great curve from Arabian Sea to the Bay of Bengal, consists of extremely fertile soils washed down by the streams and rivers for thousands of years.

Climatic contrasts are no less pronounced than the physiographic contrasts. Although a typical monsoonal realm, Indian climate exhibits a wide range of climatic variations. While the mercury may dip to (–) 40°C during winter nights at Dras or Kargil in Jammu and Kashmir, the temperature may stand at a fairly high level of 20°C to 25°C at Chennai. In summer, the day temperature at Barmer in Rajasthan may soar to 48°C–50°C while the higher reaches of the Himalayas may still remain snow covered. The differences are equally striking in rainfall patterns also. Mawsynram near Cherrapunji receives an annual rainfall of over 1,221 cm as compared to only 12 cm received at Jaisalmer. Several places in Garo hills receive more rainfall in a single day than received by Jaisalmer in a long span of ten years. The people of Mumbai experiencing maritime climate may not have any idea of extremes of climate. But Delhiites living in continental climate have to pass through the entire cycle of seasonal changes. As a result of climatic extremes, the natural vegetation varies from dense tropical evergreen forests of the Western Ghats, North-Eastern states and Andaman and Nicobar islands to the scanty shrub bush vegetation of the Thar Desert and its adjoining areas.

Extremes and diversities of the physical features and climatic conditions have produced cultured heterogeneity of a high order. On one end of the scale are the vast uninhabited areas of Ladakh and the Thar desert and on the other end are the river valleys and deltas accounting for some of the highest population densities in the world and that too based on purely agrarian economy. The length and breadth of the country comprises a rich mosaic of religions, languages, cultures and races and is, thus, heterogeneous in character and spirit. All levels of economic development from that of the *stone age* to the *satellite* and *computer* age are seen in the country. In large parts of the country, purely tribal, agricultural, industrial and commercial economies exist simultaneously. Considering its physical and cultural diversities India is often called the ***'epitome of the world'***.

UNITY IN DIVERSITY

It must not be forgotten that the above mentioned diversity of India is based on its underlying unity. India has been able to project itself as a single territorial unit in the face of physical, political, social and economic contrasts. The unifying role of the Great Plains between the Himalayan ranges on one hand and the Peninsular India on the other can hardly be ignored. Climatically, the monsoonal rhythm of seasons provides a strong element of uniformity. The concentration of monsoonal rainfall to a few months in a year and the associated agricultural activities are an all India phenomena. Many of our cultural traditions are strongly tied to the monsoons. Our saints have spread the message of universal brotherhood which has helped a great deal in uniting different sections of society in India and making the country a united nation. The *Ramayana* and the *Mahabharata* have provided themes even for tribal dances and music for thousands of years and still continue to do so. Although *Hinduism* is the way of life for majority of Indians, *Hinduism* and *Islam* are intertwined into a composite matrix on the Indian land. It is in this composite matrix that integration of India is strongly rooted. In fact there are almost as many Muslims in India as in Pakistan. Centuries of foreign rule failed to disrupt our cultural ties.

On economic front, the development of inter-regional linkage and the emergence of a national home market have played a significant role in uniting the country. For example, tea from Assam, wheat from Punjab and Haryana, minerals from Chotanagpur plateau and spices from the hill areas of the southern states are used all over the country and in turn these areas obtain items required by them from other areas. This process has been accelerated by rapid development of transportation and communication.

LAND OF POTENTIALITIES

India is blessed with a large variety of natural resources in huge quantities. Many of these still await exploitation. Whereas nature has been bountiful to India, the inhabitants of this country have not been able to develop requisite technology, in the modern context, to harness these resources. India is, therefore, often referred to as '*poorly developed rich country*' or '*a rich country inhabited by poor people*'. Sometimes it is also called the '*land of the future*' or '*land of potentialities*'.

India's huge mineral wealth encompasses a wide range which is supposed to be sufficient enough for developing a modern industrial base. India is particularly rich in the deposits of high grade iron ore, manganese and chromite. Her reserves are said to be adequate with respect to limestone, bauxite, coal and strategic minerals.

Although India's forest resources are not very large and there is urgent need to increase the area under forests to meet the growing demand for forest products and to maintain the ecological balance, yet they are able to feed many forest based industries like paper, plywood, match box, furniture, resins, lac, etc.

India has vast resources of both surface and ground water which can be used for irrigation, power generation, industries and for drinking purposes. Only a small proportion of this natural resource has actually been utilised offering us enormous potentialities. It is estimated that about 42% of the cropped area is presently irrigated whereas about three-fourths of the cropped area can be irrigated by making optimum use of the water resources available to us. Similarly only one-fourth of the total water power potential in the country is actually used. Indian rivers offer numerous sites suitable for generating hydroelectricity.

India is one of the leading agricultural countries of the world and agriculture is the most important occupation of Indians. But the overall production and the yields per hectare are very low as compared to that in the advanced countries. The total production can be increased only by increasing the yields as all the cultivable land has already been brought under plough. This requires intensive use of high yielding varieties of seeds, fertilisers and irrigation facilities.

Of course, the greatest asset of India is its population which is second only to that of China. The poverty stricken, much cursed and ever growing vast ocean of humanity, if properly channelized, could be converted into huge manpower resource and could prove to be a boon, rather than a bane, for national development. The only problem is that not many avenues are open due to backward state of economy in the present day context.

INDIA AND THE ORIENTAL WORLD

The Oriental world includes into its fold the countries of East Africa, South West Asia, South Asia and South East Asia. These countries surround the Indian Ocean which unites them through sea routes. Economically and culturally, India's major contacts with outside world for the last two millennia have been by sea, earning India, the title of ***'Mistress of the Eastern Seas'***. The opening of the Suez Canal has brought the countries of Southern Europe and North Africa very close to India. In ancient days, the boats of the Babylonians, the Egyptians and the Phoenicians used to sail in the Arabian Sea. Hindu and Buddhist cultures and religions spread to far off areas towards south and east Asia. There are a number of temples in Thailand with *slokas* from *Ramayana* engraved on the walls. Bali in Indonesia was the seat of Hindu Kingdom. Mauritius in the Indian Ocean is a '*miniature India*'.

Our relationship through land frontiers are much older than our maritime contacts. Passes, gorges and valleys in the mountain chains offered passages to travellers in the ancient times. Waves of settlers from the north-west were lured by the riches of India in general and that of the Great Plains in particular. Mongols, Turks, Arabs and Iranians entered India as conquerors and settled down here. These settlers got assimilated in the national mainstream with the passage of time which led to a mixture of races, cultures, people and ethnic groups. Some of the invaders brought architectural excellence to India and took back to their homeland the Indian numerals, the decimal system and the ideas of *Upnishads*. *Buddhism* travelled from India to Tibet through land routes and further crossed over to China, Korea and even Japan. Thus, India is an integral part of the oriental world and holds a significant position in the region.

STRATEGIC SIGNIFICANCE OF INDIA

India stands at the head of the Indian Ocean at the very centre of the *Eastern Hemisphere* commanding trade routes running in all directions. Its location, size and economic resources have made it the most dominating country among the *littoral states*. Indian Ocean is the only ocean in the world which has been named after a country *i.e.* India. This only proves the great prominence enjoyed by India in early days when these oceans were given their names. The trans-Indian Ocean routes connecting the developed countries of Europe in the west and the developing countries of Asia in the east must skirt the shores of India. No other country has such a long coastline on this ocean as India has. Therefore, *the Indian Ocean is truly Indian Ocean*. Most of the air routes between Europe, West Asia and Africa in the west and East Asia, South East Asia, Japan and Australia in the east also pass through India.

The centrality and the consequent significance of India to broader Indian Ocean geopolitics and economics has been proved beyond doubt. It was India's status as the principal entrepot in a highly profitable oceanic trade structure which attracted the West Asian Muslims, and the European colonial powers towards India. India became the '*jewel in the crown*' of the vast British empire due to its wealth and because of its role as a fulcrum upon which the imperial and commercial system in Asia was balanced.

India thus commands an important strategic position on the globe with respect to trade as well as social and cultural interaction. India is a concept. India is an experiment through ages. India is unique, India is India—no parallel example exists.

INDIA'S POLITICAL DIVISIONS

About two centuries of British rule left India fragmented into nine British provinces and 562 small

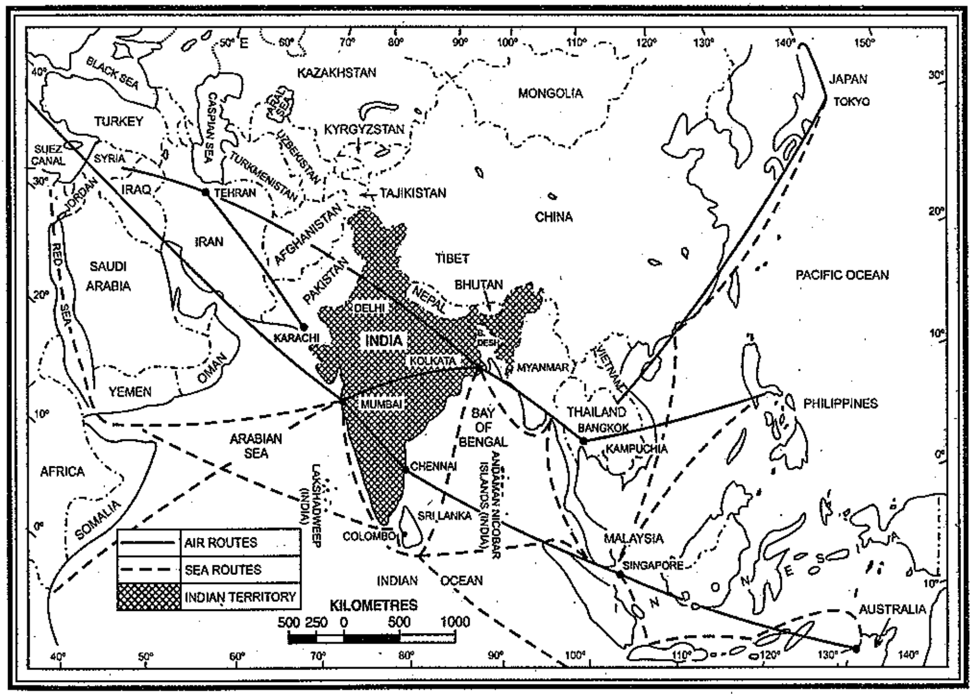

FIG. 1.15. Location of India at the head of Indian Ocean in the Oriental World on the International Highway of Trade and Commerce

princely states at the time of independence in 1947. The constitution of India was adopted with the establishment of Democratic Republic of India on 26th Jan., 1950 and India became a Union of States.

After Independence, the country was reorganised by merging various princely states and other states. During the first phase of reorganisation of Independent India, there were four categories of states :

(*i*) **States of 'A' category** which included Uttar Pradesh, Bihar, West Bengal, Assam, Odisha, Madhya Pradesh, Madras (present Tamil Nadu, Andhra Pradesh and Telangana), Bombay (present Maharashtra and Gujarat). These were governed by a governor.

(*ii*) **States of category 'B'** including PEPSU, Central India, Mysore (present Karnataka), Saurashtra, Rajasthan, Hyderabad and Travancore-Cochin. These were governed by the chief of the states.

(*iii*) **The states of 'C'** category included Ajmer, Kutch, Coorg, Delhi, Bilaspur, Bhopal, Tripura, Himachal Pradesh, Manipur and Vindhya Pradesh, governed by the Lieutenant Governors.

(*iv*) **States of 'D'** category included Andaman and Nicobar Island, governed by the central government.

States Reorganisation Commission

The above classification lacked economic viability or a sustainable administrative machinery and did not represent the unity of the nation. The Indian government devised a mechanism based on such considerations as distinctive regional, linguistic, cultural and economic characteristics. With this background and with growing demand for creation of linguistic states, the first linguistically, based Andhra state was created by separating Telugu speaking areas from the composite Madras state on October 1, 1953. Telangana area was added to Andhra state and Andhra Pradesh was formed on November 1, 1956. The formation of Andhra state in 1953, quickly sparked renewed demand of political recognition by other linguistic and cultural groups. This led to the appointment of States Reorganisation Commission in December, 1953. The commission submitted its report on 30th September, 1955, recommending reorganisation of India into 16 states and 3 territories. The government accepted the major part of the report but proposed the reorganisation of India into 15 states and 7 territories. Finally the Parliament passed the States Reorganisation Act, 1956 reorganising India into 14 states and 6 union territories as on 1st November, 1956.

Post-Reorganisation Changes

The Reorganisation of the states as per recommendations of the States Reorganisation Commission could not meet the aspirations of the people living in different parts of the country and pressing demands have been made from time to time for readjustment of politico—territorial units on linguistic, ethnic and cultural grounds. The trend had been towards creating more states thereby leading to division and fragmentation of the existing states. The influence of underlying centrifugal forces in the unity of India is conspicuous in these changes.

Within a short span of five years after the recommendations of the States Reorganisation Commission were implemented with slight modifications, the erstwhile bilingual province of Bombay was bifurcated into Gujarati speaking Gujarat and Marathi speaking Maharashtra on 1st May, 1961. The Portuguese colonies of Goa, Daman and Diu were the last remnants of the European occupation in India. These were liberated from the foreign yoke and they became part of India on 16th December, 1961. This completed the territorial integration of the Indian Union.

Several new states have been carved out in the north-eastern region of the country in response to demands by the tribals. In 1957 the north eastern part of Assam was separated and was designated as North-East Frontier Agency (N.E.F.A.). The Naga hills territory was a centrally administered area and was known as the Naga Hills Tuensang Area. It was renamed as Nagaland in 1961 and was given the status of a state on 1st December, 1963. Manipur became a Union Territory under States Reorganisation Act 1956 and became a full fledged state of Union in 1972. Meghalaya was created as an autonomous state within the state of Assam on 2nd April, 1970. The full-fledged state of Meghalaya came into existence on January 21, 1972. Tripura was annexed to the

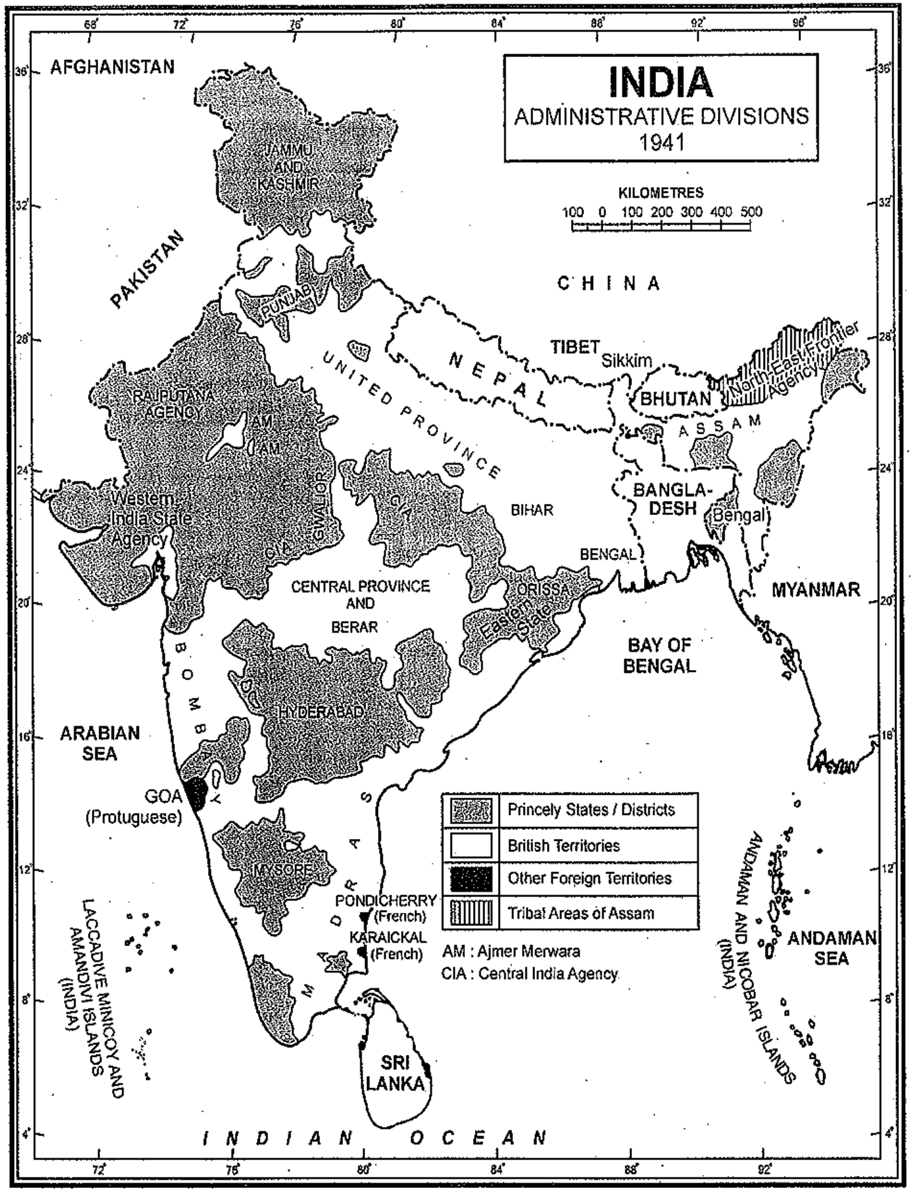

FIG. 1.16. India : Administrative Division, 1941

Indian Union in 1947 and became centrally administered territory in 1956. It was granted statehood in 1972. Thus three states in the north-eastern region came into existence in 1972. Sikkim ceased as a protectorate of India in 1974 and became an Associate State of India thereafter. It became an integral part of India as a result of referendum held on April 14, 1975. The North-East Frontier Agency (N.E.F.A.)

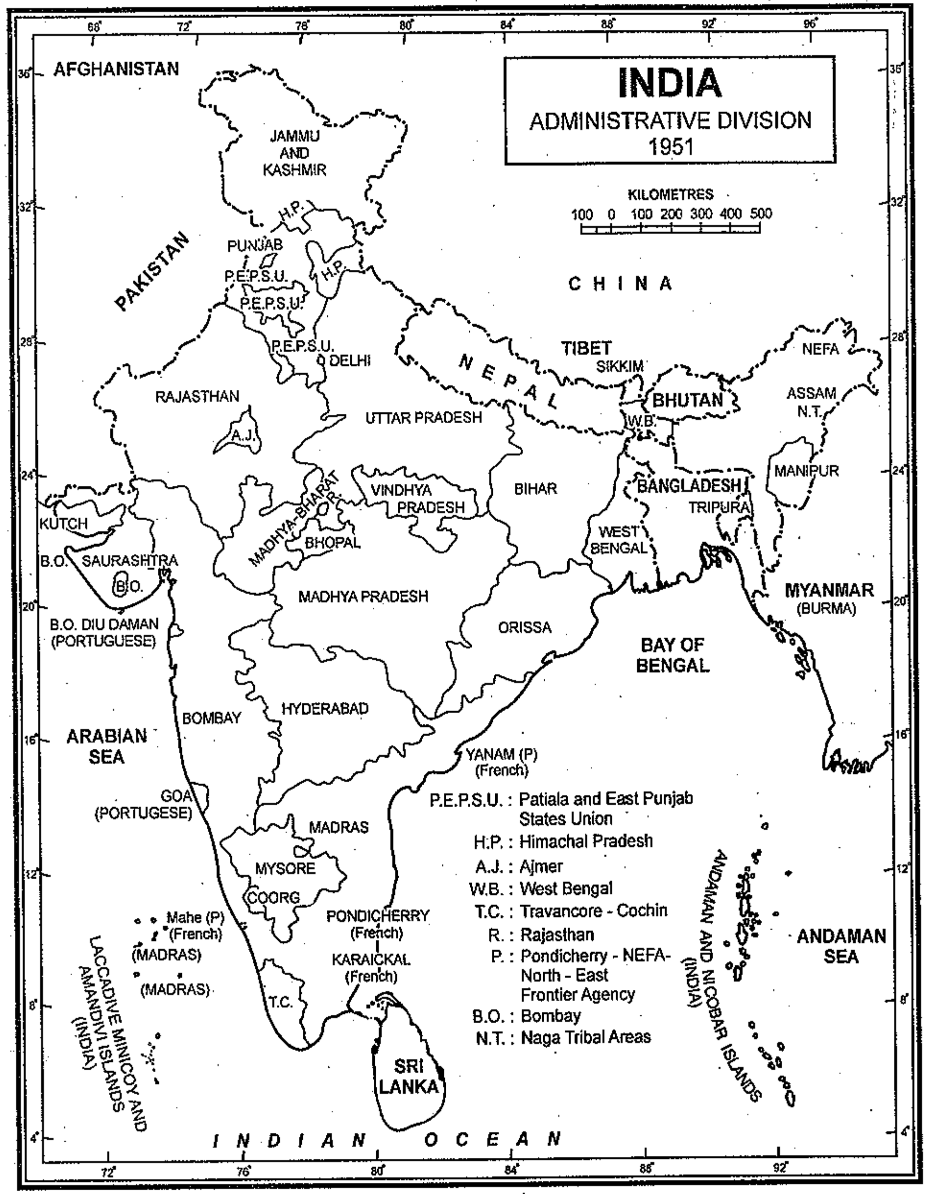

FIG. 1.17. India : Administrative Division, 1951

was given the new name of Arunachal Pradesh and was granted full statehood on February 20, 1987. Mizoram was one of the districts of Assam till 1972 when it became a union territory with the implementation of the North-Eastern Reorganisation Act. It was granted full statehood on February 20, 1987.

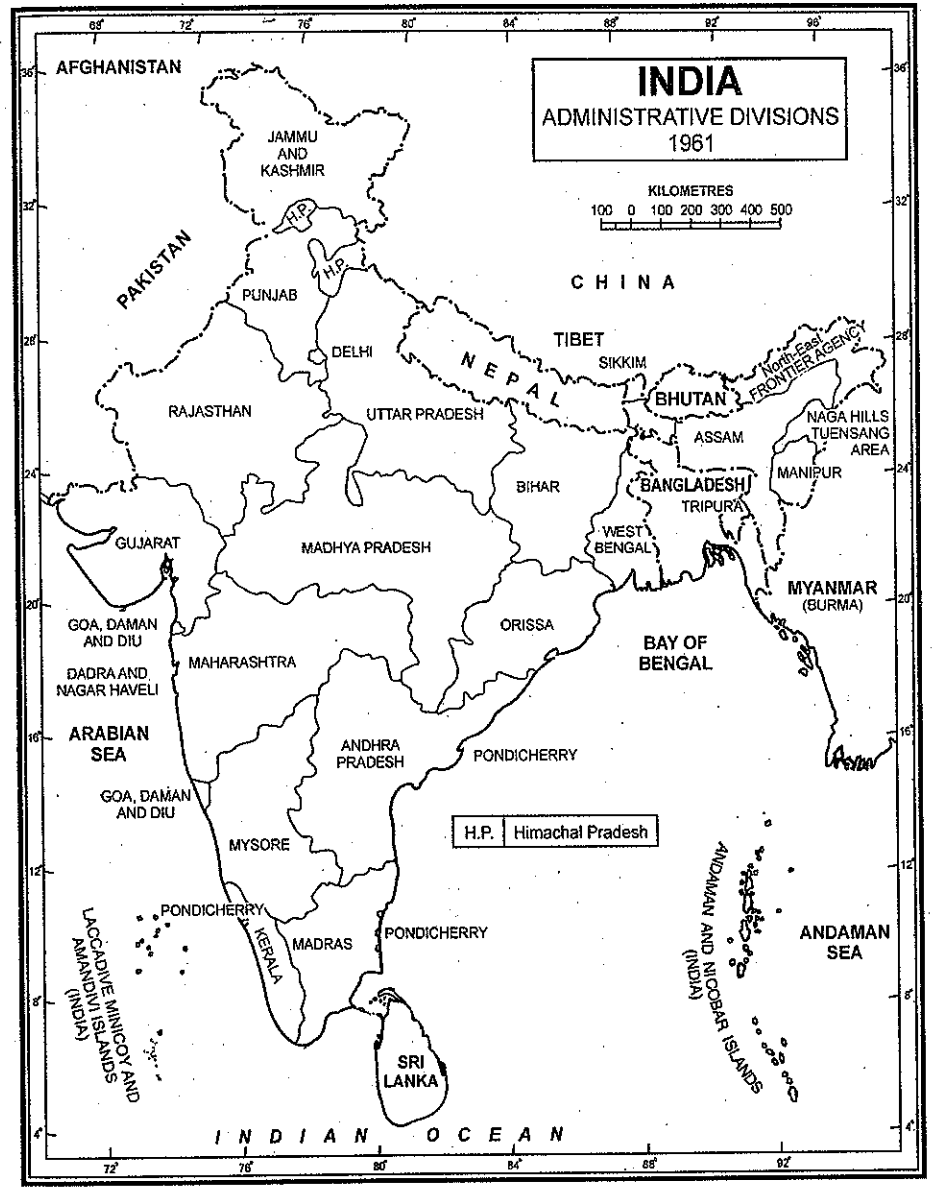

FIG. 1.18. India : Administrative Division, 1961

Turning again to the south, it is worth mentioning that the Mysore State, created in 1956, was renamed as Karnataka in 1973 on the demand of Kannada speaking majority of the area. Goa which was liberated in 1961 was conferred statehood on May 30, 1987 although Daman & Diu still remain as union territory.

FIG. 1.19. India : Political Divisions at Present

In the north-western part of the country, the bilingual state of Punjab was divided into Punjabi speaking Punjab and Hindi speaking Haryana on 1st November, 1966. Thus the new state of Haryana was born on this date. Certain hill areas of erstwhile Punjab were transferred to Himachal Pradesh. It was granted full statehood on January 25, 1971.

Three new states came into being in November 2000. Chhattisgarh was carved out of Madhya Pradesh on November 1, 2000 as the 26th state of the union to fulfill the long cherished demand of the tribal people. The hill areas of Uttar Pradesh were separated to form a new state of Uttarakhand on November 9, 2000. This is the 27th state of India which shares its

TABLE 1.3. Political Divisions of India (2011)

Sl. No.	States	Area in sq km	Capital	Principal languages	No. of districts at 2011 census
1.	Andhra Pradesh	1,60,229	Hyderabad	Telugu	13
2.	Arunachal Pradesh	83,743	Itanagar	Monpa, Miji, Aka, Sherdukpen, Nyishi, Apatani, Tagin, Hill Miri, Adi, Digaru-Mismi, Idu-Mishmi, Khamtli, Miju—Mishmi, Nocte, Tangsa and Wancho	16
3.	Assam	78,438	Dispur	Assamese	27
4.	Bihar	94,163	Patna	Hindi	38
5.	Chhattisgarh	1,36,034	Raipur	Hindi	18
6.	Goa	3,702	Panaji	Konkani and Marathi	2
7.	Gujarat	1,96,024	Gandhinagar	Gujarati	26
8.	Haryana	44,212	Chandigarh	Hindi	21
9.	Himachal Pradesh	55,673	Shimla	Hindi and Pahari	12
10.	Jammu & Kashmir	2,22,236*	Srinagar	Urdu, Kashmiri, Dogri, Pahari, Balti, Ladakhi, Punjabi, Gujri & Dadri	22
11.	Jharkhand	79,714	Ranchi	Hindi	24
12.	Karnataka	1,91,791	Bengaluru	Kannada	30
13.	Kerala	38,863	Thiruvananthapuram	Malayalam	14
14.	Madhya Pradesh	3,08,000	Bhopal	Hindi	50
15.	Maharashtra	3,07,713	Mumbai	Marathi	35
16.	Manipur	22,327	Imphal	Manipuri	9
17.	Meghalaya	22,429	Shillong	Khasi, Garo and English	7
18.	Mizoram	21,081	Aizawl	Mizo and English	8
19.	Nagaland	16,579	Kohima	Angami, Ao, Chang, Konyak, Lotha, Sangtam, Sema and Chakhesang	11
20.	Odisha	1,55,707	Bhubaneshwar	Oriya	30
21.	Punjab	50,362	Chandigarh	Punjabi	20
22.	Rajasthan	3,42,239	Jaipur	Hindi and Rajasthani	33
23.	Sikkim	7,096	Gangtok	Lepcha, Bhutia, Nepali and Limbu	4
24.	Tamil Nadu	1,30,058	Chennai	Tamil	31
25.	Tripura	10,492	Agartala	Bengali and Kokborak	4
26.	Uttar Pradesh	2,38,566	Lucknow	Hindi and Urdu	71
27.	Uttarakhand	53,484	Dehra Dun	Hindi, Garhwali, Kumaoni	13
28.	West Bengal	88,752	Kolkata	Bengali	19
29.	Telengana	1,14,840	Hyderabad	Telugu, Urdu	10

Union Territories					
1.	Andaman & Nicobar Islands	8,249	Port Blair	Hindi, Nicobarese, Bengali, Malayalam, Tamil and Telugu	3
2.	Chandigarh	114	Chandigarh	Hindi, Punjabi, English	1
3.	Dadra and Nagar Haveli	491	Silvassa	Gujarati, Hindi	1
4.	Daman & Diu	112	Daman	Gujarati	2
5.	Delhi	1,483	Delhi	Hindi, Punjabi, Urdu and English	9
6.	Lakshadweep	32	Kavaratti	Jesery (Dweep Bhasha) and Mahal	1
7.	Puducherry	492	Pondicherry	Tamil, Telugu, Malayalam, English and French	4
	India	**32,87,263**	**New Delhi**	—	**640**

*Includes 78,114 sq km under illegal occupation of Pakistan, 5,180 sq km illegally handed over by Pakistan to China and 37,555 sq km under illegal occupation of China.

The number of districts are as per Administrative Atlas of India, Census of India, 2011.

Source : (*i*) India 2011, A Reference Annual,

(*ii*) Census of India 2011, Provisional Population Totals, Paper 1, p. 32.

international boundaries with China (Tibet) in the north and Nepal in the east. Jharkhand, the 28th state of India was carved out of Bihar on November 15, 2000. This tribal state largely comprises forest tracts of Chotanagpur plateau and Santhal Pargana and has distinct cultural traditions. 29th state of Telangana was carved out of Andhra Pradesh on 2nd June, 2014 thus meeting the long standing demand of people belonging to Telangana region of Andhra Pradesh. So far this is the youngest state of the Indian Union.

There are some small scattered areas in the Union of India which are centrally administered and are known as Union Territories. As the things stand today the Indian Union comprises 29 states and 7 union territories (See **Fig. 1.19**). Their details are given in **Table 1.3**.

It is clear from **Table 1.3** that Rajasthan with an area of 3,42,239 sq km is the largest state of the Indian Union. In fact Rajasthan, Madhya Pradesh and Maharashtra have area more than three lakh sq km each and these three states account for about thirty per cent of the total area of the country. On the other end, Goa is the smallest state with an area of 3,702 sq km only. With the exception of Arunachal Pradesh and Assam, most of the north-eastern states are of small size. From administrative point of view, Uttar Pradesh has the largest number of 71 districts while Goa has only two districts. Bihar, Chhattisgarh, Haryana, Himachal Pradesh, Jharkhand, Madhya Pradesh, Uttar Pradesh, Uttarakhand, Rajasthan and NCT of Delhi have Hindi as their main language.

Demand for New States

Carving of Telangana out of Andhra Pradesh on 02-06-2014 has opened a pandora's box of demands for creating new states in different parts of the country. Demands for creating new states is very old and remained dormant for some time. But formation of new state Telengana has reinforced the old demands and generated more new demands for creating new states. Supporters of demand for new states argue that the existing states are very large and cannot be easily administered. For example Uttar Pradesh with a total population of 19,95,81,477 (Census 2011) spread over 71 districts is the most populous state of India and smooth and fair administration of such a big state is almost impossible. Most of the political parties support the concept of smaller states due to their compulsion of vote bank politics. However, there are some political parties which are opposed to the idea of dividing the present states and creation of new smaller states. They argue that such a trend will gain momentum, the lead to strengthening of centrifugal forces and even may

result in disintegration of the country as happened to erstwhile U.S.S.R. in 1990s. At present, demand for creating new states is gaining strength in several parts of the country and many more demands may spring up in future. Some of the major flash points where demands for creating new and smaller states are becoming louder, are briefly described as under :

1. Vidarbha. Vidarbha region consists of 11 districts of eastern part of Maharasthra with Nagpur as its centre. This region is very rich in mineral and forest resources and is part of cotton growing belt of Maharashtra. However, this region is plogued by poverty and malnutrition. About 70% of the farmer suicides in Maharashtra in 2010s have taken place in this region. The demand for a separate state of Vidarbha was first raised in 1956. The States Reorganisation Commission recommended a separate state of Vidarbha in mid 1950s.

2. Harit Pradesh. Not only the people, but sometimes even the government in power pleads for division of its own state. This is true in case of Uttar Pradesh where the political party in power suggested the division of the state into four states *viz*. Harit Pradesh (Western U.P.), Awadh Pradesh (Central. U.P.), Purvanchal (Eastern U.P.) and Bundelkhand in the year 2010. However, the initial demand for carving Harit Pradesh out of U.P. was made by Rashtriya Lok Dal (RLD). The issue of Harit Pradesh comprising about 24 agriculturally rich districts with its proposed capital at Meerut come-up for discussion at the National Reorganisation Commission in 1953. Thereafter the demand was raised in 1960. It was only in 1990s that serious movement for Harit Pradesh was launched by RLD, but the movement never gained much strength.

3. Awadh Pradesh. Consisting of about 21 districts, Awadh Pradesh lies in the centre of the present state of Uttar Pradesh. It forms a transitional zone between the proposed Harit Pradesh in the west and Purvanchal in the east. If formed, it will have its capital as Lucknow.

4. Purvanchal. If constituted, the state will comprise of eastern part of Uttar Pradesh with 27 districts including Gorakhpur, Allahabad and Varanasi. Movement for a separate state of Purvanchal began in 1996 which went on till 2002. No serious movement had taken place after that. If formed, this state would like have Allahabad as its capital.

5. Bundelkhand. It is a dry and under-developed zone comprising seven districts of Uttar Pradesh and five districts of Madhya Pradesh. Surprisingly Bundelkhand was a separate state at the time of independence. It was split into two and merged with Uttar Pradesh and Central Provinces (Madhya Pradesh). Bundelkhand is a distinct agro-climatic zone and needs a region-specific agricultural policy like irrigation and other agricultural inputs. Demand for a separate state of Bundelkhand was first raised by Bundelkhand Mukti Morcha (BMM) in 1989. This demand has gathered momentum following repeated droughts and crop failures during the last 15 years. If formed, this state would most popularity have Banda as its capital.

6. Gorkhaland. Gorkhaland comprises mainly Darjeeling and its adjoining areas in the northern part of West Bengal. Demand for separate state of Gorkhaland is surprisingly over 100 years old. Agitation for Gorkhaland turned violent in 1980s when 28 month long agitation spearheaded by the Gorkha National Liberation Front resulted in the loss of over 1200 lives. Since 2007, Gorkha Janmukti Morch (GJM) has been leading the demand for statehood. An autonomous set up within West Bengal for hills, as offered by the central government, has failed to satisfy the sentiments of majority of Gorkhas. The demand for a separate state of Gorkhaland is primarily for safeguarding the identity of the Gorkhas and for the overall development of the region.

7. Badoland. Badoland People's Front is demanding the creation of Bodoland out of Assam state. It is a narrow strip extending in an east-west direction just to the south of Assam-Butan boundary. Northern parts of districts of Kokrajhar, Barpeta, Nathari and Darang are included in this region.

8. Garoland. Garoland is situated in the western part of Meghalaya comprising three districts of South Garo Hills, East Garo Hills and West Garo Hills. Garos is one of the three major tribes of Meghalaya which has been demanding a separate Garoland comprising in western half of Meghalaya. The other two tribes are Khasi and Janlia.

9. Greater Cooch Behar. It consists of the present districts of Darjeeling, Jalpaiguri, Cooch

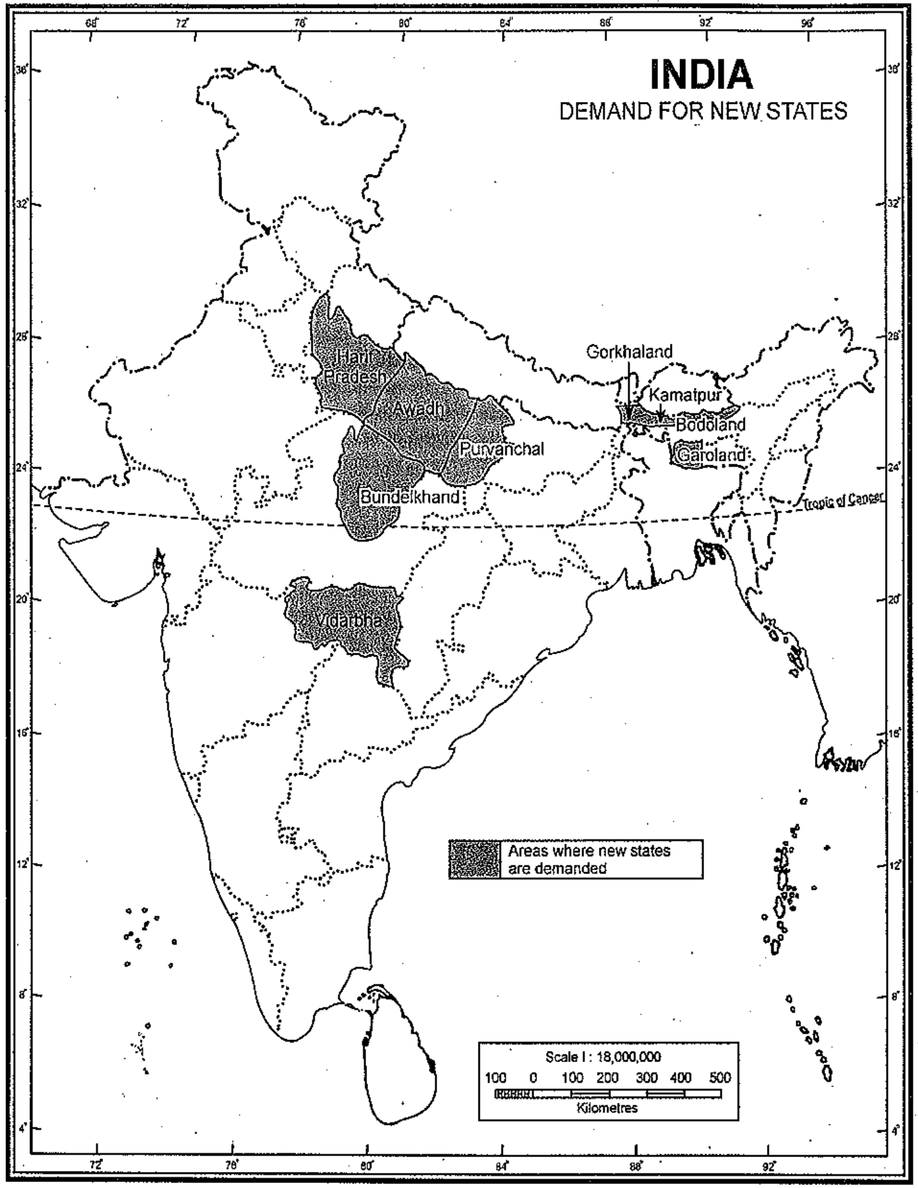

FIG. 1.20. Demand for new states

Behar, and North and South districts of Bengal and undivided district of Goalpara in Assam that included today's Bongaigoan, Dhubri and Kokrajhar districts. The British government took charge of the Cooch Behar kingdom through various treaties during 1773-1902 and returned the land to the royals 27 days before independence. On August 28, 1949, the kingdom was finally merged with India. Demand for

separate state began in 1998 but gradually dried up by 2006. However, demand for creation of this state has again gained strength after the central government created Telangana as a separate state.

10. Kamatpur. It consists of 17 districts of northern part of the present West Bengal and contiguous parts of the present Assam. People of this region are demanding a separate state on the lines of Gorkhaland and Greater Cooch Behar. There are some areas which are being claimed by the supporters of all the three states *viz*. Gorkhaland, Greater Cooch Behar and Kamatpur.

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CHAPTER 2

Geological Structure

INTRODUCTION

The geological structure, which includes the arrangement and deposition of rocks in the earth's crust, plays a dominant role in determining the relief of land and nature of soil. It also helps in knowing about the vast mineral wealth buried beneath the earth's surface. As such, study of geological structure plays a vital role in agricultural and industrial growth and in the economic prosperity of the country. For example, the vast alluvial Indo-Gangetic plain has very fertile soils and is extremely useful for agriculture. But it is almost completely devoid of any mineral deposits worth the name. On the other hand, igneous and metamorphic rocks of the peninsular plateau, especially those of the Chotanagpur plateau are very rich in mineral resources. Similarly the study of geological structure helps in land use planning, development of transport and communication lines, increasing potentials for irrigation, determining the quality and quantity of ground water resources and understanding disasters like earthquakes, volcanoes, landslides, floods, etc. Therefore, it is necessary for us to study the geology of India before we proceed to learn more about the geography of the country.

GEOLOGICAL REGIONS OF INDIA

Geologically, India is divided into three regions, *viz*., (1) *the Peninsular region*, including the Meghalaya plateau in the north-east and the Kuchchh-Kathiawar region in the west; (2) *the extra-peninsular region*—the Himalayas and their eastern extensions including Andaman and Nicobar Islands and (3) *the Indo-Gangetic plain*, between Peninsular and extra-peninsular region.

Although the *triple tectonic division* of India, as mentioned above, is generally held valid and is readily accepted by majority of geologists, some scholars recognise only two geological divisions of India *i.e.* the *Peninsular* block and the *Extra-Peninsular* region comprising the Himalayan ranges and the Indo-Gangetic plain. These macro-regions present most striking geological contrasts. The Peninsula is one of the oldest land-masses of the earth and is dominated by open senile topography. The Extra-Peninsula, on the other hand, presents the most youthful relief of the earth in the form of the Himalayas. The alluvium filled Indo-Gangetic plain presents flat, featurless and monotonous topography. The Indian Peninsula has not undergone marine

submergence since the *Cambrian period* and is not much affected by the tectonic forces. In contrast, the extra-peninuslar region has its origin in the Tethys Sea and is prone to tectonic forces resulting in devastating earthquakes. It is a weak and flexible portion of the earth's crust which has been folded, faulted and overthrust.

GEOLOGICAL HISTORY OF INDIA

Geologically India represents a monumental assemblage of rocks of different character belonging to different ages, ranging from pre-Cambrian (prior to 600 million years) to the recent times. **Sir T. Holland** of the *Geological Survey* of India has classified the rock systems of the country into following four major divisions :

1. The Archaean Rock System.
2. The Purana Rock System.
3. The Dravidian Rock System.
4. The Aryan Rock System.

The major geological systems of India are shown in **Fig. 2.1**.

1. THE ARCHAEAN ROCK SYSTEM

The word 'Archaean' was first used by **J.D. Dana** for rock structure prior to the Cambrian system. Obviously the Archaean rocks are the oldest in the world. The Archaean rock system includes the following rock groups :

(*a*) The Archaean System-Gneisses and Schists. These are the oldest rocks and were the first to be formed at the time of cooling and solidification of the upper crust of the earth's surface in the pre-Cambrian era (about 4000 million years ago). Although their broad characteristics are well known, the details of their origin continue to arouse considerable speculation. They are all azoic, thoroughly crystalline, extremely contorted and faulted, often formed as plutonic intrusions and generally have a well defined foliated structure. They often underlie strata formed subsequently and the system is generally known by names of the ***'Fundamental Complex'*** or the ***'Basement Complex'***. Their details are complex but recent advances in geochemistry are likely to enhance our understanding of their formation.

The most common Archaean rock covering about two-thirds of the Peninsular surface is gneiss. This is the rock which, in mineral composition, may vary from granite to gabro, possesses a constant, more or less foliated or banded structure. The schists, mostly crystalline, include mica, talc, hornblende, chlorite, epidote sillimanite and graphite schists.

The crystalline metamorphosed sediments and gneissic rocks cover large parts of India. The central and the southern parts of the Peninsula are occupied by this rock system. To the north-east of the Peninsula, they occupy wide areas in Odisha, Meghalaya, Madhya Pradesh, Chhatisgarh and Chotanagpur plateau of Jharkhand. They also cover the whole of Bundelkhand in the north and to the north-west, they are found in a number of isolated outcrops, extending from north of Vadodara to a long distance along the Aravalis. In the extra-peninsula, these rocks are exposed all along the Himalayas, forming the bulk of the high ranges and the backbone of the mountain system (**Fig. 2.2**).

(*b*) The Dharwar System. This system derives its name from the rocks first studied in the Dharwar district of Karnataka where such rocks are found in abundance. The Dharwars include some of the highly metamorphosed rocks of both sedimentary and igneous origin. According to **Wadia**, the Dharwar System is the most ancient metamorphosed sedimentary rock-system of India, as old as, and in some cases older than, the basement gneisses and schists. He further adds that the weathering of the pristine Archaean gneisses and schists yielded the earliest sediments which were deposited on the bed of the sea, and formed the oldest sedimentary strata, known in the geology of India as the Dharwar system. Some of the metamorphosed rocks of the igneous origin are also included in this system. Most rocks of the Dharwar system are so metamorphosed that they are practically indistinguishable from their primitive formations. The major rocks of the Dharwar system are hornblende, schists, quartzites, phyllites, slates, crystalline limestones and dolomites. These rocks were deposited in three major cycles, the earliest one is over 3,100 million years old and the latest one about 2,300 million years. They were metamorphosed around 1,000 million years ago.

The Dharwar system is very well developed in the Dharwar-Bellary-Mysore belt of Karnataka. It also

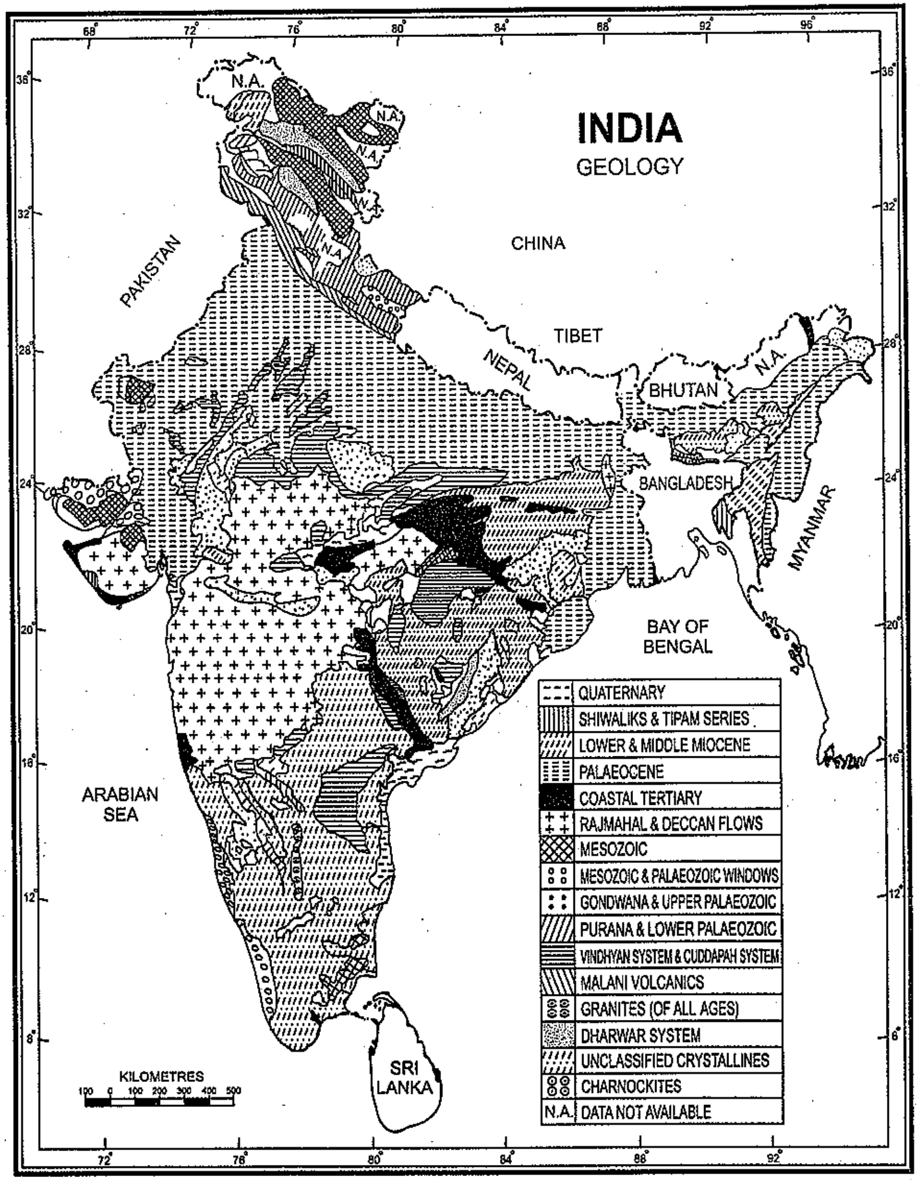

FIG. 2.1. India : Geology

occurs in Jharkhand (Ranchi, Hazaribagh), Madhya Pradesh (Balaghat, Rewa), Chhatisgarh (Bastar, Dantewara, Kanker), Odisha (Sundergarh, Keonjhar) and in the Aravalis between Jaipur and Palanpur. In the extra-Peninsular region, the Dharwar system is well represented in the Himalayas both in the central and northern zones as well as in the Meghalaya plateau (**Fig. 2.3**).

The Dharwars are economically the most important rocks because they possess valuable minerals like high grade iron-ore, manganese, copper, lead, gold, quartzites, slates, mica, etc.

2. THE PURANA ROCK SYSTEM (1400–600 MILLION YEARS)

In india, the word purana has been used in place of Proterozoic and includes two divisions : the Cuddapah System and the Vindhyas.

The Cuddapah System. A long interval of time elapsed before the rock system next to the Dharwars and Peninsular gneisses began to be deposited. A great thickness of unfossiliferous clay, slates, quartzites, sandstones and limestones was deposited presumably in great synclinal basins. This formation is known as the Cuddapah system, from the occurrence of the most typical and first-studied, outcrops of these rocks in Cuddapah district of Andhra Pradesh. Naturally the Cuddapah system is separated from the Dharwar system by a great unconformity. In some parts of southern India, we have the Cuddapah system amounting to 6,100 metres in thickness with several unconformities.

The most extensive occurrence of this system is in Cuddapah district followed by Kurnool district of Andhra Pradesh. The outcrop is of an irregular crescent shape concave towards the coast covering an area of about 45,000 sq km. The crescent shaped outcrops of the Cuddapah rocks suggest that the rocks were subjected to compressive forces directed from the concave side near which stood high mountains that supplied materials forming the rocks of the basin. Another large development of this system is in the southern parts of Chhattisgarh covering the districts of Dantewara, Bastar, Kanker, Dhamtari, Raipur, Durg and Rajnandgaon. A few isolated exposures occur in Singhbhum district of Jharkhand, Kalahandi and Keonjhar districts of Odisha and along the main axis of the Aravalli range from Delhi to Idar in Gujarat aggregating 5,200 metres in thickness at certain places. Some deposits of Cuddapah rock system are found in Karnataka also (**Fig. 2.4**).

The economic significance of the Cuddapah system lies in the fact that these rocks contain ores of iron, manganese, copper, cobalt, nickel, barytes, jasper, asbestos, steatite and cherts. They also contain large deposits of building purpose quartzites and cement grade limestones.

The Vindhyan System (1300-600 million years). This system derives its name from the great Vindhyan mountains although *Spate* has tried to distinguish between the Vindhyan rocks and the Vindhyan hills. The system comprises of ancient sedimentary rocks superimposed on the Archaean base. It is a vast stratified formation of sandstones, shales and limestones, often over 4000 m thick. Except a few traces of animal and vegetable life, this group is devoid of any recognisable fossils. Occupying a large area of over 1,00,000 sq km, the Vindhyan system stretches from Sasaram and Rohtas in western Bihar to Chittaurgarh in Rajasthan with the exception of a central tract in Bundelkhand which makes a gap in this belt. Large area of this belt is covered by the Deccan trap. The outcrop has the maximum breadth between Agra and Neemuch. These rocks are also found in Chhattisgarh, Bhima Valley of Karnataka and Kurnool district of Andhra Pradesh. The Vindhyan system has been found to continue to the north under the Gangetic alluvium and they are perhaps buckled down underneath the Himalaya. The rocks of the Vindhyan system comprise two distinct but unequal sets of deposits. The *Lower Vindhyan* (1,300-1,100 million years) is marine in origin, mostly calcareous in nature and shows tectonic deformation by folding movements. This system is well placed in the Son valley, in Chhattisgarh, in the valley of the Bhima and in a separate basin in Mewar. *The upper Vindhayan system* (1000-600 million years), on the other hand, is fluviatile in origin and is gently lying in undisturbed horizontal strata. The Lower and the Upper Vindhyans are separated by an unconformity which is quite prominent in the north but almost disappears in southern areas of Mewar, Chittaurgarh and the Son valley.

The Upper Vindhayan beds enclose two diamond bearing horizons, from which Panna and Golconda diamonds have been mined. The Vindhyan system, on the whole, is devoid of metalliferous minerals but provides large quantities of excellent and durable stones, flagstones, ornamental stones, limestone, pure glass making sand and some coal.

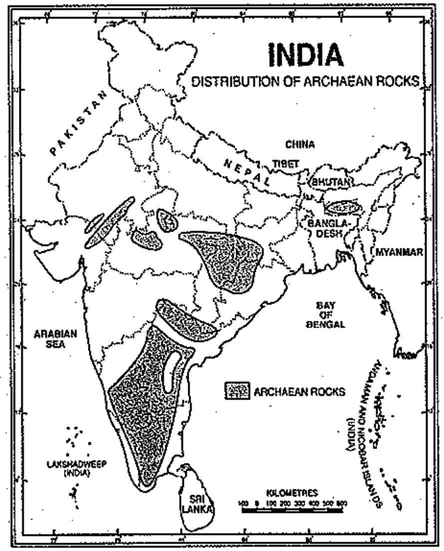

FIG. 2.2. India : Distribution of Archaeon Rocks

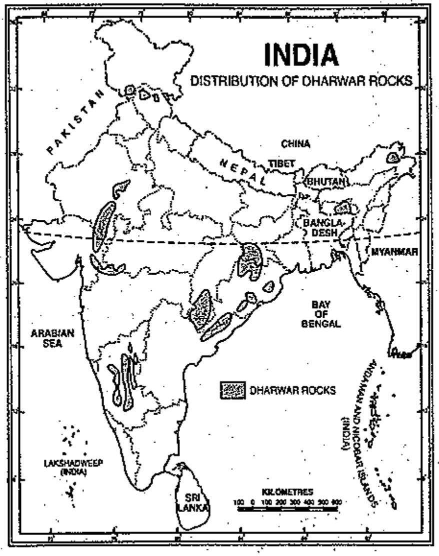

FIG. 2.3. India : Distribution of Dharwar Rocks

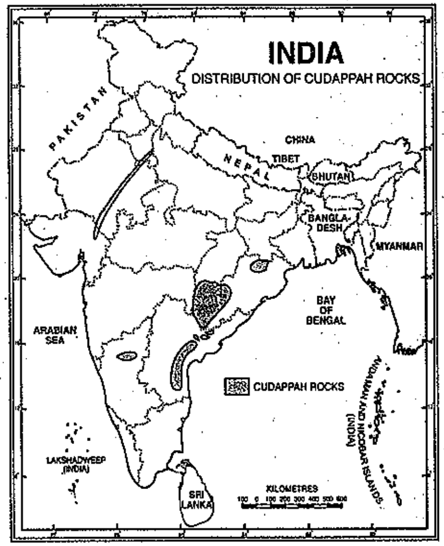

FIG. 2.4. India : Distribution of Cuddapah Rocks

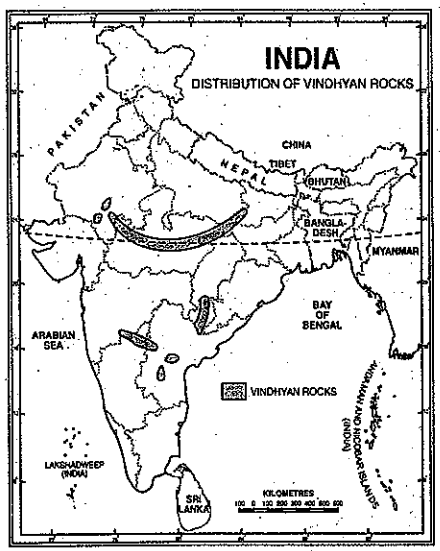

FIG. 2.5. India : Distribution of Vindhyan Rocks

3. THE DRAVIDIAN ROCK SYSTEM (PALAEOZOIC)

The rocks of the Dravidian system came into being about 600-300 million years ago. Most rocks of this system are found in the Extra Peninsular region and they are conspicuous by their absence in the Peninsular India except for one or two small patches of lower Permian age near Umaria. The Cambrian and Devonian rocks containing recognisable fossils are unknown in the Peninsula. The rocks belonging to the

Dravidian System contain abundant fossils which help in determining correctly the age of the rocks and make correlation of rocks possible over distant areas. The rocks of Cambrian, Ordovician, Silurian, Devonian and Carboniferous periods are included in the Dravidian system.

The Cambrian rocks (600 million years) named after Cambria, the Latin name for Wales in Great Britain, include slates, clays, quartzites and limestones. They are best developed in the north west Himalayan region. In the Spiti valley of Himachal Pradesh, there is an extensive fauna known as the ***Haimanta System.*** This 1600 metre thick deposit consists of slates, quartzites and dolomites. Similar formations are found north of Kullu and Lahul in Himachal Pradesh as well as in the Baramula district of Jammu and Kashmir. In Kumaon, some slaty and sandy rocks of the Cambrian period are found. In the salt range on the Indo-Pak border, the Cambrian rocks are represented by 900 metres of fossiliferous sandstones, shales and dolomites underlain by salt marl (clayey salt) known as the ***saline series.***

The Ordovician rocks (500 million years) after the Ordovices, former inhabitants of Wales include quartzites, grits, sandstones and limestones. They overlie the Haimanta system in all parts of the Spiti in the form of a thick series underlain by conglomerates. They are also present in the Lidar valley of Kashmir and in the Kumaon region.

The Silurian rocks (440 million years) after the Silures, former inhabitants on the borders of Wales and England. In the Spiti valley, the Silurian rocks are in continuation with the Ordovicians. Round the core of the Lidar anticline there runs a thin but continuous band of Silurian strata. The Lahul and the Kullu valleys of Himachal Pradesh also have some Silurian deposits. The limes and shales of the Kumaon region belong to the Silurian period.

The Devonian rocks after Devonshire in England (400 million years) are a great thickness of massive white quartzite reaching a thickness of 900 m at certain places. They are devoid of any fossil remains. These rocks have definitely been identified in the Muth quartzite of Spiti and Kumaon, on the flanks of Lidar anticline and in the Haridwar district of Uttarakhand.

The Carboniferous rocks (350 million years) comprise mainly of limestone, shale and quartzite. These rocks are generally divided into the *Upper Carboniferous, Middle Carboniferous* and *Lower Carboniferous* systems. *The Upper Carboniferous* rocks are made of limestone and dolomite. *Mount Everest* is composed of Upper Carboniferous limestones. *The Middle Carboniferous* has been the age of great upheavels. The rocks of this group are mainly found in the Spiti valley, Kashmir, Shimla and in the eastern Himalayas. In the Lower *Carboniferous group* are included slates of different types, Pir Panjal trap, and some rocks of the Kumaon region. Coal formation started in the Carboniferous age. Carboniferous in geology means *coal bearing*.

4. THE ARYAN ROCK SYSTEM

The Aryan System comprises the rock formations ranging from the *Upper Carboniferous* to the *Recent*. They are fairly preserved in the Peninsular India and are found in a perfect sequence in the Himalayan region along the entire northern border.

The Gondwana System derives its name from the Kingdom of the Gonds, the most primitive people living in Telangana and Andhra Pradesh. It has relevance with the Gond region of Madhya Pradesh also where these rocks were first discovered. The Gondwanas consist of sandstones with some shales and clays. They are of continental origin, fluviatile and lacustrine deposits laid down in geosynclinal troughs on ancient plateau surface. As the sediments accumulated, the loaded troughs subsided which led to thick deposits of fresh water and subaerial sediments into which were embedded the terrestrial plants and animals. These flat sedimentary strata, some 6,000 m thick, were laid down from the start of the Permian period some 250 million years ago. The system shows several climatic changes during its deposition.

The main areas of Gondwana rocks in the Peninsula are along the Damodar Valley in Jharkhand, along the Mahanadi river valley in Chhattisgarh and Odisha, in the southern part of Madhya Pradesh and a series of troughs along the Godavari from Nagpur to the delta (**Fig. 2.6**). In the extra-peninsular region these rocks are found in Kashmir, Darjeeling and Sikkim. Here they are so much deformed that they have lost their original identity and are entirely different from the peninsular rocks.

Economically, the Gondwana rocks are the most important in India containing about 98 per cent of her coal reserves. They have rich deposits of iron ore, copper, uranium and antimony also. Sandstones, slates and conglomerates are used as building materials.

The Triassic System meaning three fold (280-225 million years) is almost unknown in the Peninsula but is found over extensive areas from Hazara to Nepal. Impressive sections of the system are exposed on the south flank of the Great Himalaya range from Kashmir to Byans in Eastern Kumaon. The trias are generally divided into lower, middle and upper divisions. *The Lower Trias* is over 100 m thick in Kashmir, 50 m in Byans and only 12 m in Spiti. *The Middle Trias* is 275 m thick in Kashmir. *The Upper Trias* of Kashmir is 1200-1800 m thick well bedded limestones. In the Spiti both these stages are represented by about 1,000 m thick dominantly calcareous strata.

The Jurassic System, after Jura mountains on the borders of France and Switzerland (180 million years) overlies the Triassic, covering wide areas in Tibet, South Ladakh, Spiti, Nepal and Bhutan, where limestone occurs to a depth of 600-900 m. The marine transgression in the latter part of the Jurassic gave rise to thick series of shallow water deposits in Rajasthan and in Kachchh. There is 190 km long and 64 km wide area in Kuchchh which is covered by rocks of the Jurassic system. Coral limestone, oolitic limestone, sandstone, conglomerates and shales occur in Kuchchh. The Jaisalmer area of Rajasthan also has some Jurassic rocks. Another transgression on the east coast of the Peninsula between Guntur and Rajahmundry has resulted in the development of marine Upper Jurassic strata interbedded with the upper Gondwana formation.

The Cretaceous System, from Creta, the Latin name for chalk (135-70 million years), is one of the best developed marine systems of India showing a variety of faces and represented by a wide variety of rocks, deposited on the land, sea estuaries and lakes. No other system is so widely distributed in India as the Cretaceous System is, both in the Peninsular and the Extra-peninsular parts.

The Cretaceous rocks of the Spiti area include sandstones, quartzites, limestones and shales. In the Kumoun region, the important rocks are sandstones and shales. Cretaceous limestones are also found in Rupshu and Burzil areas of Kashmir. The plateau of Meghalaya has sandstones. The upper Cretaceous system occurs in the Pondicherry-Tiruchchirapalli belt. Some detached outcrops of marine Cretaceous, known as Bagh Beds in Gwalior are found along the Narmada Valley where they underlie the Deccan Trap. In the Central parts of the Peninsula occur estuarine and lacustrine deposits called the ***Lemetas***.

The Deccan Trap. From the end of the Cretaceous till the beginning of the Eocene, stupendous volcanic outburst overwhelmed a vast area of the Peninsular India, like the one which is seldom known anywhere else in the world geological history. A vast area of about ten lakh sq km was flooded by the outpourings of extremely mobile basalt lava from fissures and cracks covering fully the pre-existing topography. These volcanic deposits have flat top and steep sides so that they appear as gigantic steps from a distance, and therefore called ***'trap'***, the name derived from the Swedish word meaning a ***'stair'*** or ***'step'***. However, **Spate** feels that the term Deccan Trap is used in old literature and he prefers to use the term ***'Deccan Lava'*** instead. The individual lava flows that make up the Deccan Trap plateau vary greatly from a fraction of a metre to 36 metres in thickness. The hills formed by them are in some places over 1200 metre high.

The process of denudation over a long period has reduced the Deccan Trap to almost half of its original size and the present Deccan Trap covers about 5 lakh sq km mainly in parts of Kachchh, Saurashtra, Maharashtra, the Malwa plateau and northern Karnataka (**Fig. 2.7**). Parts of Telangana, Tamil Nadu, Jharkhand and Uttar Pradesh also have some outliers of the Deccan Trap. Thickness of the Deccan Traps is not uniform everywhere. It is as much as 3,000 metres along the coast of Mumbai which is reduced to 600-800 metres towards the southern limit, 800 metres in Kachchh and only 150 metres at Amarkantak near its eastern limit. The Deccan Trap has been divided into following groups :

(*a*) **The Upper Trap**, found in Maharashtra and Saurashtra has numerous inter-trappean beds and layers of volcanic ash and has an average thickness of about 450 m.

(*b*) **The Middle Trap** is about 1200 m thick and is spread over Central India and Malwa. It has numerous ash-beds in the upper portion and is practically devoid of inter-trappeans.

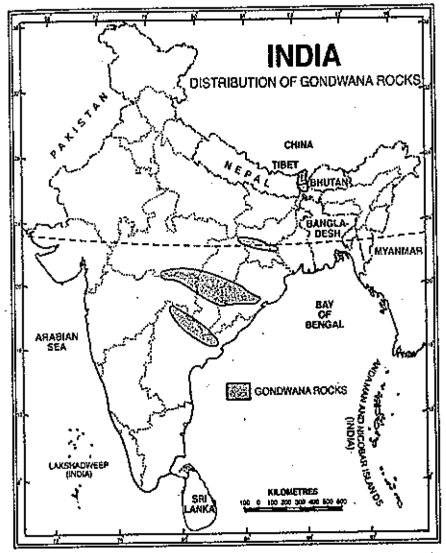

FIG. 2.6. India : Distribution of Gondwana Rocks

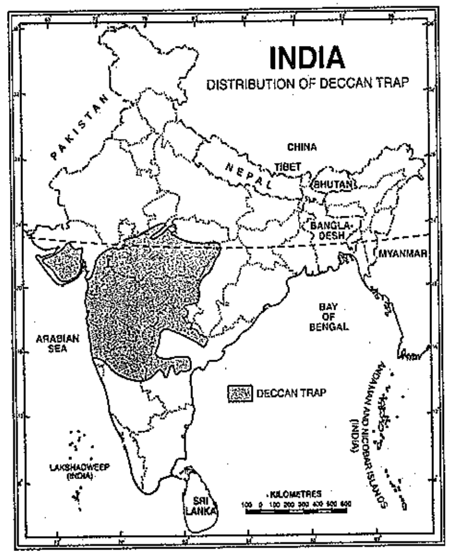

FIG. 2.7. India : Deccan Trap

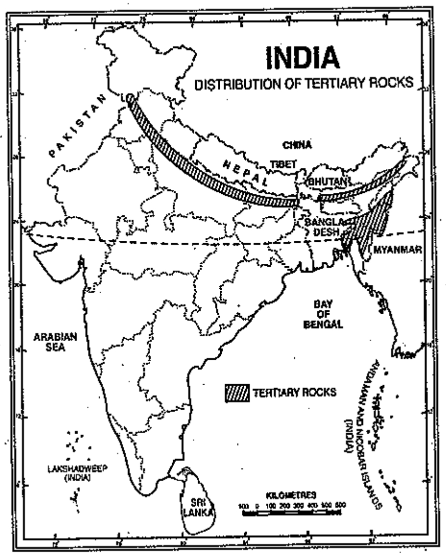

FIG. 2.8. India : Distribution of Tertiary Rocks

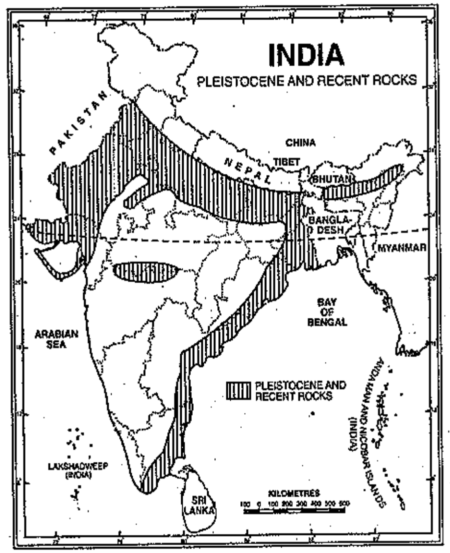

FIG. 2.9. India : Pleistocene and Recent Rocks

(*c*) **The Lower Trap** is only 150 m thick with inter trappean beds but rare ash beds. It is found in Central India and Tamil Nadu.

Basalt is the main rock but dolorite, rhyolite, gabro and many other rocks are also found. These rocks are a great source of quartz, agate, calcite, building stones and road building material. The weathering of these rocks for a long time has given birth to black cotton soil known as '*regur*'.

The Tertiary System. The rocks of the Tertiary System were formed from Eocene to Pliocene about 60 to 7 million years ago. The tertiary is the most significant period in India's geological history because the Himalayas were born and India's present form came into being in this period. The Tertiary has been called the *Age of the Mammals* because of the abundance of the fossil remains of these animals in the deposits of this period. The Tertiary System is generally divided into the following three systems.

(*a*) **The Eocene System** (60 million years ago) is mainly found in Jammu and Kashmir, Himachal Pradesh, Rajasthan, Gujarat and in the north-eastern part of India. The Eocene belt of Jammu goes upto Shimla and further east upto Mussoorie. Such deposits also occur in the southern flank of the Pir Panjal. In Rajasthan, the lignite deposits belong to the Eocene System. The Kuchchh, Surat and Broach areas of Gujarat have deposits of the Eocene System. In the north eastern part of the country, the Eocene is represented by limestones and coal-bearing sandstones in Jaintia series in the southern and eastern parts of the Meghalaya plateau. The Barail series has a wide distribution in Surma Valley and in the Naga Hills. The Tertiary coal deposits of Upper Assam are worth noting. Some Eocene deposits have recently been noticed in Puducherry.

(*b*) **Oligocene and Lower Miocene System** (40-25 million years) is very poorly developed in India. It is estimated that during a part of this period the Tertiary outcrops suffered considerable denudation which resulted in the removal of rocks belonging to this system. Rocks of the Oligocene age are found in the greater part of the Barail series of Assam where they are overlain with a marked unconformity by Lower Miocene rocks.

Unlike the Oligocene, the Miocene system is fully developed in India and is found in all the Tertiary areas of the extra-Peninsula. The outcrop of the Murree series in Jammu hills, forming a belt 25-40 km wide from the Indus to the Chenab, narrows towards the east and merges into the typical Dagshai-Kasauli band (Sirmur series) is of Shimla area. The thickness of the deposits in Dagshai-Kasauli band is about 2600 m and is dominated by red clay and sandstone. No major fossils are seen in Dagshai and Kasauli group. The coal measures of Assam, belonging to the Barail series are overlain by the Surma series. It is composed of sandstones and sandy shales, mudstones and conglomerates. The deposits of Garo Hills have large number of marine fossils. Besides some rocks of Kachchh in Gujarat, Mayurbhanj in Odisha, Durgapur in West Bengal, and Kollam in Kerala also belong to this group.

The Shiwalik System—Middle Miocene to Lower Pleistocene (14 to 0.2 million years ago) takes its name from Shiwalik hills between rivers Ganga and Yamuna, where they were first known to science. It is from here the first palaeontological treasures were obtained which have made this system extremely famous with the geologists all over the world. The Shiwalik strata are found all along the length of the Shiwalik hills. Sandstones, grits, conglomerates, clays, and silts comprise the rocks of this system. They have been deposited in lagoons and fresh water lakes by the rivers of that time upto a thickness of about 5000 m. The great bulk of the Shiwalik formation is nonfossiliferous, but in certain areas some formations are highly fossiliferous. The fauna records the sedimentation from Middle Miocene to Lower Pleistocene and has yielded a

TABLE 2.1. Division of Shiwalik Strata

Upper Shiwaliks 1800-2750 m	Boulder Conglomerate beds, Sandstones, thick earthy clays. Richly fossiliferous in Shiwalik hills	Lower Pleistocene to Upper and Lower Pliocene
Middle Shiwaliks 1800-2500 m	Gravels, sandstones, shales and clays	Upper to Middle Miocene
Lower Shiwaliks 1200-1500 m	Bright red shales and sandstones	Middle Miocene

variety of fossils showing wide range of environment—from humid forest conditions to aridity. The mammalian fossils were first discovered from the Shiwaliks near Haridwar in 1839.

The Shiwalik strata are divided into the following three sections, the passage from one into the other division being quite gradual and transitional.

In Assam the Shiwalik system is almost equivalent to the Tipam, Dupi Tila and Dihing series. In the southern part of Assam, the lower part of the Tipam series consists of coarse ferruginous sandstones and sandy shales, and has some marine fossils. Above the Tipam series lies the Dupi Tila series which consists of sandstone and conglomerates. Its lower beds contain the oil fields of Lakhimpur and Digboi. The Dihing beds overlie the Dupi Tila and correspond to the Upper Shiwaliks.

The Shiwalik rocks are also found in Kachchh and Saurashtra areas of Gujarat. Highly fossiliferous beds have been struck in a well at Karikal on the Thanjavur coast (Tamil Nadu). In Mayurbhanj area of Odisha there are rocks of Miocene age. Some rocks of Middle Miocene and Lower Pleistocene age are seen in Varkala (Kerala) as well as in the sandstones of Cuddalore and Rajahmundry.

The Shiwalik system is famous for its oil resources, lignite, bauxite and clays of different varieties.

The Pleistocene and the Recent (Quaternary) is a brief period of nearly one million years and is said to have just begun. It has two divisions without a clear-cut boundary between them. The older is the Pleistocene which is marked by cold climate and glaciation. The younger division is called ***Recent***. It started about 12,000 years ago since the withdrawal of the last glaciation. The Pleistocene age has been marked by several advances and retreats of the glaciers. This age is divided into four glacial and three inter-glacial periods by ***de Terra*** and ***Paterson***. During the glacial periods, sea level was lowered by about 100 metres than it is now and this resulted in much larger extension of land.

The Himalayan glaciers were much larger during the glacial period than their present size. They have left indelible impression on the Himalayan topography. The First Glacial and Inter-glacial periods belong to the lower Pleistocene in Kashmir. The Second Glacial and Inter-glacial periods embrace Middle Pleistocene. Heavy deposition of sediment consisting of boulder fans and thick fluvo-glacial material took place in this period. The *Karewas* of Kashmir are supposed to be of the second inter-glacial period. The flat-topped terraces of the Kashmir valley, and on the flanks of the Pir Panjal consisting of clays, sands, silts together with lenticles of conglomerate from old deltaic fans are known as ***Karewas*** in Kashmiri language. The alluvial deposits of the Narmada are also of the same period. The Upper Pleistocene includes the Third and the Fourth glaciations and the intervening Third Inter-Glacial period. Pir Panjal experienced uplift during the First and the Third Glacial periods, and the terrace deposits of Kashmir occurred at the end of the Fourth Glaciation.

The fossiferous clays, sands and gravels of the Upper Satluj and the alluvial deposits in the valleys of Tapi, Godavari and Krishna are also of the Pleistocene age.

The most important, extensive and recent deposits in India are the Indo-Gangetic alluviums filling the great depression between the foot of the Himalayas and the northern edge of the Peninsula. The older alluvium called ***bhangar*** is of the Middle or Upper Pleistocene age. The newer alluvium occupies the lower areas of the river valleys prone to annual floods is called ***khadar*** and belongs to the Upper Pleistocene age.

THE COASTLINE OF INDIA

India has about 6100 km long coast most of which is more or less uniform and regular with a few creeks, inlets, back waters and promonotories here and there. ***Suess*** has opined that the straight and regular coastline of India is the result of disruption and faulting of the Gondwanaland during the Cretaceous period. As such the coast of India does not offer many sites for good natural harbours. The peninsular shape of South India has divided the entire coast into western and eastern parts with Kanniyakumari at the southernmost tip as the dividing point. The Bay of Bengal and the Arabian Sea came into being during the Cretaceous or early Tertiary period after the disintegration of *Gondwanaland*.

The east coast of India extends from the Ganga delta to Kanniyakumari facing the Bay of Bengal. It is marked by deltas of great rivers like the Mahanadi, the Godavari, the Krishna and the Cauvery. There are several lagoons of which the Chilka lake and the Pulicut lagoon are outstanding.

The West Coast runs almost straight in the north-south direction right from the Gujarat plains to Kanniyakumari. However, it is dotted with a large number of coves, creeks and a few estuaries. The estuaries, of the Narmada and the Tapi are well known. The Malabar coast in the south has some lakes, lagoons and backwaters, the largest being the Vembanad Lake.

There are evidences to show that large parts of Indian coast have undergone submergence and emergence during the geological times and even during the historical times. The most outstanding example of submergence of the sea coast is the existence of a submerged forest on the eastern side of the island of Mumbai. It is located at depths of 6-12 m below the present sea level where a number of tree-stumps are seen with their roots *in situ* embedded in the old soil. The submergence is further proved by the raised terraces formed of coral reefs or loosely cemented fragmentary shell limestone rocks. A similar submerged forest or old land surface, about half an acre, is seen on the Tinnevelli coast. A thick bed of lignite found at Puducherry 73 m below ground level also provides proof of submergence. Such vegetable debris is also found in the Ganga delta. Sudden increase in the depth of sea about 30 km from the coast of Makran is due to the submergence of a cliff lying at the coast. Marine archaeologists have recently discovered the ancient city of Dwarka lying under shallow waters off the coast of Saurashtra.

Examples of both submergence and emergence have been found in the Rann of Kachchh. As a result of the great earthquake in 1819, an area of 5180 sq km on the western border of the Rann of Kachchh was suddenly submerged under the sea upto a depth of 3.6 to 4.5 m. The fort of Sindree on the sea coast was completely submerged excepting a single turret which remained above the water level. Simultaneously another area of about 1550 sq km was elevated by several metres. In fact there have been repeated falls in sea level in the Rann of Kachchh area which is evident from the presence of coastal dunes, sea cliffs in the islands of the Gulf, sea caves within the plains and raised beaches of littoral concrete on the fringes of the islands. The total fall in the sea level has been estimated at 26 m. Even during historic times the Rann of Kachchh was a gulf which was silted up by the rivers falling into it. This process was supplemented by the slow elevation of the floor of the gulf and the entire area was converted into a low-lying tract. Before the Rann became dry, the Luni river used to enter the Arabian Sea through the Kori estuary crossing the entire length of the great Rann, and the Western Banas flowed over the Little Rann into the Gulf of Kachchh. Some islands off the Arabian Sea coast came into existence due to submergence of low-lying areas around them. The coral archipelago of the Lakshadweep islands probably marks the site of submerged land.

Several evidences of uplift of the western coast have been given by the geologists. Raised beaches are found at altitudes ranging between 30-45 metres at many places, while marine shells are found at many places on land at a height far above the level of tides. The steep face of the Sahyadri parallel to the west coast of India, suggests that the escarpment is the result of a recent elevation of the Ghats from the sea.

Proofs of uplift of the coastal plain of Kerala are numerous and decisive. The occurrence of coral reefs below the alluvium several kilometres from the present coast and the presence of a number of lakes, lagoons, backwaters and spits are a few of them. At least two phases of uplift have been noticed.

Away from the coast in the Bay of Bengal the Andaman and Nicobar Islands were once connected with the Arakan Yoma. They have come into being as a result of submergence of the surrounding low-lying areas in the geological times. However, the shape and size of some of the islands near the Ganga delta change with the change in sea level. Old islands disappear and some new islands emerge above the sea level. The recent emergence of New Moore Island in the Ganga delta is an outstanding example of such changes.

Sri Lanka was a part of India in the geological times, and the two landmasses were connected with each other by Adam's Bridge. This link was drowned in the Quarternary times and is now represented by

Pamban Island on Indian side and the Mannar Island on the Sri Lankan side along with several other small islands lying between these two islands.

Ice Ages in India

Following three ice ages are generally recognised in India.

1. The Dharwar Ice Age. Ice age of Dharwar is reflected by conglomerates near Kaldurg in South India.

2. The Gondwana Ice Age. The Talcher series of the Gondwana system in Odisha provide proof of the glaciation during that period. Boulders found here are similar to those existing in Shimla, Hazara and Salt Range.

3. The Pleistocene Ice Age. During the Pleistocene period the effect of ice age was noticed in the Himalayas. This period was not a continuous frigid spell, rather it was marked by cold and warm spells in succession. In the Himalayas, evidences of extensive glaciation are found upto height of 1800 m while glacial drifts and terminal moraines covered hill sides and valley floors down to 1,400 m. In Kashmir region, four or five periods of glaciation with inter-glacial periods have been noticed by de **Terra** and **Peterson.** Large blocks and boulders are normally seen in different parts of the Himalayas. Rock polishing and grooving on lower steps of the Himalayas, the buff coloured sands and luminated clays inter-stratified among the Karewa deposits of Kashmir, accumulations of marine debris found on the tops and sides of many ranges of the middle Himalayas which do not have any glaciers now, ancient moraines found before the snouts of existing glacier at an elevation of about 1,650 m amply prove that this part of India experienced a glacial age in the Pleistocene period. Glaciation also led to the formation of a number of glacial lakes in different parts of the Himalayas. Kailash kund, the Sanasar basin near Batoti, the Gulmarg basin, the Sheshnag, the Kaunsarmag, etc. are some of the examples of this type of lakes. The impact of glaciation also led to sudden and large scale reduction of the Shiwalik mammals. The Peninsular part of India has no evidence of glaciation during the Pleistocene period.

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Physiography

INTRODUCTION

Physiography is that branch of geography which studies the present relief features of the earth's surface or of natural features in their causal relationships. As described in the previous chapter, the present surface features of India owe their formation to various geological events which took place in different geological periods. Both endogenetic and exogenetic forces have been consistently working to shape the present land forms on the surface of the earth. India has a unique personality with regard to physiography. The great diversity of relief features encompassed in the vast dimansions of the country is simply amazing. The physiographic diversity of India embraces lofty young fold mountains, flat plains and one of the oldest plateaus of the world. The Indian islands have their own unique personality. A rough estimate made by the Census Commission in 1951, shows that of the total land area, 10.7 per cent is more than 2135 m above sea level and is mountanious, 18.6 per cent is hilly area (305 to 2135 m), 27.7 per cent is plateau (305 to 915 m) and the remaining 43 per cent is plain area.

Due to geological complexities and geomorphological diversities, division of India into physiographic regions is a difficult task. The views expressed by geographers in this regard are as diverse as the diversities of landforms in India. Some scholars follow the *triple tectonic division* viz. (*i*) the Himalayan Mountains (*ii*) the Indo-Gangetic plains and (*iii*) the Indian Peninsula. There are some scholars who feel that the coastal plains have a separate identity and should be treated as such. More recently, it has been felt that the distant islands in the Bay of Bengal and the Arabian Sea should also be treated separately. Thus, to be more realistic and for the sake of convenience, it is preferred to divide India into following five physiographic divisions (**Fig. 3.1**).

1. The Himalayan Mountains.
2. The Great Plain of North India.
3. The Peninsular Plateau.
4. The Coastal Plains.
5. The Islands.

1. THE HIMALAYAN MOUNTAINS

The Himalayan mountains are also known as the *Himadri*, *Himavan* or *Himachal*. The Himalayas consist of the youngest and the loftiest mountain chains in the world. The magnitude of their size can be estimated from the fact that the central axial range of the main Himalayas alone stretches for a distance of over 2,400 km (over 22° longitude) from the Indus gorge in the west to the Brahmaputra gorge in the east.

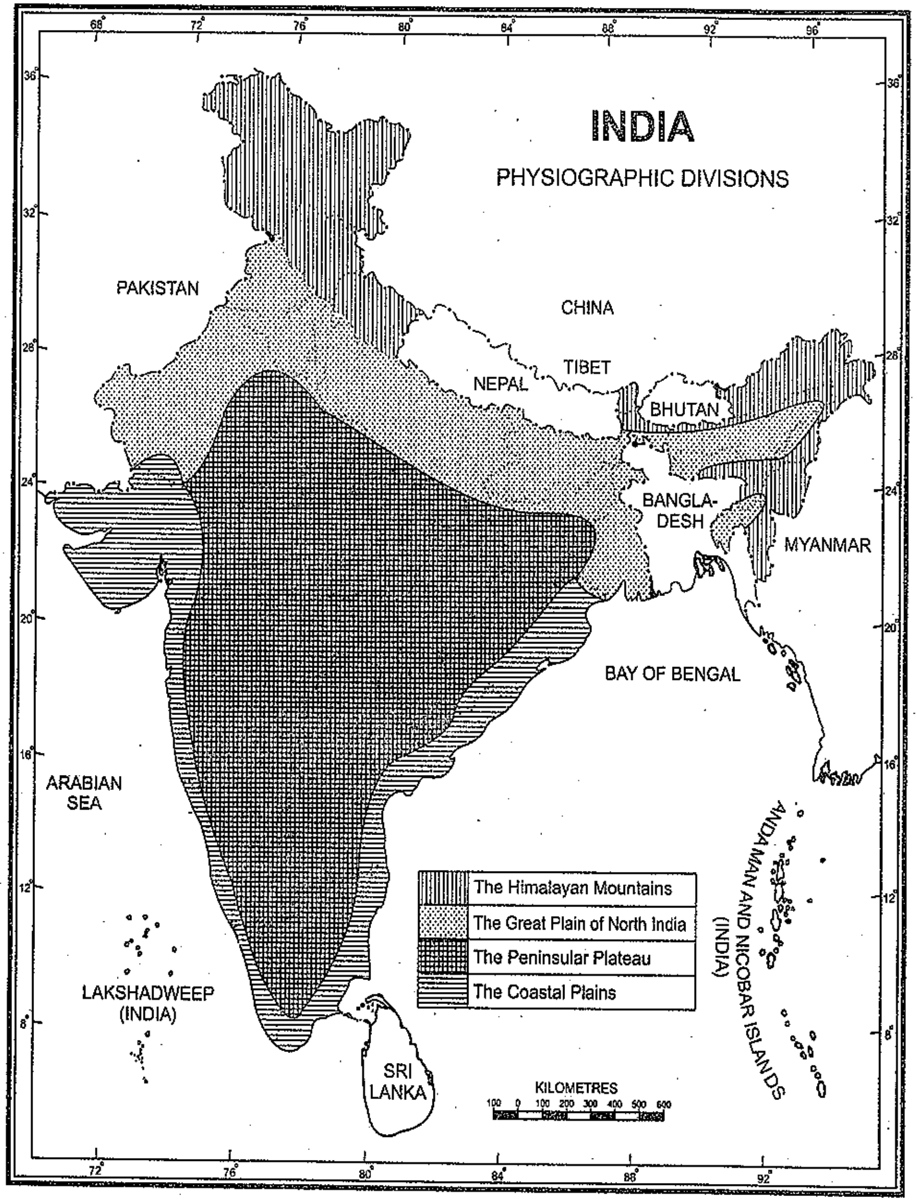


FIG. 3.1. India : Physiographic Divisions

The width of the Himalayas varies from 500 km in Kashmir to 200 km in Arunachal Pradesh. The total area of the Himalayan mountain region is nearly five lakh sq km. The Pamir, popularly known as the *roof of the world* is the connecting link between the Himalayas and the high ranges of Central Asia. From the Pamir, the Himalayas extend eastward in the form of an arcuate curve which is convex to the south. The southern boundary of the Himalayas is well defined by the foothills (300 m contour line) but the northern boundary is rather obscure and merges with the edge of the Tibet Plateau.

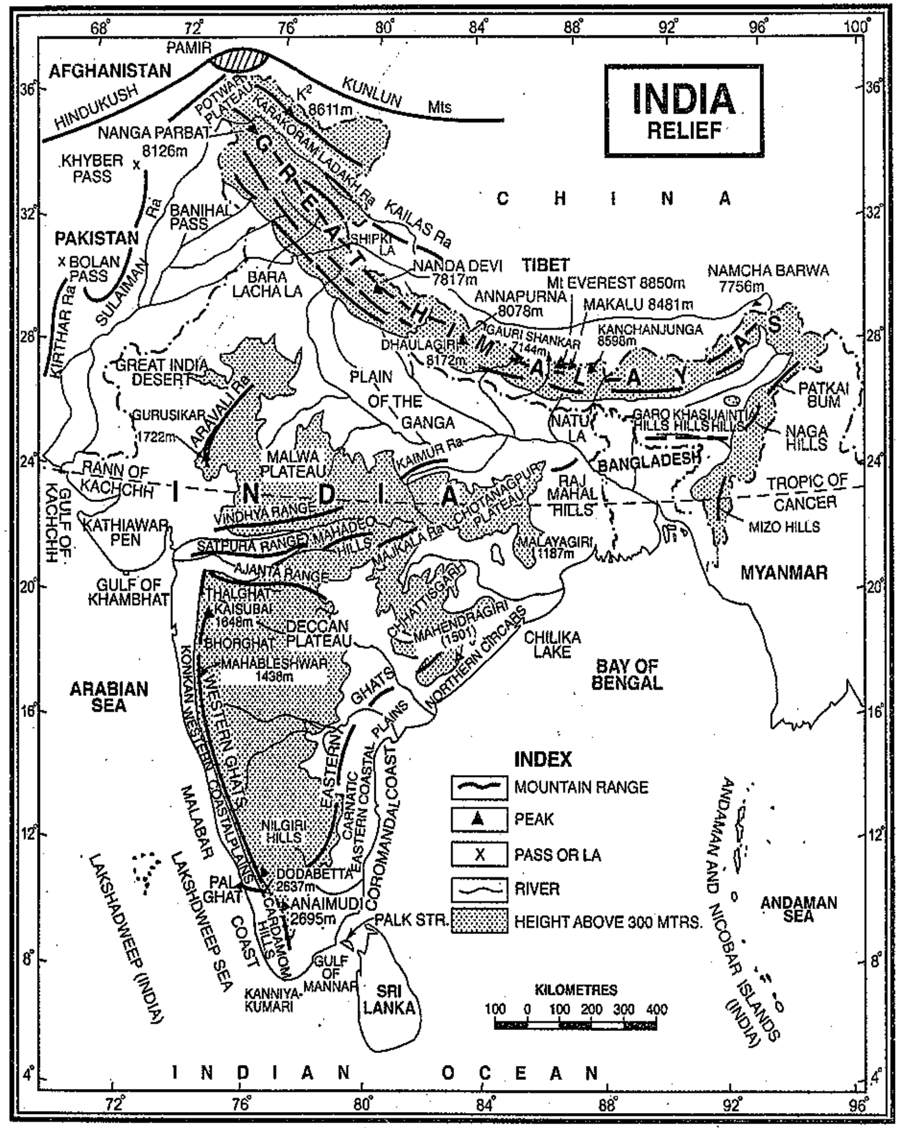


FIG. 3.2. India : Relief

The Himalayas have attained a unique personality owing to their high altitude, steep gradient, snow capped summits, deeply dissected topography, youthful drainage, complex geological structure and rich temperate flora in the subtropical latitudes.

The Himalayan mountain chains have the loftiest peaks of the world. The number of peaks higher than 8,000 metre is 14 and those over 7,500 metre total 20. Of the 94 Asian peaks which exceed 7,300 metre, all but two are in the Himalaya and Karakoram ranges. The number of peaks over 7,000 metre runs into hundreds and several peaks above 6000 metre have not been adequately counted and mapped. Many of them have not been even given their names till now.

Origin of the Himalayas

Several scholars have expressed their views regarding the origin of the Himalayas. Prominent among them are O.H.K. Spate, D.N. Wadia, M.S. Krishnan, S. Burrard, E.H. Pasco, G.E. Pilgrim, de Terra, T.T. Paterson, T. Hagen, Auden, A. Heim and A. Gansser, Wagner and a host of others. There is almost a complete unanimity that the Himalayan mountains have come out of a great geosynchine called the *Tethys Sea* and that the uplift has taken place in different phases. But divergent views have been expressed regarding the process and time of uplift as well as the forces responsible for uplift on such a vast scale. The consensus which has emerged from the views of different scholars is reproduced as under:

About 120 million years ago, the arrangement of continents and oceans was quite different from what it is today. There was a super continent known as ***Pangaea***. Its northern part consisted of the present North America and Eurasia (Europe and Asia) which was called ***Laurasia*** or ***Angaraland***. The southern part of Pangaea consisted of South America, Africa, South India, Australia and Antarctica. This landmass was called ***Gondwanaland***. In between Laurasia and Gondwanaland, there was a long, narrow and shallow sea known as the ***Tethys Sea***. Sediments were brought by rivers from these landmasses and deposited on the bed of this sea. These sediments were subjected to powerful compression, either because of the southward movement of the Angaraland or due to the northward movement of the Gondwanaland. Majority of the scientists believe that it is the northward movement of the Gondwanaland which caused compression in the sediments at the floor of the Tethys Sea. In any case, whether Angaraland moved southwards or Gondwanaland moved northwards or both moved towards each other, the net result would be the same; the sediment in the Tethys Sea was squeezed and crushed, and a series of folds were formed one behind the other giving birth to the highest relief features on the earth—the Himalayas. The curved shape of the Himalayas convex to the south, is attributed to the maximum push offered at two ends of the Indian Peninsula during its northward drift. In the northwest it was done by the Aravalis and in the north-east by the Assam ranges, both acting as two extended arms pushing out the extremities, while the central area sagged giving the arcuate shape to the Himalayas. Recent studies have shown that India is moving northwards at the rate of about five cm per year and crashing into rest of the Asia, buckling the Himalayas between Angaraland and Gondwanaland.

It is important to note that the Himalayas do not comprise a single range but a series of at least three ranges running more or less parallel to one another. Therefore, the Himalayas are supposed to have emerged out of the *Himalayan Geosyncline i.e.* the Tethys Sea in three different phases following one after the other. The first phase commenced about 120 million years ago, when the Great Himalayas were formed. Some geologists are of the opinion that the formation of the Great Himalayas was completed about 70 million years ago. The second phase took place about 25 to 30 million years ago when the Middle Himalayas were formed. The Shiwaliks were formed in the last phase of the Himalayan orogeny—say about two million to twenty million years ago (**Fig. 3.3**).

The diastrophic movements which helped in the formation of the Himalayas started in the late Cretaceous times and continued through the Eocene, Middle Miocene, Pliocene to the lower Pliocene and finally into the upper Pleistocene to sub-Recent times. There are evidences to show that the process of uplift of the Himalayas is not yet complete and they are still rising. The heights of various places as determined by trigonometrical methods indicate that the Himalayas continue to rise till date. According to the estimates made by Godwin Austen, the average elevation of the Himalayas was 2,440 m above the sea level about a

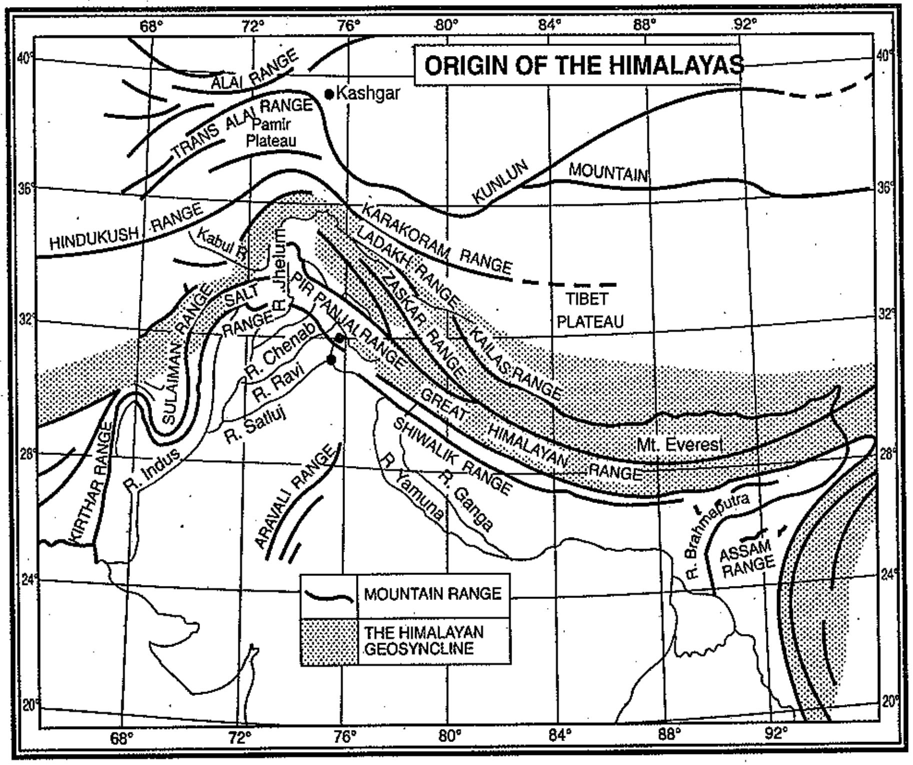


FIG. 3.3. Origin of the Himalayas

million years ago which has now risen to 3,050 m. The Mahabharat range is still in a state of rigorous uplift. Following evidences are cited to prove that the Himalayas are still rising:

(*i*) Some of the fossil formations found in the Shiwalik hills are also available in the Tibet plateau. It indicates that the past climate of the Tibet plateau was somewhat similar to the climate of the Shiwalik hills and that the elevation of Tibet plateau was almost the same as that of the present Shiwalik hills and the plateau has since risen to its present elevation.

(*ii*) Desiccation of lakes of Tibet has been observed within the recent or even in historical times. Surrounding these lakes, the sand and gravel terraces at higher levels, sometimes 60-100 metres above the present water level, are seen which prove that the water stood at a much higher level till recent times. This could be possible only in the event of uplift of the region.

(*iii*) The frequent occurrence of earthquakes in the Himalayan region shows that the Himalayas have not yet attained *isostatic equilibrium* and they still continue to rise further.

(*iv*) The Himalayan rivers are still in their youthful stage and have been rejuvenated in recent times. This is another proof of rising trend in the Himalayas. Terraces found at the valley sides suggest rejuvenation of the valley region due to uplift.

The present rate of uplift of the Himalayas has been calculated at 5 to 10 cm per year.

Plate Tectonics

Plate tectonics is the most recent and widely acclaimed theory which gives most satisfactory answers to intricate and puzzling questions regarding origin of continents and oceans, formation of mountains, occurrence of earthquakes and eruption of volcanoes. The credit for introducing this theory goes to Harry Hess (1960), R.S. Dietz (Global Tectonics, 1961), W.J. Morgan and Le Pichon (Sea Floor Spreading and Continental Drift, 1968). Plate tectonics is a theory of global dynamics in which the lithosphere is believed to be broken into a series of separate plates that move in response to convection in the upper mantle. *Plate is a broad segment of lithosphere (including rigid upper mantle plus oceanic and continental crust) that is about 100 km thick and floats on the underlying asthenosphere and moves independently of other plates.* The margins of the plates are sites of considerable geological activity such as sea-floor spreading, volcanic eruptions, earthquakes, crustial deformation, mountain building and continental drift. There are three types of plate boundaries, *viz*., (*a*) constructive, (*b*) destructive, and (*c*) conservative. *Constructive boundaries* represented zones of 'diverging margins'. In this case, two plates move away from each other. *Destructive boundaries* are also known as '*converging margins*'. In this case, two plates move towards each other, converge and in the process one plate overrides the other. The overridden plate is subducted and goes under the asthenosphere and is lost or consumed. Where two plates slide past along transform faults neither creating nor destroying earth crust it is called ***conservative zone***.

It is the converging boundary of the plates where folded mountains like the Himalayas build up. When two convergent plates composed of continental crusts collide against each other, the denser plate is subducted under the lighter plate. The resultant lateral compression squeezes and folds the sediments deposited on either side of the continental plate margins or sediments of the geosynclines lying between the two.

The Himalayas are the product of such a process on the convergence zone of the Asiatic plate in the north and the Indian plate in the south. Some 70 million years ago, the Indian plate started moving towards the Asian plate and the Tethys sea began to contract due to the movement of Indian and Asian plates towards each other. Since the Indian plate was made up of denser material than the Asian plate, the former began to subduct under the latter causing lateral compression of the marine sediment in the bed of the Tethys (**Fig. 3.4**). Geologists believe that the sediment got folded in three successive phases giving rise to three important ranges of the Himalayas. Although the process of the Indian plate moving towards the Asian plate and formation of the Himalayan ranges was more or less completed about 10 million years ago, it is believed that the Indian plate is still moving northwards and the Himalayas continue to rise further. Evidences regarding rise in the Himalayas have already been mentioned in the foregoing paragraphs.

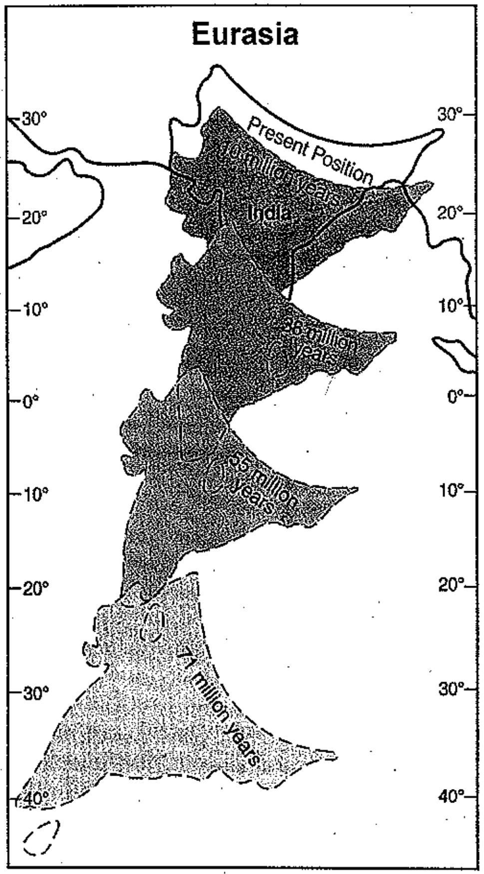


FIG. 3.4. The northerly drift of Indian plate and its collision with Asian plate

Different stages of movement of the Indian plate and the evolution of the Himalayas is illustrated in **Fig. 3.5**.

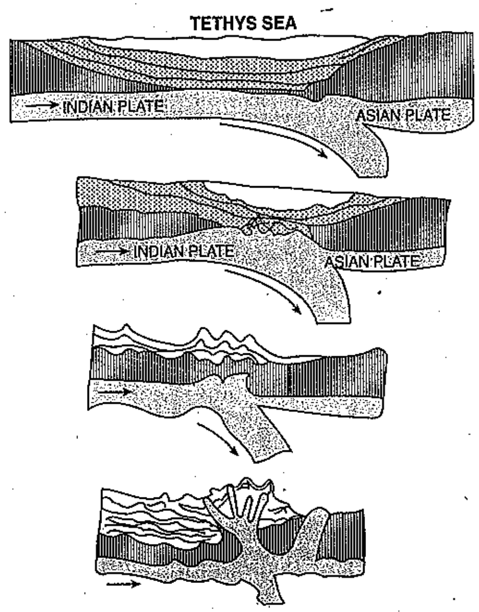


FIG. 3.5. Plate Tectonics and Evolution of the Himalayas

Recent studies have shown that convergence of the Indian plate and the Asian plate has caused a crustal shortening of about 500 km in the Himalayan region. This shortening has been compensated by sea floor spreading along the oceanic ridge in the Indian Ocean. Since the northward movement of the Indian plate is still continuing the height of the Himalayan ranges is increasing with the passage of time. It has been estimated that the Indian plate is still moving northward at a rate of about 5 cm per year. As a result of this movement, one more fracture has appeared in the outer fringes of the Shiwalik Hills which demarcates these hills from the Ganga Plain. Geologists postulate that a new mountain chain would be formed in the Ganga basin forcing the rivers of this region to migrate further south. This clearly indicates that the process of upheaval of the Himalayas is not yet over and will continue for a pretty long period in the times to come.

Division of the Himalayas

Geographers generally tend to divide the Himalayas on geographical, regional and geological bases. Geographically the entire Himalayan region can be divided into: (*i*) The Himalayan Ranges; (*ii*) The Trans-Himalayas and (*iii*) The Eastern Hills.

(*i*) The Himalayan Ranges

The Himalayas are not a single chain or range of mountains, but a series of several, more or less parallel or converging ranges. These ranges are separated by deep valleys. As in all young fold mountains, we find a densely dissected *"ridge-and-valley-topography"* in the Himalayas. The most outstanding valleys in the Himalayan region are the vale of Kashmir and the Karewas, the Kangra and Kulu valley in Himachal Pradesh; the Dun valley; the Bhagirathi valley (near Gangotri) and the Mandakini valley (near Kedarnath) in Uttarakhand and the Kathmandu valley in Nepal. The individual ranges have very steep gradient towards the south but they present a much gentler slope towards the north. In the eastern section the Himalayas rise abruptly from the plains of Bengal and Oudh and suddenly attain great elevations within a short distance from the foot of the mountains. Thus the peaks of Kanchenjunga and Everest are only a few kilometres from the plains and are clearly visible from there. In contrast, the western Himalayas rise gradually from the plains through a series of ranges. Their peaks of perpetual snow are 150 to 200 km away from the plain areas. Most of the Himalayan ranges fall in India, Nepal and Bhutan, but the northern slopes are partly situated in Tibet while the western extremity lies in Pakistan, Afghanistan and Central Asia. A succession of at least three parallel ranges from the Indo-Gangetic plain to the Tibet plateau may be recognised in the Himalayas.

(*a*) The Shiwalik Range. The Shiwalik comprises the outermost range of the Himalayas and is also known as the ***Outer Himalayas***. With its southern steep slopes, it assumes a ***hogback*** appearance. Flat scarps, anticlinal crests and synclinal valleys are the chief characteristic features of this range. Overlooking the Great Plain, this chain of hills runs almost parallel to the lesser Himalayas for a distance of about 2,400 km from the Potwar Plateau to the Brahmaputra valley. The width of the Shiwaliks varies from 50 km in Himachal Pradesh to less than 15 km in Arunachal Pradesh. It is an almost unbroken succession of low hills except for a gap of 80-90 km which is occupied by the valley of the Tista River. The gorges of the Tista and the Raidak have jointly formed a gap 80-90 km wide in the Shiwalik range. The altitude varies from 600 to 1500 metres. The Shiwaliks are formed of great thickness of Mio-Pleistocene sands, gravels and conglomerates which have been brought by the rivers flowing from the higher ranges of the Himalayas. These have been folded, faulted and indurated by the earth movements from the Middle Miocene to the lower Pliestocene ages. Obviously the Shiwaliks were formed last of all the ranges. The Shiwaliks are known by different names in different areas. They are called Jammu Hills in Jammu and Dafla, Miri, Abor and Mishmi Hills in Arunachal Pradesh. The Dhang Range, Dundwa Range (Uttarakhand) and the Churia Ghat Hills of Nepal also form part of the Shiwalik range.

As the Shiwalik Hills were formed after the formation of the Himalayas, they obstructed the courses of the rivers draining from the higher reaches of the Himalayas and formed temporary lakes. The debris brought by those rivers were deposited in these lakes. After the rivers had cut their courses through the Shiwalik Range, the lakes were drained away leaving behind plains called ***'duns'*** or ***'doons'*** in the west and ***'duars'*** in the east. Dehra Dun in Uttarakhand is the best example of such a plain which is 75 km long and 15-20 km wide. It is covered with boulder and clay deposits. Kotah, Patli Kothri, Chumbi, Kyarda and Chaukhamba are other duns. In the Jammu hills the extensive picturesque duns of Udhampur and Kotli are quite typical.

The eastern part of the Shiwalik range upto Nepal is covered with thick forests but the forest cover becomes thin in the west. The southern slopes of this range are almost completely devoid of forest cover in Punjab and Himachal Pradesh and are highly dissected by several seasonal streams locally called ***Chos***.

(*b*) The Middle or the Lesser Himalaya. In between the Shiwaliks in the south and the Great Himalayas in the north is the Middle Himalaya running almost parallel to both the ranges. It is also called the ***Himachal*** or ***Lower Himalaya***. It has an intricate system of ranges which are 60-80 km wide having elevations varying from 3,500 to 4,500 m above sea level. Locally linear longitudinal ranges have also developed, with steep, bare southern slopes and more gentle, forest covered northern slopes, they give these ranges typical *hogback* look, more pronounced here than in the Shiwalik. Many peaks are more than 5,050 m above sea level and are snow covered throughout the year. The important ranges included are the Pir Panjal, the Dhaola Dhar, the Mussoorie Range, the Nag Tiba and the Mahabharat Lekh. The Pir Panjal range in Kashmir is the longest and the most important range. It extends from the Jhelum river to the upper Beas river for 300-400 km and is separated from the Zaskar Range by the valley of Kashmir. It rises to 5,000 metres and more in elevation and contains mostly volcanic rocks. The best known passes of the Pir Panjal range are the Pir Panjal Pass (3,480 m), the Bidil (4,270 m), Golabghar Pass (3,812 m) and Banihal Pass (2,835 m). The Banihal Pass is used by the Jammu-Srinagar highway and Jammu-Baramula railway. The Kishanganga, the Jhelum and the Chenab cut through this range. South-east of the Ravi, the Pir Panjal continues as Dhaola Dhar range, passing through Dalhousie, Dharmshala, and Shimla. This is the southernmost range of the Middle Himalayas and rarely attains elevations higher than 4,000 metres.

Between the Pir Panjal and the Zaskar Range of the main Himalayas, lies the famous valley of Kashmir running over a distance of about 135 km in a south-east to north-west direction. This valley is about 40 km broad in its middle. Its total area is 4921 sq km and its average elevation is 1,585 m above mean sea level. Geographers and geologists have divergent views regarding the origin of this valley. **Wadia** thinks that the valley of Kashmir is the synclical basin enclosed between the Pir Panjal to the south and an offshoot of the central axial range to the north while **de Terra** feels that it is a recently depressed intermont basin pointing to evidence of faulting on the Himalayan flank. However, it is generally believed that this basin was occupied by a lake in the Pleistocene age. This was filled with sediment and uplifted to form the Kashmir valley. The synclinal basin of the valley is floored with a variety of alluvial deposits, lacustrine, fluvial and fluvioglacial, through which the Jehlum River meanders majestically before entering the deep gorge it has cut through the Pir Panjal. In Himachal Pradesh there is *Kangra Valley*. It is a strike valley and extends from the foot of the Dhaola Dhar Range to the south of Beas. On the other hand, the *Kulu Valley* in the upper course of the Ravi is transverse valley.

Further east, the Middle Himalayas are marked by the Mussoorie and the Nag Tibba ranges. The Mussoorie range has an average elevation of 2,000-2,600 m and runs over a distance of 120 km from Mussoorie to Lansdowne. Mussoorie, Nainital, Chakrata and Ranikhet are important hill stations situated between 1,500 to 2,000 metres above sea level. The Mahabharat Lekh, in southern Nepal is a continuation of the Mussoorie Range. Its summits rise to 3000 m and its average elevation varies from 1,500 to 2,000 m above sea level. The Kathmandu valley to its north is a very important feature of this area. East of the Sun Kosi River, the Sapt Kosi, Sikkim, Bhutan, Miri, Abor and Mishmi hills represent the lower Himalayas.

On the whole, the Middle Himalayan ranges are less hostile and more friendly to human contact. Majority of the Himalayan hill resorts like Shimla, Mussoorie, Ranikhet, Nainital, Almora and Darjeeling, etc. are located here.

(*c*) The Great Himalaya. This is also known as ***Inner Himalaya***, ***Central Himalaya*** or ***Himadri***. This is the northernmost or the innermost of all the Himalayan ranges. With an average elevation of 6,100 m above sea level and an average width of about 25 km, this is the loftiest and the most continuous mountain range of the world. It is about 150 km away from the northern edge of the plains of Northern India. It is mainly formed of the central crystallines (granites and gneisses) overlain by metamorphosed sediments. The folds in this range are asymmetrical with steep south slope and gentle north slope giving ***'hog back'*** topography. This mountain arc, convex to the south, terminates abruptly in the Nanga Parbat in north-west and in the Namcha Barwa in the north-east.

This mountain range boasts of the tallest peaks of the world, most of which remain under perpetual snow. There are several peaks over 8,000 m in altitude. The highest is the Mount Everest which is 8,850 m* above sea level. Its Nepalese name is ***Sagarmatha*** which means ***The Goddess of the Sky***. The Tibetans call it ***Chomlungma***. Located at 27° 59′ 16″ N latitude and 86° 55′ 46″ E longitude this sky touching peak was first located by George Everest, the then Surveyor General of India in 1841 and in 1852 it was established as the highest peak of the world by the Great Trigonometrical Survey of India. In 1865 it was named as Mount Everest as a tribute to Sir George Everest. Before that, it was known as Peak XV. However, Chinese want the peak to be named as Qomolangma, meaning the "Mother of the World". China claims that this peak was mapped by Qing dynasty officials in 1717. The other important peaks in descending order of altitude are, Kanchenjunga, Lhotse, Makalu, Dhaulagiri, Manaslu, Cho Oyu, Nanga Parbat, Annapurna, Gosainthan or Shisha Pangma. The number of known peaks rising over 7,000 m in elevation exceeds forty. Some of the important peaks between 7,100 and 8,000 m elevation are Nanda Devi, Kamet, Namcha Barwa, Gurla Mandhata, Badri Nath, Trisul, etc. (*see* **Table 3.1** and **Fig. 3.6** and **3.8**).

This range is so formidable that it cannot be easily crossed even through the passes because they are generally higher than 4,570 m above sea level and are snowbound for most of the year. The Burzil Pass and the Zoji La in Jammu and Kashmir, the Bara Lacha La and the Shipki La in Himachal Pradesh, the Thaga La, the Niti Pass and the Lipu Lekh pass in Uttarakhand and the Nathu La and the Jelep La in Sikkim are the important passes through the Great Himalaya. The Hindustan-Tibet Road connecting Shimla with Gartok in Western Tibet passes through the Shipki La. Another important trade route connecting Kalimpong (near Darjeeling) with Lhasa in Tibet, passes through Jelep La (4,386 m).

* Earier the height of the Mount Everest was considered to be 8848 metres. But according to the measurements made by the National Geographic Society (Washington) using Global Positioning System (GPS) satellite equipment on May 5, 2000, the height of the peak is 8850 metres.

On the basis of a new survey conducted recently, the Chinese on 9th October, 2005, reported that the height of Mount Everest had been calculated at 8,844.43 m above sea level with an error margin of 0.21 m. Chen Bangzhu, Director General of the State Bureau of Surveying and Mapping, however, added, "We cannot arrive at the conclusion that the Everest has become shorter, because there have been problems with surveying technology." According to surveyors of China and Nepal, confusion about the exact height of the Mt. Everest is primarily due to different techniques used for the purpose. Moreover, Philip's Geography Dictionary in its 2000 edition has mentioned the height of the peak as 8,850 on page 138. Therefore, it sounds logical to retain the height of the peak at 8,850 m above sea level.

TABLE 3.1. Some Important Peaks and their Heights of the Great Himalayas

Name of the Peak	Height above sea level (in metres)
1. Mount Everest	8,850*
2. Kanchenjunga	8,598
3. Lhotse I	8,501
4. Makalu	8,481
5. Dhaulagiri	8,172
6. Manaslu	8,156
7. Cho Oyu	8,153
8. Annapurna	8,078
9. Gosainthan or Shisha Pangma	8,013
10. Nanda Devi	7,817
11. Kamet	7,756
12. Namcha Barwa	7,756
13. Gurla Mandhata	7,728
14. Trisul	7,140
15. Badarinath	7,138

(ii) The Trans Himalayas

The Himalayan ranges immediately north of the Great Himalayan range are called the trans-Himalayas. This part of the Himalayan ranges is also called the ***Tibetan Himalaya*** because most of it lies in Tibet. The Zaskar, the Ladakh, the Kailas and the Karakoram are the main ranges of the Trans-Himalayan system. It stretches for a distance of about 1,000 km in east-west direction and its average elevation is 3000 m above mean sea level. The average width of this region is 40 km at the eastern and western extremities and about 225 km in the central part.

The *Zaskar Range* branches off from the great Himalayan Range near 80° E longitude and runs more or less parallel to it. The Nanga Parbat (8126 m) forms its culmination in the north-west but the adjoining Deosai Mountain may also be included in it. North of the Zaskar Range and running parallel to it is the *Ladakh Range*. It is about 300 km long and its average elevation is 5800 metre above the sea level. Only a few peaks of this range attain heights of over 6000 metres. The Rakaposhi-Haramosh Ranges beyond the Indus may be treated as extensions of the

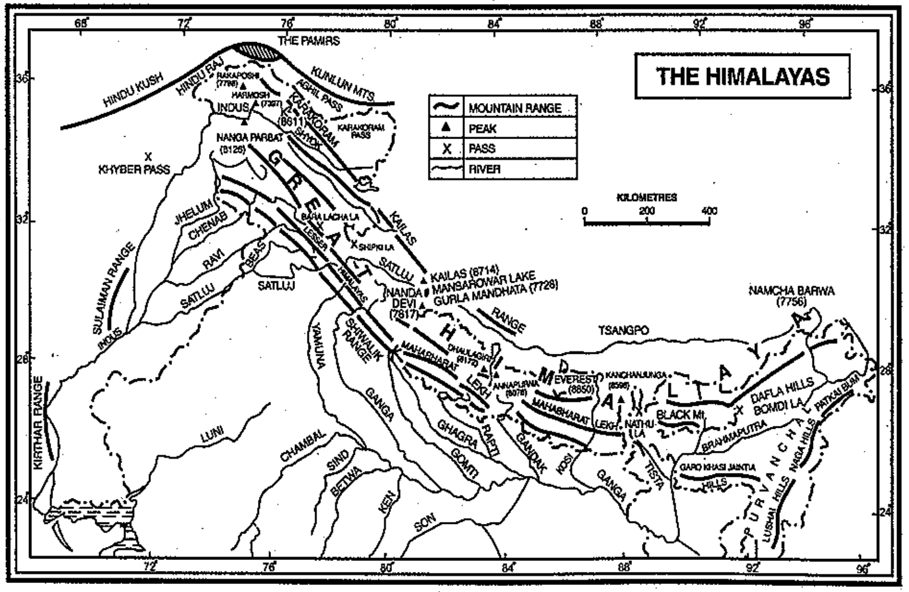


FIG. 3.6. The Himalayas

Ladakh Range to the northwest. The Kailas Range (*Gangdise in Chinese*) in western Tibet is an offshoot of the Ladakh Range. Its average elevation is 5,500-6,000 m above sea level and its average width is 30 km. The highest peak is Mount Kailas (6714 m). River Indus originates from the northern slopes of the Kailas range. The northern-most range of the Trans-Himalayan Ranges in India is the Great Karakoram Range also known as the Krishnagiri range. It forms India's frontier with Afghanistan and China and acts as the watershed between India and Turkistan. It extends eastwards from the Pamir for about 800 km. The average width of this range is 120-140 km. It is a range with lofty peaks and its elevation hardly ever falls below 5,500 m. It is the abode of some of the greatest glaciers of the world outside the polar regions. Some of the peaks are more than 8,000 metre above sea level. K^2 (8,611 m) is the second highest peak in the world and the highest peak in the Indian Union and rises majestically like a cone. It has been named as ***Godwin Austen*** by the Britishers and ***Qogir*** by the Chinese. The other peaks located in its neighbourhood and rising more than 8,000 m above sea level are the Gasherbrum I or Hidden Peak (8,068 m), Broad Peak (8,047 m) and Gasherbrum II (8,035 m). Another 19 peaks in Korakoram cross the 7,600 m elevation mark and those over 7,000 m have not yet been fully enumerated.

The Ladakh Plateau lies to the north-east of the Karakoram Range. With an average elevation of over five thousand metres above sea level, it is the highest plateau of the Indian Union. It has been dissected into a number of plains and mountains, the most outstanding among them being Soda Plains, Aksai Chin, Lingzi Tang, Depsang Plains and Chang Chenmo.

(iii) The Eastern Hills or The Purvanchal

After crossing the Dihang gorge, the Himalayas take a sudden southward turn and form a series of comparatively low hills running in the shape of a crescent with its convex side pointing towards the west. These hills are collectively called the ***Purvanchal*** because they are located in the eastern part of India. Extending from Arunachal Pradesh in the north to Mizoram in the south, they form India's boundary with Myanmar. Differing markedly from the Himalaya in the scale of their relief and in their morphology, these hill ranges none-the-less stem from the same orogeny.

In the north is the Patkai Bum which forms the international boundary between Arunachal Pradesh and Myanmar. It is made up of strong sandstone and rises to elevation varying from 2,000 m to 3,000 m. After running for some distance southwards, it merges into Naga Hills where Saramati (3,826 m) is the highest peak. Patkai Bum and Naga Hills form the watershed between India and Myanmar. The Kohima hills to the west are made up of sandstone and slate and have a very rough topography. South of Naga Hills are the Manipur hills which are generally less than 2,500 metres in elevation. They form the boundary between Manipur and Myanmar. The Barail range separates Naga Hills from Manipur Hills. Further south the Barail Range swings to south-west and then west into Jaintia, Khasi and Garo hills which are an eastward continuation of the Indian peninsular block and has been separated by the Bengal Basin. South of the Manipur Hills are the Mizo Hills (previously known as the Lushai hills) which have an elevation of less than 1,500 metres. The highest point is the Blue Mountain (2,157 m) in the south. It is obvious that the elevation of the eastern hills decreases as we move from north to south. Although comparatively low, these hill ranges are rather forbidding because of the rough terrain, dense forests and swift streams.

Regional Division of the Himalayas

Sir Sidney Burrard divided the entire length of the Himalayas into the following four divisions on the basis of the river valleys :

(i) The Punjab Himalayas

The 560 km long stretch of the Himalayas between the Indus and the Satluj rivers is known as the ***Punjab Himalayas***. A large portion of this sector lies in Jammu and Kashmir and Himachal Pradesh as a result of which it is also called the ***Kashmir and Himachal Himalaya***. Karakoram, Ladakh, Pir Panjal, Zaskar and Dhaola Dhar are the main ranges of this section. The 3,444 metre high Zoji La pass provides an easy passage. In between the main ranges, there are valleys, duns, and lakes. The general elevation falls westwards.

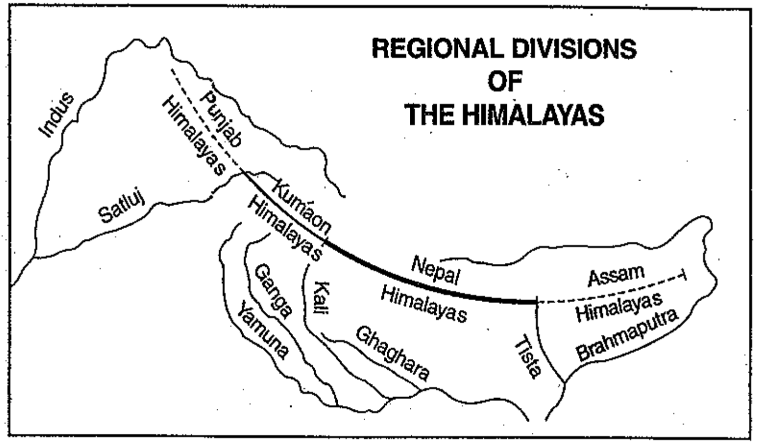


FIG. 3.7. Regional Divisions of the Himalayas

(ii) The Kumaon Himalayas

Between the Satluj and the Kali rivers is the 320 km long Kumaon Himalayas. Its western part is called **Garhwal Himalaya** while the eastern part is known as **Kumaon Himalaya** proper. The general elevation is higher as compared to Panjab Himalayas. Nanda Devi (7,817 m), Kamet (7,756 m), Trisul (7,140 m), Badrinath (7,138 m), Kedarnath (6,968 m), Gangotri (6,510 m) are important peaks. The sources of sacred rivers like the Ganga and the Yamuna are located in the Kumaon Himalayas. There are several *duns* between the Middle Himalayas and the Shiwalik Hills. Nainital and Bhimtal are important lakes.

(iii) The Nepal Himalayas

This section of the Himalayas stretches for a distance of 800 km between the Kali and the Tista rivers. Most of it lies in Nepal as a result of which it is called the ***Nepal Himalayas***. This is the tallest section of the Himalayas and is crowned by several peaks of perpetual snow. The Mount Everest (8,850 m) is the tallest peak of the world. The other major peaks are Kanchenjunga (8,598 m), Lhotse I (8,501 m), Makalu (8,481 m), Dhaula Giri (8,172 m), Cho Oyu (8,153 m) and Annapurna (8,078 m). Kathmandu is a famous valley in this region.

(iv) The Assam Himalayas

The Himalayan ranges from Tista to Brahmputra rivers covering a distance of 750 km are called the ***Assam Himalayas***. This part of the Himalayas spreads over large parts of Sikkim, Assam and Arunachal Pradesh and has elevation much lesser than that of the Nepal Himalayas. The southern slopes are very steep but the northern slopes are gentle. The Lesser Himalayas are very narrow and are very close to the Great Himalayas. The improtant peaks of this region are Namcha Barwa (7,756 m), Kula Kangri (7,554 m) and Chomo Lhari (7,327 m).

Apart from Sir Sydney Burrard, some other scholars have also divided the Himalayas in their own way. For example, **Prof. S.P. Chatterjee** (1,964) divided the Himalayan region into three meso physiographic regions. Their names are (1) Western Himalayas (Kashmir, Punjab and Kumaon Himalayas), (2) Central Himalayas (Nepal Himalayas) and (3) Eastern Himalaya—besides the Purvanchal consisting of the north-eastern ranges. **R.L. Singh** (1971) also made three fold subdivision of the Himalayas. His division was slightly different from that made by **S.P. Chatterjee. Prof. R.L. Singh's** division comprises (*i*) Western Himalaya (1. Kashmir Himalaya and 2. Himachal Himalaya), (*ii*) Central Himalaya (3. U.P. Himalaya—now Uttarakhand Himalaya, 4. Nepal Himalaya), and (*iii*) Eastern Himalaya (5. Darjeeling—Bhutan—Assam Himalaya and 6. Purvanchal).

From the above discussion, it sounds more logical to divide the Himalayas into the following three broad divisions :

1. The Western Himalayas. Stretching for 880 km between the Indus in the west and the Kali river in the east, the Western Himalayas spread in three states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand. It encompasses three physiographic provinces namely Kashmir Himalaya, Himachal Himalaya and Kumaon Himalaya.

The *Kashmir Himalaya* lies almost entirely in the state of Jammu and Kashmir. The average height of this region is nearly 3,000 m above sea level. This province is marked by a number of glaciated troughs. The Indus is the most important river which traverses this area diagonally for about 650 km. North of this river lies the imposing Karakoram range. This range has lofty peaks and a large number of big glaciers. The second highest peak of the world K_2 (8,611 m) lies in this range. The Ladakh plateau and the Kashmir valley are two important areas of this region. The chief characteristic features of the Kashmir Himalaya are high snow covered peaks, deep valleys, interlocked spurs and high mountain passes.

The *Himachal Himalayas* are mainly confined to Himachal Pradesh. All the three ranges of the Himalaya are represented in this area. The Greater Himalaya is represented by the Zaskar range, lesser Himalaya by Pir Panjal and Dhauladhar ranges and the Outer Himalaya by the Shiwalik range. The main range has some peaks which rise above 6,000 m. The southern slopes are rugged and forested while the northern slopes are bare and show plains with lakes. Zojila La, Rohtang, Bara Lacha La and Shipki La are important passes. This area has beautiful valleys of Kullu, Kangra and Lahul and Spiti.

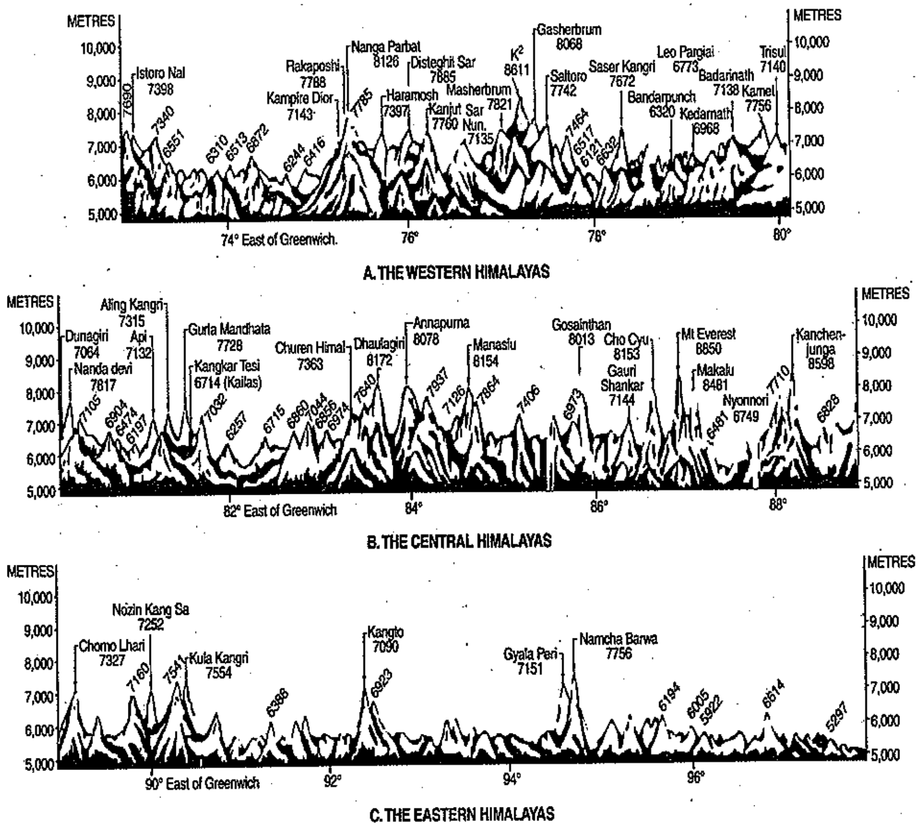


FIG. 3.8. Longitudinal cross section of the Himalayas showing important peaks

The *Kumaon Himalayas* lie in Uttarakhand and extend from the Satluj to the Kali river. Its main peaks are Nanda Devi (7,817 m), Kamet (7,756 m), Mana (7,273 m), Trisul (7,140 m), Badrinath (7,138 m), Kedarnath (6,968 m), Jauli or Shivling (6,638 m) and Gayatri (6,515 m). The Gangotri glacier is the source of the sacred Ganga. The region is dotted by about 36 lakes. The Lesser Himalayas in Kumaon Himalaya is represented by the Mussoorie and Nag Tiba ranges. The area has the famous Nainital lake. The Shiwalik in this region is about 900-1000 m high and runs south of the Mussoori range between the Ganga and the Yamuna rivers for a length of about 75 km. The flat valleys between the Lesser Himalaya and the Shiwalik range are called ***'Doons'*** or ***'Duns'*** of which ***Dehra Dun*** is the most famous. The Kumaon Himalaya is connected to Tibet by a number of mountain passes of which Thaya La, Muling La (5,669 m), Mana (5,611 m), Niti (5,068), Marhi La (4,953 m), Kungribingri, Darma and Lipin Laot are important.

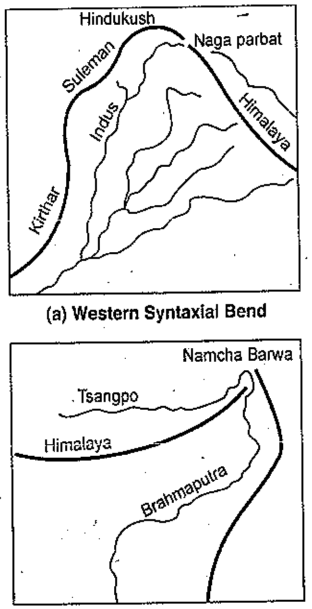
2. The Central Himalayas. The Central Himalayas stretch for a distance of about 800 km between river Kali in the west and river Tista in the east. All the three ranges of the Himalayas are present here. The Great Himalaya range attains maximum height in this portion. Some of the world famous peaks Mt. Everest, Kanchenjunga, Makalu, Annapurna, Gosainthan and Dhaulagiri are located here (**Fig. 3.8**). The Lesser Himalaya is known as ***Mahabharat Lekh*** in this region. The range is crossed by rivers like Ghaghara, Gandak, Kosi, etc. In between the Great and the Lesser Himalayas, there are Kathmandu and Pokhra valleys which represent lacustrine deposits. The Shiwalik range come very close to the lesser Himalaya towards the east and is almost non-existent beyond Narayani (Gandak).

3. The Eastern Himalayas. This part of the Himalayas lies between the Tista river in the west and the mighty Brahmaputra river in the east and stretches for a distance of about 720 km. Also known as the ***Assam Himalayas***, the Eastern Himalayas occupy mainly the areas of Arunachal Pradesh and Bhutan. This part of the Himalayas is known by a number of different names according to the names of the tribal people living in different areas. The prominent peaks of this area are Namcha Barwa (7,756 m), Kula Kangri (7,554 m), Chamo Lhari (7,327 m), Hozin Kang Sa (7,252 m), Gyalaperi (7,151 m) and Kangto (7,090). A number of mountain passes are found in the Eastern Himalayas. The important passes are Jalep La (4,535 m), Bum La (4,331 m), Tse La (4,740 m), Tunga (5,044 m), Yonggyap (3,962 m), and Kangri Karpo La (5,636 m). The Jelep La in the Chumbi valley of Sikkim and Bum La in Arunachal Pradesh provide passage to the Tibetan Capital Lhasa. The Assam Himalayas show a marked dominance of fluvial erosion due to heavy rainfall.

The Himalayas take a sudden southward turn after the Dihang gorge and the hill ranges running in more or less north-south direction along India's border with Myanmar are collectively known as the ***Purvanchal***. These are known by various local names such as *Patkai Bum*, *Naga hills*, *Kohima hills*, *Manipur hills*, *Mizo hills* (previously known as the Lushai hills), Tripura hills and Barail range. The extension of the Purvanchal Himalaya continues southwards upto Andaman and Nicobar Islands through the Myanmar range and even upto the Indonesian archipelago.

Syntaxial Bends of the Himalayas

It has already been mentioned that the Himalayas extend in the east-west direction from the Indus gorge in the west to the Brahmaputra gorge in the east. This east-west trend of the Himalayas is suddenly terminated at its western and eastern extremities and the Himalayan ranges take sharp southward bends. These bends are called ***syntaxial bends*** of the Himalayas. The bend on the western extremity is called the ***western syntaxial bend*** and that on the eastern extremity is known as the ***eastern syntaxial bend***. The ***western syntaxial bend*** occurs near the Naga Parbat where the Indus river has cut a deep gorge. It forms a great knee-bend some 500 km deep and effects the strike of the ranges probably as far as the foot of the Pamirs. The geological formations take a sharp hairpin bend as if they were bent round pivotal points. The ***eastern syntaxial bend*** occurs at the eastern extremity of the Himalayas where the Himalayan range takes a sharp bend in the southern direction and the eastern trend of the ranges terminates here. The bend is conspicuous in Arunachal Pradesh where the mountain ranges turn southward after crossing the Brahmaputra. The strike of the ranges also has a deep knee-bend towards the south.



(a) Western Syntaxial Bend

(b) Eastern Syntaxial Bend

FIG. 3.9. Syntaxial Bends of the Himalayas

Glaciers of the Himalayas

As the name implies, the Himalayas are the *abode of snow* and are called the ***storehouse of snow***. Out of a total area of five lakh square kilometres of the Himalayas, about 33,000 sq km area is covered by snow. Evidences of large snow areas in the past are available in abundance. The active glaciers and the associated landscape provide an ideal platform for investigation of historic glacial variation. Obviously the Pleistocene ice was far more extensive than that of today. There are about 15,000 glaciers in the Himalayas lying between the two syntaxial bends in the east and west. The ***snow line, the lowest level of perpetual snow***, varies to a great extent in different parts of the Himalayas depending upon latitude, amount of precipitation and local topography. While the glaciers of Kanchenjunga in Sikkim portion hardly move below 3,965 m, and those of Kumaon and Lahul to 3,660 m, the glaciers of the Kashmir Himalayas may descend to 2,500 m above sea level. **T.D. La Touche** while elaborating the cause of these variations, has suggested that in part it is due to the increase in latitude from 28° N in Kanchenjunga to 36° N in the Karakoram, and in part because of the fact that the eastern Himalayas rise abruptly from the plains without the intervention of high ranges. Though the total precipitation is much less in the western Himalayas it all takes place in the form of snow. In the Great Himalayan ranges, the snow line is at lower elevation on the southern slopes than on the northern slopes because the southern slopes are steeper and receive more precipitation as compared to the northern slopes.

Glaciers of the Karakoram Range

Maximum development of glaciers occurs in the Karakoram range. This range accounts for about 16,000 sq km or about half of the snow bound area of the Himalayan region. Some of the largest glaciers outside the polar and sub-polar regions are found in this range. The southern side of this range nourishes a number of gigantic glaciers, some of which are exceeded in size by the great Humboldt of Greenland only. The 75 km long *Siachen Glacier* in Nubra valley has the distinction of being the largest glacier outside the polar and the sub-polar regions. Lolofond and Teram Shehr are its main tributaries. The second largest is the 74 km long *Fedchenko Glacier*. It covers an area of 450 sq km in the north-western Pamir and has a depth of nearly 550 m of ice. Third comes the *Hispar Glacier*. It is 62 km long and occupies a tributary of the Hunza River. It combines with 59 km long *Biafo Glacier* occupying about 65 sq km area of Braldoh valley. Kunyong or Lak (24 km) is an important tributary of the Hispar Glacier. The west flowing *Baltoro Glacier* also flows in the Braldoh valley. The depth of solid ice at the end of the Baltoro Glacier is about 120 m; the thickness in the middle of the glacier could be much greater. The great *Godwin Austen Glacier* drains three sides of K_2 and joins the Baltoro Glacier. The *Punmah Glacier* also flows in the Braldoh valley. This 27 km long glacier has a complex system of branches in its upper reaches. The *Batura Glacier* draining the Hunza is 58 km long and is considered to be the fifth longest glacier, along with Baltoro, outside the polar and sub-polar regions. The sixth largest glacier outside the polar and sub-polar regions is the 50 km long *Chogo Lungma* glacier in the Rakaposhi Range. It terminates at an altitude of 2075 m, the lowest recorded in the Himalayas. The other two glaciers draining into the

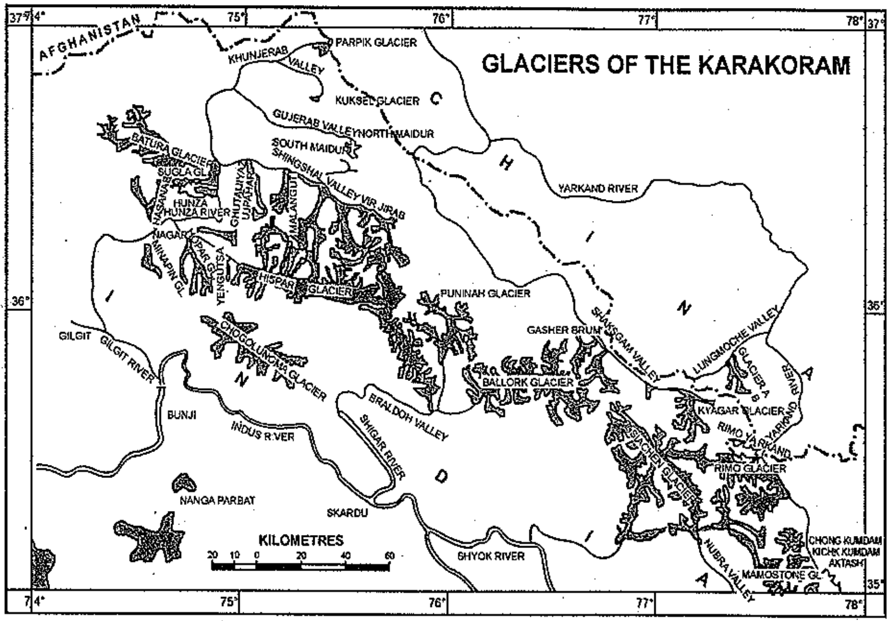


FIG. 3.10. Glaciers of the Karakoram

Hunza Valley are the *Pasu* (25 km) and *Sasaini* or *Ghulkin* (18 km). The *Rimo Glacier* occupying the Shyok valley is about 40 km long. It is joined by the 20 km long *Yarkand Rimo* from the north. The other Glaciers in the Shyok valley are the *Chong Kumdan* (21 km), *Kichik Kumdan* (11 km) and *Aktash* (8 km). The *Khurdopla Glacier* in Shingshal valley is 47 km long. The other glaciers of this valley are the *Virjerab Glacier* (40 km), the *Mombil Yaz* (32 km), *Yazghil* (31 km) and the *Malangutti Yaz* (23 km) The *Gasherbrum* and the *Kyagar* in the Shaksgam valley are 21 km long each. The *Urdok Glacier* lying below these two glaciers is nearly 23 km long.

Glaciers of the Pir Panjal Range

The glaciers of the Pir Panjal Range are less numerous and smaller in size as compared to those of the Karakoram Range. The longest *Sonapani Glacier* in the Chandra Valley of Lahul and Spiti region is only 15 km long. Rising at about 4000 m near the Rohtang Pass and flowing in south west direction it has developed a dry lake basin about 2.5 km long and 1.5 km wide, just below the ice cliff. The *Bara Shigri Glacier* also occupies the Chandra Valley. The rough estimates put its length varying from 10 to 20 km. The largest glacier in the Nun Kun massif is the *Gangri Glacier* which is 13 km long. The glaciers of the Nanga Parbat massif are small in size and are moving fast due to steep slope. The *Chungphar*, *Rakhiot*, *Buzhi* and *Tashan* are important glaciers.

Glaciers of the Kumaon-Garhwal Region

In the Kumaon-Garhwal region of the Himalayas, the largest is the 30 km long *Gangotri Glacier* which is the source of the holy Ganga. It is fed by five tributary glaciers, the largest of which is 24 km long. The second largest glacier of this region is the *Milam Glacier* which occupies the valley of the Gori Ganga River. It is 20 km long and is formed by the union of nine tributary glaciers. The other glaciers of this region are the *Mana Glacier* (18 km), the *Bhagirath-Kharak Glacier* (18 km), the *Satopanch* (16 km) the *Sankalpa Glacier* (12 km) and the *Raikane Glacier* (9 km).

Glaciers of Central Nepal

Central Nepal comprises the mountain ranges between Cho Oyu and Dhaulagiri. Little known

TABLE 3.2. Important Glaciers of the Himalayan Mountains

Name of the Glacier	Length (km)	Location
The Karakoram Range		
1. Siachen	75	Nubra Valley
2. Fedchenko	74	South-Western Pamir
3. Hispar	62	Tributary of Hunza River
4. Biafo	59	Brabloh Valley
5. Batura	58	Hunza
6. Baltoro	58	Braldoh Valley
7. Chogo Lungma	50	Rakaposhi Range
8. Khurdopla	47	Shingshal Valley
9. Lolofond	40	West of Siachen
10. Yarkand Rimo	40	Shyok Valley
11. Mohil Yaz	32	Shingshal Valley
12. Yazhit	31	Shingshal Valley
13. Godwin Austen	30	K_2
14. Pasu	25	Hunza
15. Kunyang	24	Muztagh, Karakoram
16. Chong Kumdon	21	Shyok
17. Gasherbrum	16	Gasherbrum
The Pir Panjal Range		
18. Sonapani	15	Chandra Valley of Lahul and Spiti
19. Bara Shigri	10-20	Chandra Valley
20. Rakhiot	15	Nanga Parbat
21. Gangri	13	Nun Kun Massif
22. Chungphar	13	Nanga Parbat
The Kumaon-Garhwal Region		
23. Gangotri	30	Source of the Ganga
24. Milam	20	Gori Ganga
25. Bhagirath Kharak	18	Near Badrinath
26. Mana	18	Mana Valley north of the Gangotri
27. Satopanch	16	Near Badrinath
The Central Nepal Region		
28. Yepokangara	13.5	Gosainthan
29. Lidanda	11	Manaslu
30. Chhuling	11	Manaslu
31. Mayondi	11	Dhaulagiri Himal
The Kanchenjunga-Everest Region		
32. Rongbuk	52	Northern (Tibetan) side of the Mount Everest
33. Zemu	25	Zemu Valley (Forms headwaters of the Tista River)
34. Kanchanjunga	21	North of Kanchanjunga, occupies head of Kangchen river.
35. Khumbu	20	South of Mt. Everest
36. Kangshung	19	East of the Mt. Everest
37. Tolam Bau	19	South-west of the Mt. Everest
38. Barun	15	North-east of Baruntse peak
39. Rambang	10	Kanchanjunga

glaciers of this region are confined to the surroundings of Gosainthan, Manaslu, Annapurna and Dhaulagiri mountains. The 13.5 km long *Yepokangara* glacier is in the Gosainthan mountain. Two 11 km long ones are the *Lidanda* and *Chhuling* glaciers, both on the south-eastern side of the Manaslu. The *Annapurna* glacier is in the Annapurna mountain. Another 11 km long Mayondi glacier is in the north of the Dhaulagiri.

Glaciers of the Kanchenjunga-Everest Region

In the Kanchenjunga-Everest region, there is *Rongbuk Glacier* on the northern side of the Mount Everest. This is 52 km long and is considered to be the largest outside the Karakoram. Another important glacier of the Everest group is the *Khumbu Glacier*, (20 km) lying to the south of the Everest. The 25 km long *Zemu Glacier* flows in the easterly direction at the head of the Zemu River. It is about one kilometre wide with 180 metre thick ice. The 21 km long *Kanchenjunga Glacier* descends from the peak of the same name and occupies the head of Kangchen river. Both the Zemu and the Kanchenjunga glaciers are formed as a result of the union of several branches coming down from the peaks. The *Yalung Glacier* is 16 km long and flows in a south-west direction from the Kanchenjunga peak. The *Talung Glacier* (13 km) also flow southwest wards. This glacier is separated from the *Alukthang Glacier* by a ridge. Though only 5 km long the Alukthang glacier is unique because it is clearly visible from Darjeeling at the foot of the Kanchenjunga in clear weather. The *Knagshung Glacier* is 19 km long and flows east of the Everest. The *Barun Glacier* flowing down the Baruntse peak is about 15 km long.

Main Passes of the Himalayas

Although the mighty Himalayas rise abruptly from the Indus-Ganga-Brahmaputra plain and stand like a great wall providing little opportunity to cross. Yet there are some passes across this mountain wall which offer passes to cross. Some of the important passes are briefly described below :

A. Passes of the Western Himalayas

The Western Himalayas are dotted with a number of passes which offer passages through them. States of Jammu and Kashmir, Himachal Pradesh and Uttarakhand are included in this part of the Himalayas.

I. Jammu and Kashmir

1. Mintaka Pass. It lies near the trijunction of India-China and Afghanistan border and joins north Kashmir with China.

2. Parpik Pass. It lies to the east of Mintaka pass on the Indo-China border and joins north Kashmir with China.

3. Khunjerab Pass. This pass lies at an altitude of 4934 m on the Indo-China border and gives access between Kashmir and China.

4. Aghil Pass. Lying in the north of K_2 Peak (the highest peak in India and the second highest peak in the world). This pass is situated at the elevation of about 5000 m above sea level and join the Ladakh region of India with the Xinjiang (Sinkiang) Province of China. Being located at a high altitude and surrounded by lofty mountains, it remains snow covered during the winter season and is closed from November to May.

5. Banihal Pass. It is situated at an elevation of 2832 m across the Pir-Panjal Range. It remains snow covered during winter season and cannot be used as a transport route in that season. To provide round-the-year transport facilities between Jammu in south and Srinagar in the north, a tunnel named as ***The Jawahar Tunnel*** (after Pandit Jawaharlal Nehru, the first prime minister of India) was inaugurated in December, 1956. Another 11 km long tunnel provides railway link between Banihal and Kazigund. It was thrown open to railway transport in July, 2013.

6. Chang-La. Located at the border between India and China at an altitude of 5360 m, this pass joins Ladakh with Tibet. Road after Chang La is very steep. This has a temple dedicated to Chang-La Baba after whom the temple has been named. This pass remains closed to traffic during the winter season because of heavy snowfall.

7. Khardung La. This pass is situated at an altitude of 5602 m near Leh in the Ladakh range. The world's highest motorable road passes through this pass. However, this road remains closed in winter due to heavy snowfall.

8. Lanak La. Located near the border between India and China at an altitude exceeding five thousand metres in the Akasai-Chin area of Jammu and Kashmir, this pass provides passage between Ladak and Lhasa. A road to connect Xinjiang Province with Tibet has been constructed by the Chinese.

9. Pir-Panjal. Lying across the Pir Panjal range, it had been a traditional pass on the Mughal Road and provides the shortest and the easiest metal road between Jammu and Kashmir Valley. But this route had to be closed down as a result of partition of the subcontinent.

10. Qara Tag La. It is situated on the Indo-China borer across the Karakoram Range. It remains snow bound and closed to traffic during winters because it is located at an elevation of over six thousand metres. It was an offshoot of the Great Silk Route.

11. Imis La. Situated at the Indo-China border at an altitude of over 4500 m, this pass provides passage between Ladakh region of India and Tibet in China. However, the access is not very easy due to difficult terrain and steep slopes. It remains snowbound and closed during the winter season.

12. Pensi La. Situated to the east of the famous Zoji La in the Greater Himalayas at an elevation of over five thousand metres, this pass provides a vital link between the Kashmir Valley and Kargil. It remains closed to traffic from November to mid-May due to heavy snowfall.

13. Zoji La. It is located at an altitude of 3850 m above sea level and provides an important road link between Srinagar on one side and Kargil and Leh on the other side. The road passing through this pass has been designated at the National Highway (NH-1D). Border Road Organisation (BRO) is responsible for maintaining the road and cleaning it off snow during winter. In spite of all these efforts, the road through this pass remains closed from December to mid-May.

II. Himachal Pradesh

14. Bara Lacha La. This mountain pass is situated at an altitude of 4883 m and provides passage between Himachal Pradesh and Jammu and Kashmir. National highway connecting Mandi in Himachal Pradesh with Leh in Jammu and Kashmir passes through this pass. Being situated at high altitude, it remains snow covered in winter and is not used as a transport route.

15. Debsa Pass. Situated at an elevation of 5270 m above sea level in the Greater Himalayas, it provides a link between Kullu and Spiti districts. It offers a much easier and shorter alternative route to traditional Pin-Parbati Pass route between Kullu and Spiti.

16. Rohtang Pass. It is located at an altitude of 3979 m and provides road link between Kullu, Lahul and Spiti Valleys. Border Road Organisation (BRO) is responsible for constructing and maintaining roads in this area. Rohtang pass is a great tourist attraction and traffic jams are very common because this route is widely used by military, public and private vehicles.

17. Shipki La. It is located at the Indo-China border at an altitude of over 6000 m through the Jhalum Gorge and provides a road connection between Himachal Pradesh and Tibet. It remains snow bound for most of the winter season and is not available for transport.

III. Uttarakhand

18. Lipu Lekh. Situated near the trijunction of Uttarakhand (India), Tibet (China) and Nepal borders, in Pithoragarh district, it provides a link between Uttarakhand and Tibet. This pass is used by pilgrims to Kailash-Mansarowar. Use of this pass becomes difficult due to landslides in the rainy season and avalanches in the winter season.

19. Mana Pass. Situated a little north of the holy place of Badrinath at an elevation of 5610 m near the Indo-China border in the Greater Himalayas, this pass connects Uttarakhand with Tibet. It remains closed for six winter months in the year due to heavy snowfall.

20. Mangsha Dhura. Situated at an altitude of over five thousand metres at the Indo-China border in the Greater Himalayas in Pithoragarh district, this pass connects Uttarakhand with Tibet. It is used by pilgrims going to Kailash-Mansarowar. Landslides during the rainy season and avalanches during the winter season pose great threat to pilgrims using of this route.

21. Niti Pass. Located at an altitude of 5068 m at the Indo-China border across the Greater Himalayas, this pass joins Uttarakhand with Tibet. It remains snow covered and hence closed to traffic from November to mid-May.

22. Muling La. It is situated in the north of Gangotri at an elevation of 5669 m in the Great Himalayas. It provides passage between Uttarakhand and Tibet but remains closed during winter season due to heavy snowfall.

B. Passes of the Eastern Himalayas

This part of the Himalayas includes states of Sikkim and Arunachal Pradesh.

IV. Sikkim

23. Nathu La. Situated at an altitude of 4310 m on the Indo-China border, it forms part of an offshoot of the ancient Silk Route. It connects Sikkim with Tibet and is an important trade route between India and China. It was closed after the Chinese aggression on India in 1962 but was reopened in 2006 as the governments of the two countries decided to enhance their trade through land routes.

24. Jelep La. It lies at the Sikkim-Bhutan border at an altitude of 4538 m and passes through Chumbi Valley. This pass provides an important link between Sikkim and Lhasa.

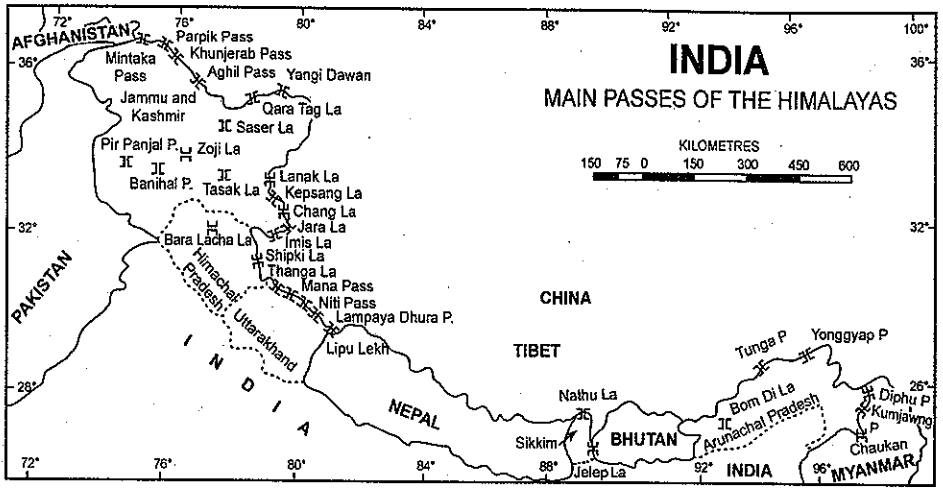


FIG. 3.11. India : Main pass of the Himalayas

V. Arunachal Pradesh

25. Bom Di La. Situated at an altitude of 4331 m near the western boundary of Bhutan in the Greater Himalayas, this pass connects Arunachal Pradesh with Lhasa. It is snowbound in winter and remains closed for traffic.

26. Dihang Pass. Situated at an elevation of more than 4000 m it provides passage between Arunachal Pradesh and Myanmar.

27. Yonggyap Pass. It lies at an altitude of 3962 m on the Indo-China border and joins Arunachal Pradesh with Tibet.

28. Dipher Pass. Lying at the trijunction of India, China and Myanmar border at an altitude of 4353 m, it provides an easy access between Arunachal Pradesh and Mandalay in Myanmar. It is an important land trade route between India and Myanmar and remains open throughout the year.

29. Kumjawng Pass. It lies on the Indo-Myanmar border at an altitude of 2929 m and joins Arunachal Pradesh with Myanmar.

30. Hpungan Pass. Lying at an altitude of 3072 m on the Indo-Myanmar border, it provides an important link between India and Myanmar.

31. Chankan Pass. This pass also lies on the Indo-Myanmar border at an elevation of 2432 m and joins Arunachal Pradesh with Myanmar.

The Significance of the Himalayas

The Himalayas comprise the most dominating geographical feature of India. No other mountain range anywhere in world has affected the life of people and shaped the destiny of a nation as the Himalayas have in respect of India. *The Himalayas are the body and soul of India.* In a very special measure, the Himalayas constitute India's national mountain system. The following few points will bring out the significance of the Himalayan mountains to India.

1. Climatic Influence. The Himalayas play a very significant role in influencing the climate of India. By virtue of their high altitude, length and direction, they effectively intercept the summer monsoons coming from the Bay of Bengal and Arabian Sea and cause precipitation in the form of rain or snow. Besides, they prevent the cold continental air masses of central Asia from entering into India. Had there been no Himalayas, the whole of India would have been a desert in the absence of precipitation and its winters would have been very severe under the influence of cold airmasses coming from Central Asia. According to the latest meteorological studies, the Himalayas are responsible for splitting the jet stream into two branches and these in turn play an extremely important role in bring monsoons in India.

2. Defence. The Himalayas have been protecting India from outside invaders since the early times thus serving as a defence barrier. But the Chinese aggression on India in October, 1962 has reduced the defence significance of the Himalayas to a considerable extent. In spite of advancement in modern warfare technology, the defence significance of the Himalayas cannot be ignored altogether.

3. Source of Rivers. Almost all the great rivers of India have their sources in the Himalayan ranges. Abundant rainfall and vast snow-fields as well as large glaciers are the feeding grounds of the mighty rivers of India. Snow melt in summer provides water to these rivers even during dry season and these are perennial rivers. The Himalayan rivers, along with hundreds of their tributaries, form the very basis of life in the whole of north India.

4. Fertile Soil. The great rivers and their tributaries carry enormous quantities of alluvium while descending from the Himalayas. This is deposited in the Great Plain of North India in the form of fertile soil, making the plain one of the most fertile lands of the world. It has been estimated that the Ganga and the Indus carry 19 and 10 lakh tonnes of silt, per day respectively and the silt carried by the Brahmaputra is even more. It is, therefore, often said that *the great plain of north India is a Gift of the Himalayas.*

5. Hydroelectricity. The Himalayan region offers several sites which can be used for producing hydroelectricity. There are natural waterfalls at certain places while dams can be constructed across rivers at some other places. The vast power potential of the Himalayan rivers still awaits proper utilisation.

6. Forest Wealth. The Himalayan ranges are very rich in forest resources. In their altitude, the Himalayan ranges show a succession of vegetal cover from the tropical to the Alpine. The Himalayan forests provide fuel wood and a large variety of raw materials for forest based industries. Besides many medicinal plants grow in the Himalayan region. Several patches are covered with grass offering rich pastures for grazing animals.

7. Agriculture. The Himalayas do not offer extensive flat lands for agriculture but some of the slopes are terraced for cultivation. Rice is the main crop on the terraced slopes. The other crops are wheat, maize, potatoes, tobacco and ginger. Tea is a unique crop which can be grown on the hill slopes only. A wide variety of fruits such as apples, pears, grapes, mulberry, walnut, cherries, peaches, apricot, etc. are also grown in the Himalayan region.

8. Tourism. By virtue of their scenic beauty and healthy environment, the Himalayan ranges have developed a large number of tourist spots. The hilly areas in the Himalayas offer cool and comfortable climate when the neighbouring plains are reeling under the scorching heat of the summer season. Millions of tourists from different parts of the country as well as from abroad throng the Himalayan tourist centres to enjoy their natural beauty and to escape from the summer heat of the plains. The increasing popularity of winter sports and the craze to enjoy snowfall has increased the rush of tourists in winters also. Srinagar, Dalhousie, Dharamshala, Chamba, Shimla, Kulu, Manali, Mussoorie, Nainital, Ranikhet, Almora, Darjeeling, Mirik, Gangtok, etc. are important tourist centres in the Himalayas.

9. Pilgrimage. Apart from places of tourists interest, the Himalayas are proud of being studded with sanctified shrines which are considered to be the abodes of the Gods. Large number of pilgrims trek through difficult terrain to pay their reverence to these sacred shrines. Kailas, Amarnath, Badrinath, Kedarnath, Vaishnu Devi, Jwalaji, Uttarkashi, Gangotri, Yamunotri, etc. are important places of pilgrimage.

10. Minerals. The Himalayan region contains many valuable minerals. There are vast potentialities of mineral oil in the tertiary rocks. Coal is found in Kashmir. Copper, lead, zinc, nickel, cobalt, antimony, tungsten, gold, silver, limestone, semi-precious and precious stones, gypsum and magnesite are known to occur at more than 100 localities in the Himalayas. Unfortunately, many of the mineral resources cannot be exploited at the present level of technological advancement due to adverse geographical conditions. Further advancements in modern technology may help in exploiting these resources. So the future possibilities of mineral exploitation in the Himalayas are great.

2. THE GREAT PLAIN OF NORTH INDIA

To the south of the Himalayas and to the north of the Peninsula lies the Great Plain of North India. It is an aggradational plain formed by the depositional work of three major river systems *viz*., the Indus, the Ganga and the Brahmaputra. This arcuate plain is also known as Indo-Gangetic-Brahmaputra Plain. This is the largest alluvial tract of the world extending for a length of 3,200 km from the mouth of the Indus to the mouth of the Ganga, of which the Indian sector alone accounts for 2,400 km in length. Its average width varies from 150 to 300 km. It is widest in the west where it stretches for about 500 km. Its width decreases in the east. It is about 280 km wide near Allahabad and 160 km near Rajmahal Hills. It widens to about 460 km in West Bengal but narrows down in Assam where it is only 60-100 km wide. It covers a total area of 7.8 lakh sq km. The northern boundary of this plain is well defined by the foothills of the Shiwaliks but its southern boundary is a wavy irregular line along the northern edge of the Peninsular India.

Rivers flowing through this plain, especially those originating in the Himalayas have deposited a thick layer of alluvium throughout the length and breadth of this plain. Thus it is a classical example of an aggradational plain. However, the thickness of the alluvium deposit varies from place to place and different estimates have been made about it. According to **Oldham**, the maximum depth of the alluvium is about 5,000 m near its southern edge. It has probably maximum depth between Delhi and Rajmahal Hills and is shallow in Rajasthan and Assam. According to recent computations of seismic soundings, the maximum depth of the alluvium upto the basement rocks is about 6,100 m. The depth of alluvial deposits at some important locations are Meerut (1066.8 m), Kalyan (2286.0 m), and Siliguri (5577.8 m). The variation in thickness of the alluvium largely depends upon the morphological processes. The cones of Kosi in the north and those of Son in the south exhibit greater alluvial thickness while the intra-cone areas have relatively shallower deposits.

Extreme horizontality of this monotonous plain is its chief characteristic. Whereas its average elevation is about 200 m above mean sea level, its highest elevation is 291 m above mean sea level between Ambala and Saharanpur. The comparatively higher area near Ambala forms the watershed which divides the drainage system of the Ganga from that of the Indus. It is, in fact, a low land and is hardly perceptible as one enters Panjab-Haryana plain from the Uttar Pradesh plains. Its average gradient for about 1500 km from Saharanpur to Kolkata is 20 cm per km and it decreases to 15 cm per km from Varanasi to the Ganga delta.

Origin of the Plain

It is almost universally accepted that this vast plain has been formed as a result of filling of a deep depression lying between the Peninsular and the Himalayan regions by the depositional work of the rivers coming from these two landmasses. However, divergent views have been expressed regarding the origin of this great depression and the process of filling it. **Wadia** postulates that these plains were originally a deep depression or furrow lying between the Peninsula and the mountain region. The great Austrian geologist **Edward Suess** has suggested that a *"foredeep"* was formed in front of high crust-waves of the Himalayas as they were checked in their southward advance by inflexible solid landmass of the Peninsula. This foredeep was like a large syncline in which alluvium brought by the Himalayan and the Peninsular rivers was deposited. In due course of time, this was filled with alluvium and the Great Plain of North India was formed. It rests on the hard and crystalline rocks through which the region is connected to the Himalayan and the Peninsular blocks **(Fig. 3.12)**. **Sir Sydney Burrard**, on the other hand, thinks that the Indo-Gangetic alluvium conceals a great deep rift, or fracture, in the earth's sub-crust, several thousand metres deep, the hollow being subsequently filled up by detrital. He ascribes to such sub-crustal cracks or rifts a fundamental importance in geotectonics and detritus the elevation of the Himalayan chain to an incidental bending or curbing movement of the northern wall to the fissure. Such sunken tracts between parallel, vertical dislocations are called ***'Rift Valleys'***. The rift valley between the Himalayan ranges and the Peninsula which gave birth to this plain was about 2,400 km long and hundreds of metres deep. His findings were based on some anomalies in the observations of the deflections of the plumb line and other geodetic considerations. He described some other rift valleys of the Himalayan region as well as the rift valleys of Narmada and Tapi in the Peninsular India. Scholars like **Hayden** and **R.D. Oldham** as well as other geologists of the

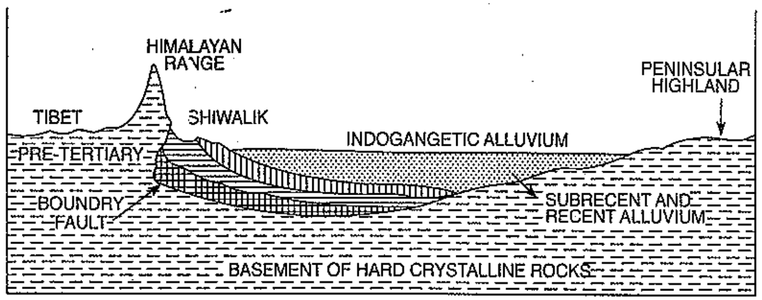


FIG. 3.12. Deposition of alluvium in the Indo-Gangetic trough and formation of the Indo-Gangetic Plain

Geological Survey of India have not accepted Burrard's view of the Indo-Gangetic depression. The main objection to Burrard's views is that there is no trace of a rift valley at the northern edge of the Peninsula and that such a vast rift valley is not possible.

According to the recent views expressed by many geologists and geographers, sediment deposited at the bed of the Tethys Sea was folded and warped due to northward drift of the Peninsula. Consequently the Himalayas and a trough to the south were formed. The origin of this depression or trough, lying at the foot of the mountain, is doubtless intimately connected with the latter. The Great plain represents the infilling of the foredeep warped down between the advancing Peninsular Block and the Himalayas. The infilling has been done by the deposition of the detritus of the mountain brought by the numerous rivers emerging from them during the period of great gradational activity. Geologically most parts of this plain are of the Pleistocene and Recent formations. Thus, the surface deposits of this tract belong to the last chapter of the earth's history and conceal beneath them the older peninsular and other formations.

Geomorphology of the Plain

There is a tendency amongst geographers to treat the Great Plain of North India as a monotonous, flat and featureless plain; but it has its own geomorphological varieties which have their own significance. The following geomorphological features may be noticed depending upon the nature of relief and soil structure.

The Bhabar is a narrow belt about 8-16 km wide running in east-west direction along the foot of the Shiwaliks with a remarkable continuity from the Indus to the Tista. Rivers descending from the Himalayas deposit their load along the foothills in the form of alluvial fans. These fans, consisting of gravel and unassorted sediments, have merged together to build up the bhabar belt which forms the northern boundary of the Great Plain. The porosity of the pebble studded rock beds is so high that most of the streams sink and flow underground. Therefore, the area is marked by dry river courses except in the rainy season. The Bhabar belt is comparatively narrow in the east and extensive in the western and north-western hilly region. The area is not suitable for agriculture and only big trees with large roots thrive in this belt.

The Tarai (Hindi : '*Tar'-wet*) is a 15-30 km wide marshy tract in the south of Bhabar running parallel to it. It is marked by the re-emergence of the underground streams of the Bhabar belt. The re-emerged water converts large areas along the rivers into ill-drained marshy lands of excessive dampness covered with thick forests giving shelter to a variety of wild life. The Tarai is more marked in the eastern part than in the west because the eastern parts of the plain receive higher amount of rainfall than their western counterparts. Most of the Tarai land, especially in Punjab, Uttar Pradesh and Uttarakhand, has been reclaimed and turned into agricultural land which gives good crops of sugarcane, rice and wheat.

The Bhangar (or Bangar) is composed of old alluvium of the Middle Pleistocene age and forms the alluvial terrace above the level of flood plains. It is often impregnated with colcareous concretions known as *kankar*. Remnants of the *bhangar* are eroded by every change in the direction of river channels, and are being levelled down by their meandering tendencies. It mostly occupies the Pleistocene terrace dating back to Middle and Upper Pleistocene periods. It also contains fossils of animals like rhinoceros, hippopotamus, elephants, etc.

The Khadar is composed of newer alluvium and forms the flood plains along the river banks. A new layer of alluvium is deposited by river flood almost every year. These deposits are normally confined to the vicinity of the present river channels. The clays have less kankar, and the organic remains entombed in them belong to still living species. The *khadar* imperceptibly merges into the deltaic and other accumulations of prehistoric times.

Reh or *Kallar* comprises barren saline efflorescences of drier areas in Uttar Pradesh and Haryana. Reh areas have spread in recent times with increase in irrigation.

Bhur denotes an elevated piece of land situated along the banks of the Ganga river especially in the upper Ganga-Yamuna Doab. This has been formed due to accumulation of wind-blown sands during the hot dry months of the year.

Regional Divisions of the Great Plain of India

Although the Great Plain of North India is treated as a geographical unit with low elevation and gentle slope, this vast area exhibits distinctive fluvial patterns, directions of flow and geomorphology in different parts allowing it to be divided into the following four major regions : **(Fig. 3.13)**

1. The Rajasthan Plain.
2. The Punjab-Haryana Plain.
3. The Ganga Plain.
4. The Brahmaputra Plain.

1. The Rajasthan Plain

The western extremity of the Great Plain of India consists of the *Thar* or the *Great Indian Desert* which covers western Rajasthan and the adjoining parts of Pakistan. The desert is about 650 km long and 250-300 km wide. Its total area is about 2.0 lakh sq km out of which 1.75 lakh sq km lies in India. About two-thirds of the Indian desert lies in Rajasthan, west of the Aravali Range, and the remaining one-third is in the neighbouring states of Haryana, Punjab and Gujarat. Recently, some geomorphic studies by using remote sensing techniques in conjunction with ground truth were undertaken by the Central Arid Zone Research Institute, Jodhpur. This vast desert is an undulating plain whose average elevation is about 325 m above mean sea level. It descends to about 150 m above mean sea level near the Indo-Pak border as well as towards the Indus Valley and the Rann of Kachchh. The desert proper is called ***Marusthali*** and accounts for greater part of the *Marwar* plain. The average elevation of the Marusthali is 200-250 m above sea mean level. It has a vast stretch of sand with a few outcrops of bedrock of gneisses, schists and granites which proves that geologically it is a part of the Peninsular Plateau and it is only at the surface that it looks like an aggradational plain. In general, the eastern part of the Marusthali is rocky while its western part is covered by shifting sand dunes locally known as ***dhrian***.

The eastern part of the Thar Desert, upto the Aravali Range is a semi-arid plain which is known as the ***Rajasthan Bagar***. It runs in a north-east to south-west direction from the edge of the Aravalli in the east to the 25 cm *isohyet* (line joining places of equal rainfall) in the west. It is drained by a number of short seasonal streams originating from the Aravali and supports agriculture in some patches of fertile tracts called ***rohi***. Even the important river, the Luni, is a seasonal stream which flows towards the south-west to the Rann of Kachchh. The tract north of the Luni is known as ***thali*** or sandy plain.

The LANDSAT imageries have been used to study the geomorphological characteristics of this Great Desert including its sand dunes. Based on the morphological, spatial and spectral characteristics, six types of sand dunes, *viz*. obstacle, parabolic, longitudinal, transverse, barchan and shrub-coppice have been identified in this desert. The mean height of the dunes varies from 8 m in Jaipur and Sikar districts to 30 m in Barmer district. The length of the dunes also varies greatly and some may be 5-10 km long.

North of the Luni basin, there is a large area of inland drainage on the eastern edge of the Thar Desert having several saline lakes. They are a great source of common salt and many other salts. The *Sambhar*, the *Didwana*, the *Degana*, the *Kuchaman*, the *Sargol* and

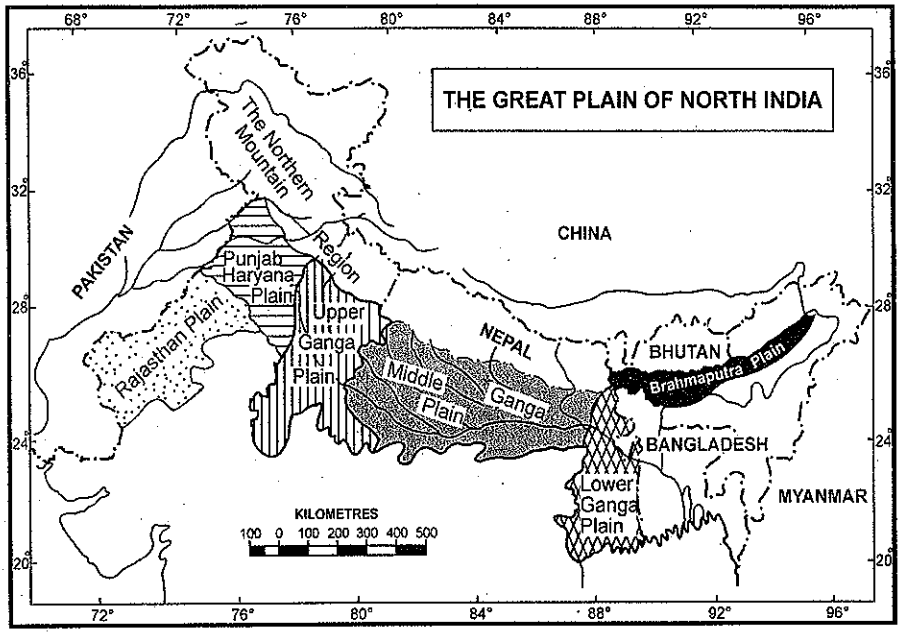


FIG. 3.13. Regional Divisions of the great Plain of North India

the *Khatu* are some of the important lakes. The largest and the most outstanding is the Sambhar lake about 65 km west of Jaipur. Situated at an altitude of about 360 m in the Aravali terrain, this lake is about 30 km long with an average width of 3-8 km. It occupies an area of about 225 sq km during the rainy season but shrinks considerably in dry season.

2. The Punjab-Haryana Plain

The Great Indian Desert imperceptibly gives way to the fertile plains of the Punjab and Haryana towards the east and north east. The entire plain extends for a length of 640 km in north-west to south-east direction and is about 300 km wide in east-west direction. The total area of this plain is about 1.75 lakh sq km. Its eastern boundary in Haryana is formed by the Yamuna river. The average elevation of the plain is about 250 m above mean sea level. Its northern part is nearly 300 m above mean sea level and it drops to about 200 m in the south-east. Part of the plain shows a flat to slightly convex planation controlled by subsurface Delhi-Aravali ridge.

The part of the plain, formed as a result of alluvial deposts by five rivers, *viz*., the Satluj, the Beas, the Ravi, the Chenab and the Jhelum, is known as the Punjab Plain—***the land of five rivers***. It is primarily made up of '***doabs***'—*the land between two rivers*. From east to west these doabs are as under :

(*a*) Bist-Jalandhar Doab, lying between the Beas and the Sutluj;

(*b*) Bari Doab, between the Beas and the Ravi;

(*c*) Rachna Doab, between the Ravi and the Chenab;

(*d*) Chaj Doab, between the Chenab and the Jhelum; and

(*e*) Sind Sagar Doab, between the Jhelum-Chenab and the Indus.

The depositional process by the rivers, continuing since long, has united these doabs and has given a homogenous geomorphological entity to the entire area. However, the mass of alluvium has been broken by the river courses which have carved for themselves broad flood plains of khadar flanked by bluffs, locally known as ***dhayas***. These bluffs, as high as 3 metres or more, have been heavily gullied. The *khadar* belt, known as ***bet lands***, though liable to flooding, is agriculturally valuable.

The northern part of this plain adjoining the Shiwalik hills has been intensively eroded by numerous streams called ***Chos***. This has led to enormous gullying. The erosion by the Chos is particularly noticed in Hoshiarpur district of Punjab. In a short stretch of about 130 km nearly a hundred Chos debouch on the plains. To the south of the Satluj river there is *Malwa* plain of Punjab.

The area between the Ghaggar and the Yamuna rivers lies in Haryana and is often termed as ***'Haryana Tract'***. It acts as water-divide between the Yamuna and the Satluj rivers. The only river between the Yamuna and the Satluj is the Ghaggar which is considered to be the present day successor of the legendary **Saraswati River**.

3. The Ganga Plain

This is the largest unit of the Great Plain of India stretching from Delhi to Kolkata in the states of Uttar Pradesh, Bihar and West Bengal covering an area of about 3.75 lakh sq km. The Ganga is the master river after whose name this plain is named. The Ganga along with its large number of tributaries originating in the Himalayan ranges *viz*., the Yamuna, the Gomati, the Ghaghara, the Gandak, the Kosi, etc. have brought large quantities of alluvium from the mountains and deposited it here to build this extensive plain. The peninsular rivers such as Chambal, Betwa, Ken, Son, etc. joining the Ganga river system have also contributed to the formation of this plain. The general slope of the entire plain is to the east and south east. Depending upon its geographical variations, this plain can be further subdivided into the following three divisions :

(*a*) The Upper Ganga Plain.

(*b*) The Middle Ganga Plain.

(*c*) The Lower Ganga Plain.

(*a*) **The Upper Ganga Plain.** Comprising the upper part of the Ganga Plain, this plain is delimited by the 300 m contour in Shiwaliks in the north, the Peninsular boundary in the south and the course of the Yamuna river in the west. Its eastern boundary is rather obscure and has become a controversial topic among geographers. The limit drawn by **L.D. Stamp** and later adopted by **O.H.K. Spate**, roughly corresponding with 100 cm *isohyet* seems to be far from being practical. Physiographically, the 100 m contour (line joining places of equal height) has been accepted by the geographers as the most effective line of demarcation. This plain is about 550 km long in the east-west direction and nearly 380 km wide in north-south direction, covering an approximate area of 1.49 lakh sq km. Its elevation varies from 100 to 300 m above mean sea level. The plain is drained by the Ganga and its tributaries like the Yamuna, the Ram Ganga, the Sarda, the Gomati and the Ghaghara rivers. Almost all the rivers follow NW-SE course concomitant with the lie of the land. The average gradient of the land is about 25 cm per km. The gradient is comparatively steep in the northern part. The rivers flow sluggishly in the plain as the gradient decreases. The monotony of this flat and featureless plain is broken by the *tarai-bhabar* submontane belt and on micro level by the river bluffs, river meanders and oxbow lakes, levees, abandoned river courses, sandy stretches (Bhurs) and the river channels themselves. The western part of this plain consists of comparatively higher Ganga-Yamuna Doab. East of this doab are the low lying Rohilkhand plains which merge into the Avadh plains further east. The Ghaghara is the main stream of the Avadh Plains. The khadar of this river is very wide because the river meanders through this area. Moreover it often changes its course. At places this khadar is 55 km wide. Consequently, there is a constant fear of devastating floods.

(*b*) **The Middle Ganga Plain.** To the east of the Upper Ganga plain is Middle Ganga plain occupying eastern part of Uttar Pradesh and Bihar. It measures about 600 km in east-west and nearly 330 km in north-south direction accounting for a total area of about 1.44 lakh sq km. Its northern and southern boundaries are well defined by the Himalayan foothills and the Peninsular edge respectively. Its western and eastern boundaries are rather ill defined and the region is wide open on both the sides giving it the personality of the ***east-west continuum*** of the vast isotropic Ganga Plain. There is no physical boundary worth the name and the plain imperceptibly opens up in the west from out of the upper Ganga Plain and so invisibly dies out into the lower Ganga Plain in the east. As such, it is a *transitional region par excellence*, interposed in the enormity of the Ganga Valley. However, several efforts have been made to demarcate the western and the eastern boundaries of

this transitional zone. The most accepted boundaries are those made by 100 m contour in the west, 75 m contour in the north-east and by 30 m contour in the south-east. Obviously this is a very low plain, no part of which exceeds 150 m in elevation.

This plain is drained by the Ghaghara, the Gandak and the Kosi rivers, all tributaries of the Ganga coming from the Himalayas. These rivers are responsible for filling up with alluvial deposits of 2,000 metre deep trough at the foot of the Nepal Himalayas. They flow sluggishly in this flat land as a result of which the area is marked by local prominences such as levees, bluffs, oxbow lakes, marshes, *tals*, ravines, etc. The *kankar* formation is comparatively less due to the preponderance of the *khadar*. Almost all the rivers keep on shifting their courses making this area prone to frequent floods. The Kosi river is very notorious in this respect. It used to flow near Purnea in 1736 and now its course is about 110 km west of it. At occasions its water level has risen by 10 metres in a short span of 24 hours. It has long been called the ***'Sorrow of Bihar'***. Strenuous efforts both by India and Nepal are being made to tame this river. The major units of this plain are Ganga-Ghaghara doab, Ghaghara-Gandak doab and Gandak-Kosi doab (Mithila Plain).

Some rivers join the Ganga from the south also, the Son being the most important. Here the gradient is a bit steeper, 45 cm per km, as compared to 9-10 cm per km in east Uttar Pradesh and only 6 cm per km in the Mithila Plain. East of Son river is the Magadh Plain.

(*c*) **The Lower Ganga Plain.** This plain includes the Kishanganj tehsil of Purnea district in Bihar, the whole of West Bengal (excluding the Purulia district and the mountainous parts of Darjeeling district) and most parts of Bangladesh. It measures about 580 km from the foot of the Darjeeling Himalaya in the north to Bay of Bengal in the south and nearly 200 km from the Chotanagpur Highlands in the West to the Bangladesh border in the east. The total area of this plain is about 81 thousand sq km. Its width varies greatly and it narrows down to a mere 16 km between the Rajmahal Hills and the Bangladesh border. The 50 m contour roughly corresponds with its western boundary. The northern part of this plain has been formed by the sediment deposited by the Tista, Jaldhaka and Torsa. Besides, this area is marked by the Duars (Darjeeling *Tarai*) and the Barind plain, a tract of old alluvium between the Kosi-Mahananda corridor in the west and the river Sankosh in the east. The delta formation accounts for about two-thirds of this plain. This is the largest delta in the world. The Ganga river divides itself into several channels in the delta area. The slope of the land here is a mere 2 cm per km. Two thirds of the area is below 30 m above mean sea level. The entire land upto Kolkata would be completely submerged if the sea level rose by only 7 metres. The seaward face of the delta is studded with a large number of estuaries, mud flats, mangrove swamps, sandbanks, islands and forelands. Large part of the coastal delta is covered by thick impenetrable tidal forests. These are called the ***Sunderbans*** because of the predominance of *Sundri* tree here.

4. The Brahmaputra Plain

This is also known as the Brahmaputra valley or Assam Valley or Assam Plain as most of the Brahmaputra valley is situated in Assam. Though often treated as the eastern continuation of the Great Plain of India, it is a well-demarcated physical unit girdled by the Eastern Himalaya of Arunachal Pradesh in the north, Patkai and Naga Hills in the east and the Garo-Khasi-Jaintia and Mikir Hills in the south. Its western boundary is formed by the Indo-Bangladesh border as well as the boundary of the lower Ganga Plain. Extending from the easternmost end of Assam near the syntaxial bend of the Eastern Himalayas to the west of Dhubri near the Bangladesh border this plain is about 720 km long and its average width is 60-100 km. The entire plain covers an area of about 56 thousand sq km. It is an aggradational plain built up by the depositional work of the Brahmaputra and its tributaries. The Brahmaputra river enters this plain near Sadiya and flows farther to Bangladesh after turning southwards near Dhubri. The general level of the plain varies from 130 m in the east to 30 m in the west. The average gradient of the land is 12 cm per km in the N.E. to S.W. direction. The area is well demarcated by 150 m contour beyond which the surrounding hill terrain dominates the scene. The northern margin has steep slope from the foothills of Arunachal Pradesh but the southern margin is marked by gradual fall from the hill ranges. The innumerable tributaries of the Brahmaputra river coming from the north debouch abruptly upon the main valley and form a number of alluvial fans. Consequently, the tributaries branch out in many channels giving birth to river mendering leading to formation of *bill* and ox-bow lakes. There are large marshy tracts in this area. The alluvial fans formed by the coarse alluvial debris have led to the formation of tarai or semi-tarai conditions. Some southern tributaries also have meandering courses and there are a good number of *bills* and ox-bow lakes.

Significance of the Plain

With its fertile alluvial soils, flat surface, slow moving perennial rivers and favourable climate, the Great Plain of North India is of great significance. It is the home of about half of the Indian population although it accounts for less than one fourth of the total area of the country. The plain supports some of the highest population densities depending purely upon agro-based economy in some of these areas. The extensive use of irrigation has made some parts of this plain, especially Punjab, Haryana and western part of Uttar Pradesh the *granary of India*. The entire plain except the Thar Desert, has a close network of roads and railways which has led to large scale industrialisation and urbanization. The development of trade and commerce in this plain is a natural sequel of industrialization and urbanization. There are many religious places along the banks of the sacred rivers like the Ganga and the Yamuna which are very dear to Hindus. Here flourished the religions of Budha and Mahavira and the movements of Bhakti and Sufism. In short, this vast plain is the hearthrob of India and constitutes its very soul.

3. THE PENINSULAR PLATEAU

The Peninsular Plateau of India is roughly triangular in shape with base coinciding with the southern edge of the great plain of North India and its apex is formed by Kanniyakumari in the southern extremity. The northern boundary of the Peninsular block is an irregular line running from Kachchh along the western flank of the Aravali range to near Delhi, and thence roughly parallel to the Yamuna and the Ganga as far as the Rajmahal Hills and the Ganga Delta. It is surrounded by the hill ranges on all the three sides. To its north are the Aravali Range, the Vindhya, the Satpura, the Bharmer and the Rajmahal Hills. To the south of about 22° N latitude, the Western Ghats (The Sahyadris) and the Eastern Ghats form its western and eastern boundaries respectively (**Fig. 3.14**). The entire plateau measures about 1,600 km in north-south and 1,400 km in east-west direction. It covers a total area of about 16 lakh sq km which is about half of the total land area of the country. It is thus the largest physiogrpahic unit of India. The average height of the plateau is 600-900 m above sea level although many parts are well over 1000 m. The general slope of the palteau is from west to east with the exception of Narmada-Tapi rift which slopes westwards.

The Peninsular Plateau is an ancient tabular block composed mostly of the Archaean gneisses and schists. It has been a stable shield which has gone through little structural changes since its formation. Ever since the dawn of geological history the Peninsula has been a land area and has never been submerged beneath the sea except in a few places where marine transgressions have been made and that too locally and temporarily. Undoubtedly, the entire Peninsular Plateau is an aggregation of several smaller plateaus and hill ranges interspersed with river basins and valleys. A brief description of these plateaus, hill ranges and the intervening river valleys will be of great help in describing the relief of this great plateau.

The Plateaus of the Peninsular India

1. The Marwar Upland. This is also called the Upland of eastern Rajasthan as it lies in the east of the Aravali Range. The average elevation of this area is 250-500 m above sea level and it slopes down eastwards. It is made up of sandstone, shales and limestones of the Vindhayan period. The Banas river originates in the Aravali Range and flows for about 400 km before joining the Chambal river. The area has been carved into a rolling plain by the erosional work of the Banas river and its tributaries.

2. The Central Highland. Also called the *Madhya Bharat Pathar* is in the east of the Marwar Upland. Most of it comprises of the basin of the Chambal river which flows in a rift valley. The *Sindh* and the *Parbati* are its main tributaries. It is an open rolling plateau made of old rocks which is interspersed with rounded hills composed of sandstone. Thick forests grow here. To the north are the *ravines* or *badlands* of the Chambal river.

3. The Bundelkhand Upland. To the south of the Yamuna river between the Madhya Bharat Pathar

and the Vindhyan Scarplands is the old dissected upland of the 'Bundelkhand gneiss' comprising of granite and gneiss. This is called Bundelkhand upland. Covering an area of about 54,560 sq km this upland spreads over five districts of Uttar Pradesh (Jalaun, Jhansi, Lalitpur, Hamirpur and Banda) and four districts of Madhya Pradesh (Datia, Tikamgarh, Chhatarpur, and Panna). With an average elevation of 300-600 m above sea level, this area slopes down from the Vindhyan Scarp toward the Yamuna River. The area is recognised by a mass of rounded hummocky hills made of granite and sandstone. In the north-west and north-east, the system is covered by the Ganga-Yamuna alluvium and in the south-west by the Deccan Trap. The erosional work of the rivers flowing here has converted it into an undulating area and rendered it unfit for cultivation. The region is characterised by senile topography. About 67.7 per cent of the area is under 300 m and only 3.6 per cent is above 450 m in altitude. Streams like Betwa, Dhasan and Ken have carved out steep gorges, precipitous rocky banks and waterfalls.

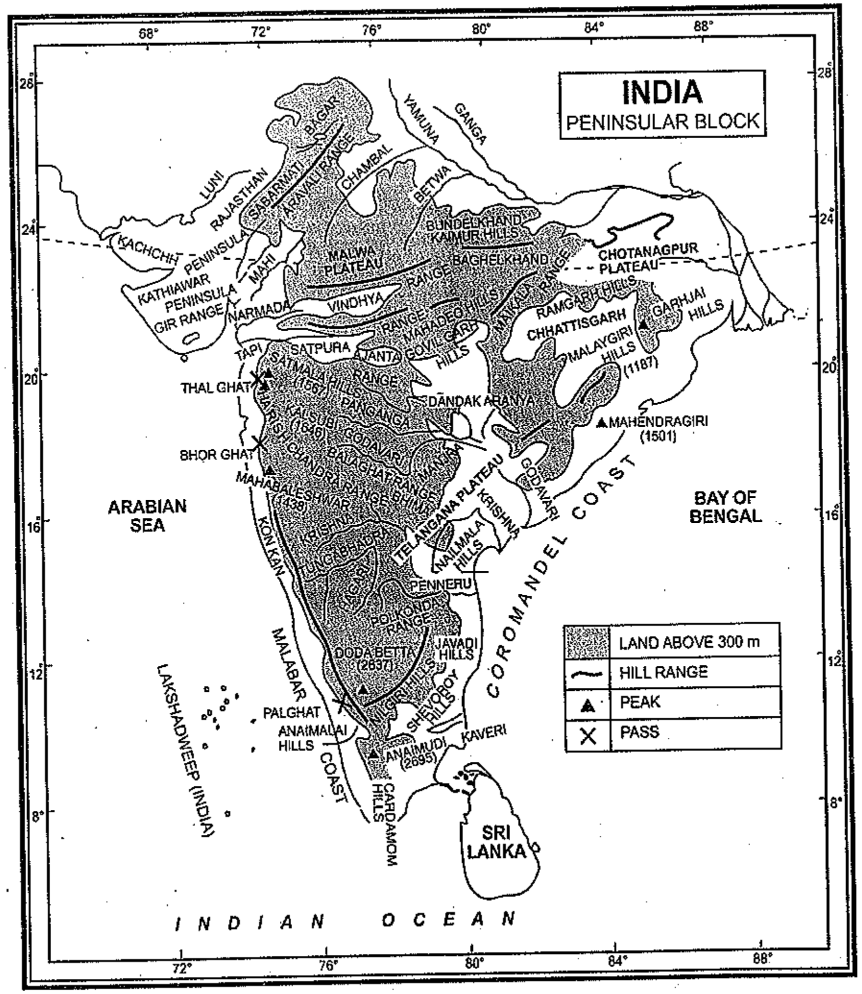


FIG. 3.14. India : Peninsular Block

4. The Malwa Plateau. The Malwa Plateau roughly forms a triangle based on the Vindhyan Hills, bounded by the Aravali Range in the west and sharply defined scarp overlooking Bundelkhand in the east. The plateau inherits a complex geology; scarcely any one of the peninsular groups is unrepresented here. This plateau has two systems of drainage; one towards the Arabian sea (The Narmada, the Tapi and the Mahi), and the other towards the Bay of Bengal (Chambal and Betwa, joining the Yamuna). With a length of 530 km and a width of 390 km, it spreads over an area of 1,50,000 sq km. In the north it is drained by the Chambal and many of its right bank tributaries like the Kali, the Sindh and the Parbati. It also includes the upper courses of the Sindh, the Ken and the Betwa. It is composed of extensive lava flow and is covered with black soils. The general height decreases from 600 m in the south to less than 500 m in the north. There are rolling surfaces and flat-topped hills dissected by rivers flowing through the area. In the north, the plateau is marked by the *Chambal ravines*.

5. The Baghelkhand. East of the Maikal Range is the Baghelkhand made of limestones and sandstones on the west and granite in the east. It covers an area of about 1.4 lakh sq km. It is bounded by the Son river on the north, and to its south occur anticlinal highlands and synclinal valleys of sandstones and limestones. The central part of the plateau acts as a water divide between the Son drainage system in the north and the Mahanadi river system in the south. The region has a general elevation of 150 m to 1,200 m and has uneven relief. The main elements of physiography are scarps of the Vindhyan sandstones between the Ganga plain and the Narmada-Son trough. The Bhanrer and Kaimur are located close to the trough-axis. The general horizontality of the strata shows that this area has not undergone any major disturbance.

6. The Chotanagpur Plateau. East of Baghelkhand, the Chotanagpur plateau represents the north-eastern projection of the Indian Peninsula. It covers an area of over 87 thousand sq km mostly in Jharkhand, northern part of Chhatisgarh and Purulia district of West Bengal. The Son river flows in the north-west of the plateau and joins the Ganga. The average elevation of the plateau is 700 m above sea level. This plateau is composed mainly of Gondwana rocks with patches of Archaean granite and gneisses and Deccan Lavas. The Chotanagpur plateau virtually consists of a series of plateaus standing at different levels of elevation. The highest general elevation of about 1,100 m is in the mid-western portion known as the *Pat* lands (high level laterite plateau). From here, the land descends in all directions in a series of steps which are marked by waterfalls across the rivers. The plateau is drained by numerous rivers and streams in different directions and presents a *radial drainage* pattern. Rivers like the Damodar, the Subarnrekaha, the North Koel, the South Koel and the Barkar have developed extensive drainage basins. The Damodar river flows through the middle of this region in a rift valley from west to east. Here are found the Gondwana coal fields which provide bulk of coal in India.

North of the Damodar river is the **Hazaribagh plateau** with an average elevation of 600 m above mean sea level. This plateau has isolated hills; Parasnath in the east rises to 1,366 m. The area is made of granites and gneisses while the hills have quartz rocks. It looks like a peneplain due to large scale erosion.

The **Ranchi Plateau** to the south of the Damodar Valley rises to about 600 m above mean sea level. The maximum height is found in western part where *pats* of high *mesas* capped with laterite steeply rise to an altitude of about 1100 m. The *Netarhat Pat* and *Goru* rise to 1,119 and 1,142 m above sea level respectively. Most of the surface is rolling where the city of Ranchi (661 m) is located. At places it is interrupted by monadnocks and conical hills.

The **Rajmahal Hills** forming the north eastern edge of the Chotanagpur Plateau are mostly made of basalt and are covered by lava flows. They run in north-south direction and rise to average elevation of 400 m (highest mount is 567 m). These hills have been dissected into separate plateaus.

7. The Meghalaya Plateau. The rocks of the peninsular plateau of India extend further north-east beyond the Rajmahal hills and form a rectangular block known as the Meghalaya or the Shillong plateau. This plateau has been separated from the main block of the peninsular plateau by a wide gap known as the ***Garo-Rajmahal Gap***. This gap was formed by down-faulting and was later on filled by

sediments deposited by the Ganga. Extending over an area of about 35 thousand sq km, this plateau is largely formed by Archaean (Dharwarian) quartzites, shales and schists with granite intrusions and some basic silts. The plateau slopes down to Brahmaputra valley in the north and the Surma and Meghna valleys in the south. Its western boundary more or less coincides with the Bangladesh border. The western, central and the eastern parts of the plateau are known as the ***Garo Hills*** (900 m), the ***Khasi-Jaintia Hills*** (1,500 m) and the ***Mikir Hills*** (700 m). Shillong (1,961 m) is the highest point of the plateau.

8. The Deccan Plateau. This is the largest unit of the Peninsular Plateau of India covering an area of about five lakh sq km. This triangular plateau is bounded by the Satpura and the Vindhya in the north-west, the Mahadev and the Maikal in the north, the Western Ghats in the west and the Eastern Ghats in the east. With an average elevation of 600 m it rises to 1000 m in the south but dips to 500 m in the north. Its general slope is from west to east which is indicated by the flow of its major rivers like the Mahanadi, the Godavari, the Krishna and the Cauvery. These rivers have further subdivided this plateau into a numbmer of smaller plateaus described as under :

(*a*) ***The Maharashtra Plateau*** lies in Maharashtra and forms the northern part of the Deccan Plateau. Much of the region is underlain by basaltic rocks of lava origin. The area looks like a rolling plain due to weathering. The horizontal lava sheets have led to the formation of typical *Deccan Trap* topography. The broad and shallow valleys of the Godavari, the Bhima and the Krishna are flanked by flat-topped steep sided hills and ridges. The Ajanta range lies to the south of the Tapi river. The entire area is covered by black cotton soil known as *regur*.

(*b*) ***The Karnataka Plateau*** also known as the Mysore plateau lies to the south of the Maharashtra plateau. Made up primarily of the Archaean formations, it is a rolling country with an average elevation of 600-900 m. It is highly dissected by numerous rivers rising from the Western Ghats. It contains the heads of the *Tungabhadra* and the *Cauvery rivers*. The general trend of the hills is either parallel to the Western Ghats or athwart it. The highest peak (1913 m) is at Mulangiri in *Baba Budan Hills* in Chikmaglur district. The plateau is divided into two parts called ***Malnad*** and ***Maidan***. The *Malnad* in Kannada means hill country. It is dissected into deep valleys covered with dense forests. The *Maidan* on the other hand is formed of rolling plain with low granite hills. The plateau tapers between the Western Ghats and the Eastern Ghats in the south and merges with the Niligiri hills there.

(*c*) ***The Telangana plateau*** consists of Archaean gneisses at an average elevation of 500-600 m. The southern part is higher than its northern counterpart. The region is drained by three river systems, the Godavari, the Krishna and the Penneru. The entire plateau is divided into two major physiographic regions, namely, the *Ghats* and the *Peneplains*.

9. The Chhattisgarh Plain. The Chhattisgarh plain is the only plain worth the name in the vast stretch of plateaus and hill ranges of the Peninsular plateau. It is a saucer shaped depression drained by the upper Mahanadi. The whole basin lies between the Maikala Range and the Odisha hills. The region was once ruled by *Haithaivanshi Rajputs* from whose thirty six forts (*Chhattisgarh*) it derives its name. The basin is laid with nearly horizontal beds of limestone and shales deposited during the Cuddapah age. The general elevation of the plain ranges from 250 m in the east to 330 m in the west.

Hill Ranges of the Peninsular Plateau

The above mentioned plateaus of the Peninsula are separated from one another by hill ranges and river valleys. The hills of the Peninsular India are much lower than the Himalayan ranges. Most of these hills are of the relict type, being remnants of the originally higher hills but some typical horsts are also seen. Some of the important hill ranges are described as under :

1. The Aravali Range. One of the major physiographic elements of the Peninsular India is the Aravali range running in a north-east to south-west direction for 800 km between Delhi and Palanpur (near Ahmedabad) in Gujarat. The Aravalis represent the relict of the world's oldest mountain formed as a result of folding at the close of the Archaean era. Obviously, their dimensions were much larger and probably even higher than the present Himalayas. Although its north-eastern end is marked by the Delhi ridge, it is supposed to continue upto Haridwar buried under the allivium of the Great Plains.

M.S. Krishnan, has expressed the view that one Branch of the Aravalis extends to the Lakshadweep Archipelago through the Gulf of Khambhat and the other into Andhra Pradesh and Karnataka. According to **D.N. Wadia**, the Aravalis were a prominent feature in the old Palaeozoic and Mesozoic periods and extended as a continuous chain of lofty mountains from Deccan to possibly beyond Garhwal. What we at present see of them are the eroded remnants of these mountains; their mere stumps laid bare by repeated cycles of erosion.

Prof. S.P. Chatterjee has brought out some interesting features of the Aravali Range. According to the conclusion drawn by him, the Aravali, which occupies the site of an ancient geosyncline and was uplifted and folded in synclinorium for the first time during the *Algonkian* age, 600 to 700 million years ago. The present Aravali has lost its range character in many parts and is now a relic of what it was in the past when it formed India's main watershed, extending from Kumaon Himalaya to the farthest end of the Peninsular plateau on the south, and perhaps one of its arms reaching eastwards across Central India. In that remote age several of its summits rose above the snow-line and nourished glaciers of stupendous magnitude, which in their turn fed many rivers. This range was later reduced by long continuous erosion almost to sea level. There is evidence to suggest that in the late Mesozoic times, perhaps about 100 million years ago, the peneplaned Aravali was uplifted for the second time by at least 1200 m near Udaipur, and 200 m at its two ends near Delhi and Ahmedabad.

Although its general elevation is only 400-600 m, parts of this range rise well above 1,000 m. The Aravali range has a lower elevation between Delhi and Ajmer where it is characterised by a chain of detached and discontinuous ridges. However, it becomes a continuous range south of Ajmer where it rises to 900 m. At the south-west extremity the range rises to over 1,000 m. Here Mt. Abu (1,158 m), a small hilly block, is separated from the main range by the valley of the Banas. Guru Sikhar (1,722 m), the highest peak, is situated in Mt. Abu. Barr, Pipli Ghat, Dewair and Desuri passes allow movement by roads and railways.

2. The Vindhyan Range. The Vindhaya Range rises as an escarpment flanking the northern edge of the Narmada-Son Trough overlooking the Narmada valley. It runs more or less parallel to the Narmada Valley in an east-west direction from Jobat in Gujarat to Sasaram in Bihar for a distance of over 1,200 km. The general elevation of the Vindhyan Range is 300 to 650 m and it rarely goes above 700 m. The northern slope of this range is rather gentle and there are no well marked spurs, steep falls and valleys. Most parts of the Vindhayan Range are composed of horizontally bedded sedimentary rocks of ancient age. The western part of this range is covered with lava. The Vindhayas are continued eastwards as the *Bharner* and *Kaimur* hills. The Vindhya-Kaimur scarp exceeds 610 m at a few places only. This range acts as a watershed between the Ganga system and the river systems of south India and forms the northern boundary of the Deccan. The rivers Chambal, Betwa and Ken rise within 30 km of the Narmada.

3. The Satpura Range. '*Sat*' in Sanskrit means seven and '*pura*' means mountains. Therefore, the Satpura range is a series of seven mountains. It runs in an east-west direction south of the Vindhyas and in between the Narmada and the Tapi, roughly parallel to these rivers. Commencing from the Rajpipla Hills in the west, through the Mahadev Hills to the Maikala Range, it stretches for a distance of about 900 km. These hills appear to be affected by tectonic disturbances. There are evidences that parts of the Satpuras have been folded and upheaved. They are regarded as structural uplift or 'horst'.

No other east-west tectonic mountain of Peninsular India is as high as the Satpura. Most of the hills rise to elevation of 900 to 1,000 m. Dhupgarh (1,350 m) near Pachmarhi on Mahadev Hills is the highest peak. The other peaks are the Astamba Dongar (1,325 m) and Amarkantak (1,127 m).

4. The Western Ghats (or The Sahyadris). Forming the western edge of the Deccan tableland, the Western Ghats run in north-south direction, parallel and close to the Arabian Sea coast, from the Tapi valley (21° N latitude) to a little north of Kanniyakumari (11° N latitude) for a distance of 1,600 km. As the name implies, the Western Ghats are, down to Malabar, steep-sided, terraced, flat-topped hills or cliffs presenting the mesa-like stepped topography facing the Arabian Sea coast. This is due to the horizontally bedded lavas, which on weathering, have given a characteristic '*landing stair*

aspect' to the relief of this mountain chain. South of Malabar, the Nilgiris, Anamalai, etc. present quite different landscape due to the difference in geological structure. The Western Ghats abruptly rise as a sheer wall to an average elevation of 1,000 m from the Western Coastal Plain and appear to be an imposing mountain. But they slope gently on their eastern flank and hardly appear to be a mountain when viewed from the Deccan tableland.

The northern section of the ghats from 21° N to 16° N latitudes *i.e.* from Tapi valley to a little north of Goa is made of horizontal sheets of Deccan lavas forming a formidable wall looking over the West Coastal Plain. The average height of this section of the Ghats is 1,200 m above mean sea level, but some peaks attain more heights. Kalasubai (1,646 m) near Igatpuri, Salher (1,567 m) about 90 km north of Nashik, Mahabaleshwar (1,438 m) and Harishchandragarh (1,424 m) are important peaks. Thalghat and Bhorghat are important passes which provide passage by road and rail between the Konkan Plains in the west and the Deccan Plateau in the east. LANDSAT imagery shows a large density of faults along the trend of the Ghats.

The Middle Sahyadri runs from 16°N latitude upto Nilgiri hills. This part is made of granites and gneisses and presents rougher topography. Lying at a stone's throw from the Arabian Sea coast, this area is covered with dense forests. The western scarp is considerably dissected by headward erosion of the west flowing streams. The average height is 1200 m but many peaks exceed 1500 m. The Vavul Mala (2,339 m.), the Kudremukh (1,892 m) and Pashpagiri (1,714 m) are important peaks. The Nilgiri Hills which join the Sahyadris near Gudalur rise abruptly to over 2,000 m and mark the junction of the Western Ghats with Eastern Ghats. Doda Betta (2,637 m) and Makurti (2,554 m) are important peaks of this area.

The southern part of the Western Ghats is separated from the main Sahyadri range by Palghat Gap which presents a sudden break in the continuity of this mountain range. The high ranges terminate abruptly on either side of this gap. This 24-30 km wide gap has an elevation ranging from 75 to 300 m while the bordering hills rise to 1500-2000 m above mean sea level. In all probability, it is a rift valley which has been formed by subsidence of the land between two parallel fault lines. This gap is used by a number of roads and railway lines to connect the plains of Tamil Nadu with the coastal plain of Kerala. It is through this gap that moist-bearing clouds of the south-west monsoon can penetrate some distance inland, bringing rain to parched Mysore region. South of the Palghat Gap there is an intricate system of steep and rugged slopes on both the eastern and western sides of the Ghats. Anai Mudi (2,695 m) is the highest peak in the whole of southern India. This is a nodal point from which three ranges radiate in different directions. These ranges are the Anaimalai (1800-2000 m) to the north, the Palni (900-1,200 m) to the north-east and the Cardamom Hills or the *Ealaimalai* to the south.

5. The Eastern Ghats. Bordering the eastern edge of the Deccan Plateau, the Eastern Ghats run almost parallel to the east coast of India leaving broad plains between their base and the coast. In striking contrast to the continuous eminence of the Western Ghats, it is a chain of highly broken and detached hills starting from the Mahanadi in Odisha to the Vagai in Tamil Nadu. The hills constituting the Eastern Ghats have neither structural unity nor physiographic continuity. In fact, they almost disappear between the Godavari and the Krishna. The name Eastern Ghats is, therefore, something of a misnomer and various mountains and hill groups are generally treated as independent units. In view of the heterogenous character, **Spate** has preferred to use the terms ***Eastern Hills*** for the northern, ***Cuddapah Ranges*** for the central, and ***Tamilnad Hills*** for the southern group in place of the collective term of Eastern Ghats. Still many geographers tend to use the term Eastern Ghats to this discontinuous linear assemblage of hills, each group of hills having its separate identity.

Depending upon the relief and structure, the Eastern Ghats can be divided into northern and southern parts, the dividing boundary lying somewhere south of the Godavari valley. It is only in the northern part, between the Mahanadi and the Godavari, that the Eastern Ghats exhibit true mountain character with a width of 200 km in the north and 100 km in the south. This part comprises the Maliya and the Madugula Konda ranges. The peaks and ridges of the Maliya range have a general elevation of 900-1,200 m and Mahendra Giri (1,501 m) is the tallest peak here. The Madugula

Konda range has higher elevations ranging from 1,100 m and 1,400 m with several peaks exceeding 1,600 m. Arma Konda (1,680 m), Gali Konda (1,643 m) and Sinkram Gutta (1,620 m) are important peaks.

Between the Godavari and the Krishna rivers, the Eastern Ghats lose their hilly character and the saddle between these two rivers is occupied by Gondwana formations. The Eastern Ghats reappear as more or less a continuous hill range in Cuddapah and Kurnool districts of Andhra Pradesh. Here, the arcuate Nallamalai Range with general elevation of 600-850 m is the most prominent. It is composed of quartz and slate. The southern part of this range is called the Palkodna range. To the south, the hills and plateaus attain very low altitudes; only Javadi Hills and the Shevroy-Kalrayan Hills form two distinct features of 1,000 m elevation. The Biligiri Rangan Hills in Coimbatore district attain a height of 1,279 m. These hills have steep slope and bold relief because they are made of charnockites. Further south, the Eastern Ghats merge with the Western Ghats.

Significance of the Peninsular Plateau

The Peninsular Plateau of India is the oldest and the most stable landmass of the Indian sub-continent. It contains a rich variety of minerals which occur in large quantities. There are huge deposits of iron, manganese, copper, bauxite, chromium, mica, gold, etc. Above all, 98 per cent of the Gondwana coal deposits of India are found in the Peninsular Plateau. Besides, there are large reserves of slate, shale, sandstones, marbles, etc. A large part of north-west plateau is covered with fertile black lava soil which is extremely useful for growing cotton. Some other areas of the Peninsular Plateau are suitable for the cultivation of tea, coffee, rubber, millets, spices, tobacco and oilseeds. Some low lying areas of the plateau are suitable for growing rice. A variety of tropical fruits is also grown here. The highlands of the plateau are covered with different types of forests which provide a large variety of forest products. The rivers originating in the Western Ghats offer great opportunity for developing hydroelectricity and providing irrigation facilities to the agricultural crops. The plateau is also known for its hill resorts such as Udagamangalam (Ooty), Panchmarhi, Kodaikanal, Mahabaleshwar, Khandala, Matheron, Mount Abu, etc.

4. THE COASTAL PLAINS

The narrow coastal strip between the edges of the Peninsular Plateau and the coastline of India running for a distance of about six thousand kilometres from the Rann of Kachchh in the west to the Ganga-Brahmaputra delta in the east is called the coastal plains. The area between the Western Ghats and the Arabian Sea coast is known as the ***West Coastal Plain*** and that between the Eastern Ghats and the Coast of the Bay of Bengal is called the ***East Coastal Plain.*** The two coastal plains meet each other at the southernmost tip *i.e.* Kanniyakumari.

The West Coastal Plains

Stretching from Rann of Kachchh in the north to Kanniyakumari in the South, there are narrow west coastal plains with an average width of about 65 km. It is quite narrow in the middle and a bit broader in the northern and southern parts. Depending upon relief and structure, it can be divided into following subdivisions.

The Kachchh Peninsula was an island surrounded by seas and lagoons. These seas and lagoons were later filled by sediment brought by the Indus river which used to flow through this area. Thus, the island became a part of the mainland and comparatively broad plain was formed. Some scholars do not consider it as part of the west coastal plain and treat it as a separate identity. There are other geographers who consider Kachchh and Kathiawar as part of the Peninsular plateau because Kathiawar is made of the Deccan Lava and there are tertiary rocks in the Kachchh area. The true west coastal plain, according to them, lies between Surat and Kanniyakumari for a distance of 1600 km. But the ground reality is that it is, more or less, a plain area and lies near the west coast of India. Hence it should be treated as an integral part of the West Coastal Plain.

Due to scarcity of rain and flowing surface water, the work of wind is felt everywhere and this has given rise to arid and semi-arid landscape. Coastal sand dunes, sandy plains, interrupted with bare rocky hills are the chief characteristic physiographic features.

All along the north of Kachchh there lies a broad level salt-soaked plain. This is the ***Great Rann***. Its southern continuation, known as the ***Little Rann*** lies

on the coast and south-east of Kachchh. The flat and unbroken Great Rann is about 320 km long with a maximum width of 160 km, covering an area of about 21,500 sq km. It rises only a few metres above the sea level and is flooded by the Banas and the Luni rivers during the rainy season. Some places are actually below sea level and are inundated during high tides. Most of the area is formed of sun-baked dark silt encrusted with salt. A few patches of high ground are covered with grass and break the monotony of the otherwise flat plain.

The Kathiawar Peninsula lies to the south of the Kachchh. It is encircled on the east and north-east by the Little Rann and the Nal Basin. The average elevation is less than 200 m. The central part is a highland of Mandav Hills from which small streams radiate in all directions. Mt. Girnar (1,117 m), the highest point, is supposed to be of volcanic origin. The Gir Range is located in the southern part of the Kathiawar peninsula. It is covered with dense forests and is famous as home of the Gir lion.

The Gujarat Plain lies east of Kachchh and Kathiawar and slopes towards the west and south west. It may almost be described as an intrusion of Indo-Gangetic conditions into the Peninsula. Formed by the rivers *Narmada*, *Tapi*, *Mahi* and *Sabarmati*, the plain includes the southern part of Gujarat and the coastal areas of the Gulf of Khambhat. This is a low plain no part of which exceeds 150 m in elevation. The eastern part of this plain is made of sediments and is fertile enough to support agriculture, but the greater part near the coast is covered by wind blown loess which has given rise to semi-arid landscape. A chain of saline marshes near the coast is prone to floods during high tide.

The Konkan Plain south of the Gujarat plain extends from Daman to Goa for a distance of about 500 km with its width varying from 50 to 80 km. It has some features of marine erosion including cliffs, shoals, reefs and islands in the Arabian Sea. Mumbai was an island but parts of the sea lying between the mainland and the island have been reclaimed in recent years to connect it with the mainland. The Thane creek of the Ulhas around Mumbai is an important embayment which provides an excellent natural harbour on the southern side of the island. South of Mumbai, the Konkan coast has a series of small bays and coves lying between jutting head-lands containing beaches of sand. Behind the alluvial coastal belt, there is a series of parallel ridges reaching 450-600 m in which rivers like the Vaitarni, Ulhas and Amba have lower courses more or less parallel to the coast before reaching it transversely. Some lateritic hillocks rise to 100 m above mean sea level.

The Karnataka Coastal Plain from Goa to Mangalore is about 225 km long. It is a narrow plain with an average width of 30-50 km, the maximum being 70 km near Mangalore. The central part of this plain is crossed by numerous spurs projecting from the Ghats. These spurs approach so close to the coast that the breadth of the lowland is reduced to 5-7 km at 14°N latitude where the Ghat's crest is only 13 km away from the sea. Running like ridges, the spurs attain heights of more than 600 m near the Ghats. At some places the streams originating in the Western Ghats descend along steep slopes and make waterfalls. The Sharavati while descending over such a steep slope makes an impressive waterfall known as ***Gersoppa (Jog) Falls*** which is 271 m high. Marine topography is quite marked on the coast.

The Kerala Plain also known as the ***Malabar Plain***, between Mangalore and Kanniyakumari is about 500 km long. This is much wider than the Karnataka plain and at places it is 96 km wide. It is a low lying plain and at no place its height exceeds 30 m. The existence of lakes, lagoons, backwaters, spits, etc. is a significant characteristic of the Kerala coast. The backwaters, locally known as ***kayals*** are the shallow lagoons or inlets of the sea, lying parallel to the coastline. The largest among these is the Vembanad lake which is about 75 km long and 5-10 km wide and gives rise to a 55 km long spit. Kochi is situated on its opening into the sea. This and several other lagoons have been joined together by canals to provide excellent inland waterways from the mouth of the Ponnani in the north to Thiruvananthapuram in the south.

The East Coastal Plains

Between the Eastern Ghats and the east coast of India are located the East Coastal Plains extending from the Subarnarekha river along the West Bengal-Odisha border to Kanniyakumari. A major part of the plains is formed as a result of the alluvial fillings of the littoral zone by the rivers Mahanadi, Godavari, Krishna and Cauvery comprising some of the largest deltas. Its western boundary is a discontinuous line of the Eastern Ghats, more precisely by the contours of 75 m in Odisha, 100 m in Andhra Pradesh and 150 m in Tamil Nadu. In contrast to the West Coastal Plains, these are extensive plains with an average width of 120 km although it may be as wide as 200 km in the deltaic regions and as narrow as 35 km in-between the deltas. This plain is known as the *Northern Circars* between the Mahanadi and the Krishna rivers and *Carnatic* between the Krishna and the Cauvery rivers. Depending upon physiographic variations, the entire plain is divided into three regions.

The Utkal Plain comprising coastal areas of Odisha is about 400 km long. It includes the Mahanadi delta with Cuttack at its head. There is thick layer of alluvium covering this delta. The most prominent physiographic feature of this plain is the **Chilka Lake** in the south of the Mahanadi delta. This lagoon on the Odisha coast is about 70 km long and its maximum width on the north-east is nearly 22 km narrowing to about 7 km on its south-western end. It is the biggest lake in the country and its area varies between 780 sq km in winter to 1,144 sq km in the monsoon months. South of Chilka Lake, low hills dot the plain.

The Andhra Plain lies south of the Utkal Plain and extends upto *Pulicat Lake*, some 40 km north of Chennai. This lake has been barred by a long sand spit known as Sriharikota Island, on which is located the satellite launching station of the Indian Space Research Organisation. The lagoon is about 60 km long and about 16 km wide in its widest part. The most significant feature of this plain is the delta formation by the rivers Godavari and Krishna. In fact, the two deltas have merged with each other and formed a single physiographic unit. The combined delta has advanced by about 35 km towards the sea during the recent years. This is clear from the present location of the Kolleru lake which was once a lagoon at the shore but now lies far inland. This part of the Andhra plain is quite wide. Andhra plain has a straight coast and badly lacks good harbours with the exception of Vishakhapatnam and Machilipatnam.

The Tamil Nadu Plain stretches for 675 km from Pulicat lake to Kanniyakumari along the coast of Tamil Nadu. Its average width is 100 km. The most important feature of this plain is the Cauvery delta where the plain is 130 km wide. The fertile soil and large scale irrigation facilities have made the Cauvery delta the **granary of South India**.

Significance of the Coastal Plains

Large parts of the coastal plains of India are covered by fertile soils on which different crops are grown. Rice is the main crop of these areas. Coconut trees grow all along the coast. The entire length of the coast is dotted with big and small ports which help in carrying out trade. About 98% of our international trade is carried through these ports. The sedimentary rocks of these plains are said to contain large deposits of mineral oil. The sands of Kerala coast have large quantity of monazite which is used for nuclear power. Fishing is an important occupation of the people living in the coastal areas. Low lying areas of Gujarat are famous for producing salt.

5. THE INDIAN ISLANDS

Apart from the large number of islands in the near proximity of the Indian coast, there are two main groups of islands in the Indian Ocean far away from the coast. One of these is the Andaman and Nicobar Archipelago in the Bay of Bengal and the other is a group of tiny islands known as the Lakshadweep Islands in the Arabian Sea. These islands have gained much importance and their study has become almost indispensable in view of the increasing interest of super powers in the geopolitics of the Indian ocean.

The Andaman and Nicobar group of islands form an arcuate chain, convex to the west, extending from 6° 45′ N to 13° 45′ N and from 92° 10′ E to 94° 15′ E for a distance of about 590 km with a maximum width of about 58 km. This archipelago is composed of 265 big and small islands covering a cumulative area of about 8249 sq km. The entire chain consists of two distinct groups of islands. The Great Andaman group of islands in the north is separated by the *Ten Degree Channel* from the Nicobar group in the south. The Andaman is a closely knit group of about 203 islands. It is 260 km long and 30 km wide with a total area of 6596 sq km. This group of islands is divided into three major groups *viz.* North Andaman, Middle Andaman and South Andaman. Little Andaman is separated from the Great Anadmans by 50 km wide Duncan Passage.

The Nicobar group of islands consists of 7 big and 12 small islands together with several tiny islands. They are scattered over a length of 262 km with maximum width of 58 km covering an area of 1,653 sq km. The Great Nicobar, as its name suggests, is the largest island measuring 50 × 25 km. It is the southernmost island and is only 147 km away from Sumatra island of Indonesia.

Most of these islands are made of tertiary sandstone, limestone and shale resting on basic and ultrabasic volcanoes. The Barren and Narcondam islands, north of Port Blair, are volcanic islands. Some of the islands are fringed with coral reefs. Many of them are covered with thick forests and some are highly dissected. Most of the islands are mountainous and reach considerable heights. Saddle peak (737 m) in North Andaman is the highest peak.

The Lakshadweep Islands in the Arabian Sea, though literally mean one lakh islands is only a group of 25 small islands. They are widely scattered over an area of 108.78 sq kms extending from 8° N to 12° 20′ N and 71° 45′ E to 74 °E about 200-500 km south-west of the Kerala coast. The islands north of 11° N are known as *Amendivi Islands* while those south of this latitude are called *Cannanore Islands*. In the extreme south is the Minicoy island. All are tiny islands of coral origin and are surrounded by fringing reefs. The largest and the most advanced is the Minicoy island with an area of 4.53 sq km. Betra has an area of only 0.12 sq km. Most of the islands have low elevation and do not rise more than five metre above sea level. Their topography is flat and relief features such as hills, streams, valleys, etc. are conspicuous by their absence. Shallow lagoons are seen on their western side, while on the eastern seaboard the slopes are steeper.

PHYSIOGRAPHIC REGIONS OF INDIA

The term physiography was conceived as 'a description of nature' or 'of natural features' in their causal relationships. After some time, the term became almost synonymous with physical geography. Gradually, it became limited to the study of landforms,

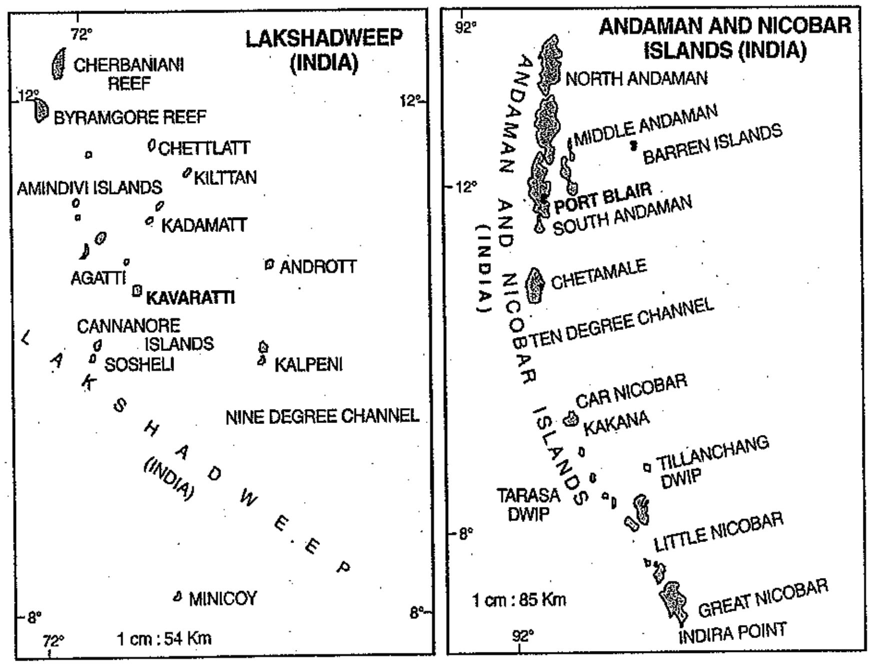


FIG. 3.15. Andaman and Nicobar Islands and Lakshadweep

especially in the U.S.A. By some authorities the term has now been superseded by more scientific term geomorphology. However, other authorities still regard it in wider terms as an integration of geomorphology, plant geography and pedology. We will confine ourselves to the study of land features of India in this context.

L.D. Stamp was the first scholar who made an attempt to classify natural regions or physiographic regions of India in 1922. His scheme was based on the homogeneity of physiography, structure and climate. He divided India into 3 major natural regions and 22 sub-regions. Another attempt was made by **J.N.L. Baker** in 1928. His scheme was based on the work of Wood and was in close agreement with the work of L.D. Stamp. Following the empirical approach adopted by Stamp and Baker, **O.H.K. Spate** presented a detailed scheme of physiographic regions of India in 1954 and slightly revised it at a later stage. In the third edition of his book entitled "India and Pakistan : A General and Regional Geography" published in 1967, he divided India into 3 macro regions which were further divided into 34 regions of first order (excluding islands), 74 regions of second order and 225 subdivisions of these regions. Three macro regions, as suggested by Spate are (*i*) the mountain rim, (*ii*) the Indo-Gangetic plain and (*iii*) the Peninsula.

S.P. Chatterjee presented his detailed study of physiographic divisions of India in The Gazetteer of India Vol. I published by Publication Division of India in 1965. He divided India into seven major physiographic divisions on the basis of topography. They are (1) Northern Mountains which include the Himalayas and mountain ranges in the north-east, (2) Great Plains, (3) Central Highlands, (4) Peninsular Plateaus, (5) East Coast, (6) West Coast and (7) Bordering Seas and Islands. Further divisions and subdivisions of these major regions are briefly described as under :

1. The Northern Mountains. This chain of mountains include the mighty Himalayas and the mountain ranges which extend in the north-east. The Himalaya extent almost uninterruptedly for a distance of 2500 kms and cover an area of about 5,00,000 sq km. This mountain range is divided into the Western Himalaya and the Eastern Himalaya. Between these two is the Himalayan country of Nepal. The **Western Himalaya** are further divided into four regions *viz.* (*a*) the North Kashmir Himalayas, (*b*) the South Kashmir Himalayas, (*c*) the Punjab Himalayas and (*d*) the Kumaon Himalayas. The **Kashmir Himalaya** is the broadest part which is 700 km from west to east and 500 km from north to south. It spreads over an area of about 3,50,000 sq km. The Great Himalayan Range acts as the dividing line between the North Kashmir Himalayas and the South Kashmir Himalayas. Kashmir Valley lying between Pir Punjab in the south and Zaskar Range in the north is the most density populated part of the Western Himalayas. Srinagar, the summer capital of Jammu and Kashmir lies in the heart of this valley. It is situated at an elevation of 1893 m above sea level. The **Punjab Himalaya** includes the portion of the Himalaya lying in Himachal Pradesh and Punjab. It covers an area of about 45,000 sq km and is drained by four important rivers namely the Satluj, the Beas, the Ravi and the Chenab. These rivers have their sources in the upper reaches of the Himalayas. The **Kumaon region** lies in the mountain region of Uttar Pradesh (now forming a separate state of Uttarakhand) and stretches over an area of about 30,000 sq km. The most important rivers, the Ganga and the Yamuna, originate in the Kumaon Himalayas. The religious places like Hardwar, Rishikesh, Kedarnath and Badrinath as well important places of tourist interest like Mussorie, Nainital, Almora and Ranikhet are located in this part of the Himalayas.

The **Eastern Himalaya** can be divided into (*a*) the Sikkim Himalaya, (*b*) the Darjeeling Himalaya, (*c*) the Bhutan Himalaya and (*d*) The Assam Himalaya.

The **Sikkim Himalaya** is an 'anticlinal valley' and this area is drained by the Tista river (a tributary of the Brahmaputra river). The **Darjeeling Himalaya** mainly consists of two north-south ranges. The Darjeeling Range is known all over the world for its tea gardens and Darjeeling tea is considered to be the best tea available anywhere in the world. The **Bhutan Himalaya** consists of high ranges and deep valleys and covers an area of about 22,500 sq km. The **Assam Himalaya** lies in NEFA (North-East Frontier Agency) of Assam which is now separate state of Arunachal Pradesh. It spreads over an area of about 67,500 sq km.

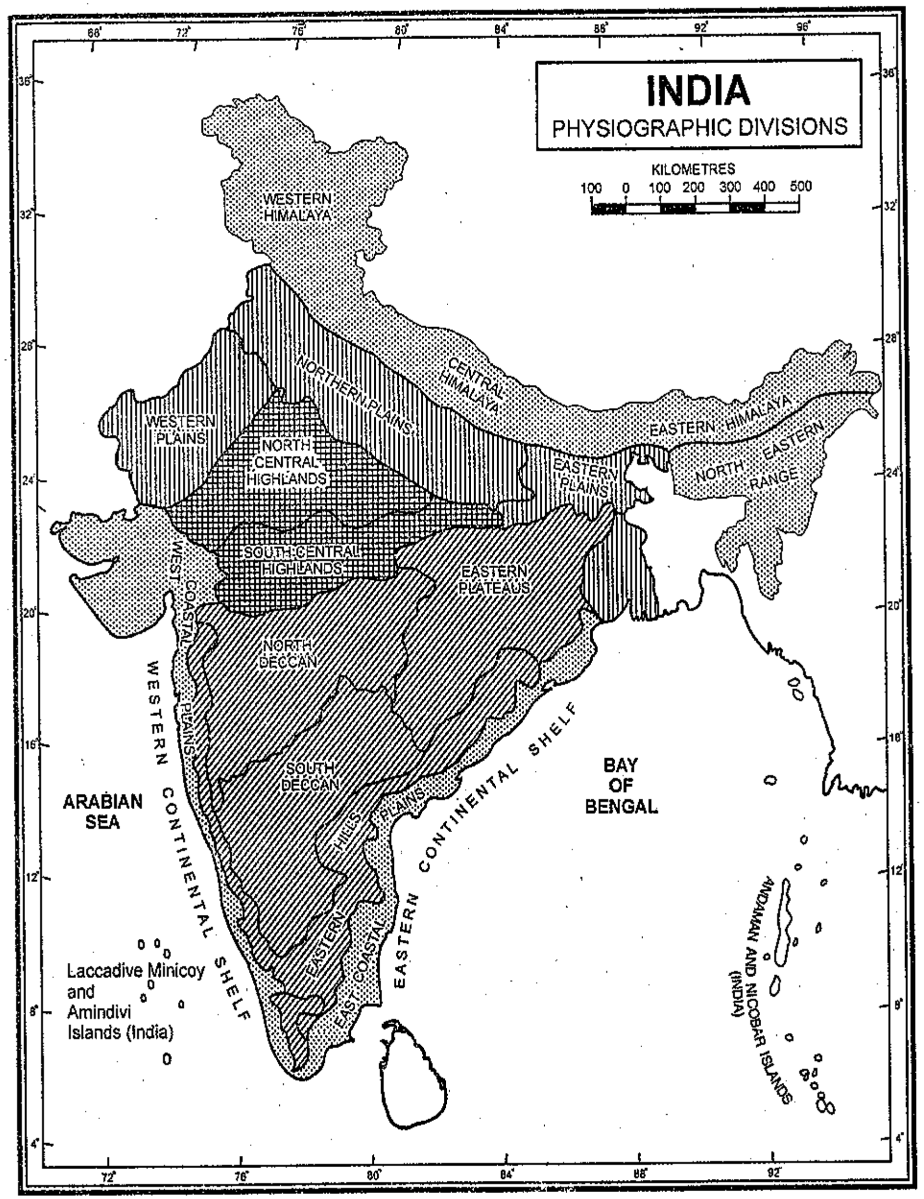


FIG. 3.16. Physiographic Divisions

The north-eastern mountains are subdivided into three physiographic provinces namely (*a*) Purvanchal, (*b*) the Meghalaya or Shillong Plateau and (*c*) the Assam valley. The **Purvanchal** includes lofty 'mountain ranges' which border India in the north-east, hills and plains in Manipur, Tripura and adjoining districts of Assam. The Purvanchal may be further sub-divided into six sub-divisions. Purva

NEFA, the Nagaland, the Manipur Hills, the North Cachar Hills, the Mizo Hills and the Tripura Hills. The Meghalaya Plateau contains Chirrapunji, the Khasi, the Jaintia, the Goro and the Makir Hills. The **Assam Valley** can be divided into two physiographic parts *viz.* the Upper Assam and the Lower Assam. Each is about 75 km wide with low relief, easy accessibility and extremely fertile land.

2. The Great Plains. In between the Himalayan mountain ranges in the north and the peninsular plateau region in the south, lies the Great Plain of India which stretches from the Indus delta in the west to the Ganga delta in the east. A part of it lies in Pakistan but major part is in India. This Great Plain can be divided into three broad divisions—Western Plains, Northern Plains and Punjab Plains.

The **Western plain** consists of arid land of Rajasthan. It has a well defined boundary in the east marked by the Aravalli range. This is a sandy desert with distinct aeolian topography. The eastern part is less sandy, comparatively more humid and is clothed with steppe vegetation. The **Punjab plains** are flat and the general elevation is 200 to 240 (except the Hoshiarpur plains). To the south of the Punjab plains lies the Haryana tract.

To the east of the Punjab plains is the **Ganga** plain which occupies about 55% of the total area of the Great Plains and stretches over the states of Uttar Pradesh, Bihar and West Bengal. The region between Ganga and its main tributary Yamuna is known as **Ganga-Yamuna Doab** which can be divided into Upper, Middle and Lower sections depending on elevation, rainfall and character of older flood plains. The **Upper Doab** extends from Hardwar in the north to Aligarh in the south. This region is irrigated by East Yamuna and Upper Ganga canals and is one of the most fertile areas giving bumper crops. It also receives more rainfall than the Middle and the Lower Doabs. The **Lower doab** is a flat area which ends at Allahabad at the confluence of Ganga and Yamuna. East of the Ganga-Yamuna Doab, lies the vast stretch of the alluvial plains, from the foot of the Himalayas to the Ganga. These are known as the **Rohilkhand** plains. These plains lie in UP and cover an area of about 35,000 sq km. The **Avadh plains** are other plains of Uttar Pradesh. To the east of the Rohilkhand and the Avadh plains, lie in **Bihar plains** covering an approximate area of 88,000 sq km. These plains are divided into the North Bihar Plains and the South Bihar Plains. The North Bihar Plains are drained by the rivers Ganga, Ghaghara, Gandak and Kosi accompanied by a large number of mountain streams passing through these plains. "The combined work of these streams has resulted in a 2000 m deep trough at the foot of the Nepal Himalaya being filled up with alluvial deposits. One of the most extensive alluvial plains of the world, 54,000 sq km in North Bihar was formed." The portion of the Great Plains coming under North Bengal covers an approximate area of 23,000 sq km and extends from the foot of the Eastern Himalayas to the northern limit of the Bengal basin. "This region has evolved from an extensive sheet of waste materials brought down from the Eastern Himalaya by a number of powerful streams like the Tista, Jaldhaka and Torsa." Its eastern part is drained by the rivers joining the Brahmaputra while its western part is drained by the tributaries of the Ganga. The Bengal basin embraces most of the alluvial plains of West Bengal and Bangladesh and the Ganga delta occupies the major portion of this basin.

3. Central Highlands. Lying in the central part of India, the Central Highlands separate the Great Plains in the north from the plateaus and coastal plains of the Deccan. "It forms a compact block of mountains, hills, and plateaus, interspersed with valleys and basins, covering about one sixth of the total area of India." It covers about half of Madhya Pradesh one-third of Rajasthan and a small part of Uttar Pradesh.

The Central Highlands can be divided into North Central Highlands and South Central Highlands. The **North Central Highlands** can further be subdivided into four divisions namely (*a*) the Aravalli Range, (*b*) Eastern Rajasthan upland, (*c*) Madhya Bharat Pathar and (*d*) Bundelkhand upland. Similarly, the **South Central** Highland can be divided into four divisions *viz.* (*a*) Malwa Plateau, (*b*) Vindhya Scarplands, (*c*) Vindhya Range and (*d*) Narmada Valley.

The **Aravalli range** runs for a distance of 800 km from Delhi to Ahmedabad. To the east of the Aravalli range lies **East Rajasthan Upland.** It's elevation varies from 250 to 500 m. It is drained by the Chambal river which enters Rajasthan near the northern end of the Gandhi Sagar and flows in this state for a distance of 360 km. The **Madhya Bharat Pathar** lies to the east of the Chambal river. It is a rocky surface with dense forests. The **Bundelkhand** lies between the Yamuna and the northern Aravali scarp of the Vindhyan plateau.

The southern part of the Central Highlands consists of the Malwa Plateau, the Vindhya Scarplands, the Vindhya range and the Narmada Valley. The **Malwa Plateau** forms a great triangle based on the Vindhyan Hills and bounded on the north-west by the Great Boundary Fault of Aravallis, on the east by the sharply-defined scarp overlooking Bundelkhand. Most part of this plateau lies in Madhya Pradesh. It has general northward slope, good drainage and black soil. **The Vindhyan** range is really an escarpment which varies in character and height depending on the structure and lithology of the underlying sector. For the first 100 km from its western terminus, Gomanpur peak (554 m) in the Dhar district of Madhya Pradesh, the Vindhya range runs in curve, its convex side facing the Narmada valley and following a 300 m contour line. It has dense forests but sparse population. For the next 160 km a more open type of country prevails and the escarpment, still built of basalt, becomes more prominent. Near Hoshangabad, the rock type changes; the Vindhya range comes down very close to the Narmada river and presents a terraced slope built of hard stand stones alternating with shales. The strong sand stones of Kaimur, Rewa and Bhander are the principal makers of the Vindhyan scarpland. The **Narmada Valley** lies to the extreme south of the central highlands. It is a rift valley caused by tectonic forces in which the Narmada river flows from east to west and empties itself in the Arabian Sea.

4. The Peninsular Plateaus. The Peninsular Plateaus constitute the largest physiographic division of India facing the Bay of Bengal in the east and the Arabian Sea in the west. Its maximum length from Pachmarhi in the north to Cape Comorin (Kanniyakumari) in the south is 1600 km and its maximum width from the Sahyadri in the west to the Rajmahal hills in the east is 1400 kms. The peninsular plateaus consist of five distinct physiographic subdivisions, namely (*i*) Western hills, (*ii*) North Deccan plateau, (*iii*) South Deccan plateau, (*iv*) Eastern plateaus and (*v*) Eastern hills.

(*i*) The **Western hills** cover all the three sections of the Sahyadris (Western Ghats) namely Northern Sahyadri, Middle Sahyadri and Southern Sahyadri. (*ii*) the **North Deccan plateau** comprises Satpura range and the Maharashtra plateau. The Satpura range extends in east-west direction between the Narmada river in the north and the Tapi river in the south. It represents folding and upheaval and is an ancient tectonic range. Its present physiography is that of scarped blocks (on the whole steeper towards the Tapi), largely covered with Deccan Lavas but with some inliers of gneissic plateau country. To the south of Solapur is the Maharashtra plateau, almost whole of which is formed of plateau basalt, which on weathering has given rise to rolling plains with intervening shallow valleys. The west-flowing Tapi river forms its northern boundary. Further south is the Godavari river which enters Maharashtra plateau at Nasik and flows for 650 km eastwards to the farthest end of this region. (*iii*) **The South Deccan** plateau can be divided into Telangana plateau and the Karnataka plateau. The Godavari river, after receiving a number of tributaries, enters the **Telangana plateau** and divides it into two parts. The northern part is very hilly and forested and is sparsely populated. The southern part is dotted with low hills and shallow depressions. One such depression, surrounded by low hills, 130 m high provided the site for the living cities of Hyderabad-Securadabad. The **Karnataka plateau** can also be divided into two sections on the basis of altitude. These sections are the northern section and the Mysore plateau. The Krishna and the Tungabhadra flow through the northern section. **The Mysore plateau** is the loftiest and well defined plateau of South India. This plateau is bounded by the Sahyadri in the west, the Eastern Ghats in the east and the Nilgiris in the south. Physiographically the Mysore plateau may be divided into two sections *viz.* Malnad and Maidan. The **Malnad** is a hilly area bordering the Sahyadri. It has a mean elevation of about 1000 m and its average width is 35 km. It is dissected into steep hills and deep valleys and has dense forests. The **Maidan** consists of rolling plains with low granitic hills. Cauvery is the most important river. (*iv*) **The Eastern plateaus** consist mainly of the plateaus of **Chotanagpur** of which Ranchi plateau and Hazaribagh plateau are the major parts. Rounded hills of massive granite and slightly elevated terraces of older flood plains mark the topography of the Ranchi plateau. The Damoder river rises in the hills of Chotanagpur plateau and drains through Ranchi. Hazaribagh, Dhanbad, Santhal Parganas, Bankura and

Burdwan. It flows in a rift valley and traverses a distance of 541 km before it joins the Hugli river near Kolkata. To the west of the Chotanagpur plateau is the **Bhagelkhand plateau.** It is bounded by the Ganga plain in the north, Maikala hills in the south and Kaimur hills in the west. Its general slope is in the north and north-west direction as is indicated by the flow of the Son river and its tributaries. The Mahanadi basin lies in the southern part of the Eastern plateau and the central part of the Mahanadi basin is known the Chhattisgarh basin. To its south lies the **Dandakaranya.** It encompasses the districts of Bastar, Kalahandi and Koraput and some parts of Andhra Pradesh. The region is well demarcated and enjoys the central location between Chhattisgarh basin in the north, Andhra Pradesh in the south, Maharashtra Plateau in the west and Eastern coastal plains towards the east. It has an undulating topography with well marked elevations and depressions.

5. East Coast. The eastern coastal strip lies between the Eastern Ghats and Bay of Bengal and stretches from the Ganga delta to Cape Comorin (Kanniyakumari). It is marked by a number of deltas such as the deltas of the Mahanadi, the Godavari, the Krishna, and the Cauvery. It is known by different names in different parts. In Orissa (Odisha) it is known as Utkal plain which includes the Mahanadi delta with Cuttack at its head. From the southern limit of the Utkal plain, stretch the Andhra plain. Rivers Godavari and Krishna flow through this region and form deltas in their lower reaches. In the south of the Andhra plain is the Tamil Nadu plain. This plain is about 675 km long and 100 km wide. The Cauvery delta is the most important physiographic feature of this plain. In Tamil Nadu and Andhra Pradesh, the East coast is called the Payan Ghat which extends from Cape Comorin (Kanniyakumari) northwards to the united deltas of the Krishna and the Godavari for 1100 km with an average width of 100-130 km.

6. West Coast. The west coast strip extends from the Gulf of Cambay (Gulf of Khambhat) in the north to Cape Comorin (Kanniyakumari) in the south and from the Western Ghats in the east to the Arabian sea coast in the west. It is made up of mud brought down by the short streams originating from the Western Ghats. At the northern end are two peninsulas namely Kutch (Kachchh) and Kathiawar and the vast extensive plain of Gujarat. To the south of the Gujarat plain are the coastal plains which are divided into three plains. Starting from north to south, they are (*i*) the Konkan coast, (*ii*) the Karnataka coast and (*iii*) the Kerala cost. The limits of these areas are conforming to the state boundaries.

7. The Islands. India is blessed with a large number of islands in both the Bay of Bengal and the Arabian sea. There are hundreds islands in the Bay of Bengal which are known as the Andaman and Nicobar Islands. The Andaman islands are divided into three main islands *i.e.* North, Middle and South. Separated from these islands by the Duncan passage is the Little Andaman. The North Andaman Island is 80 km long and has a maximum width of 20 km. The Middle Andaman is much wider and less indented. It is 70 km long and 30 km wide. The South Andaman consists of parallel ranges and valleys. Port Blair, the capital of Andaman Nicobar Islands and the most important port town lies in the South Andaman. Off these main islands lie numerous smaller islands. South of Andamans are the Nicobar islands, consisting of 19 islands 12 of which are inhabited. The Great Nicobar is the largest, occupying 862 sq km. The Car Nicobar is the northernmost island, 229 km from Port Blair.

In the Arabian Sea, there are three types of islands. (*i*) Amindivi Islands (consisting of six main islands of Amini, Keltan, Chetlat, Kadmat, Bitra and Perumul Par). (*ii*) Laccadive Islands (consisting of five major islands of Androth, Kalpeni, Karavatti, Pitti and Suheli Par) and (*iii*) Minicoy. At present these islands are collectively known as Lakshadweep.

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Drainage

INTRODUCTION

India is blessed with hundreds of large and small rivers which drain the length and breadth of the country. Rivers constitute the most useful natural resource. They have attracted the attention of planners, economists, geographers, geologists, hydrologists and a host of other specialists from different fields. They are a great source of water for irrigation, industry and domestic purpose and offer innumerable sites for producing hydro-electricity. Almost all the fertile areas of the country have been formed by the depositional work of rivers. Many rivers are used as channels for inland water transport. Fishing has become an important occupation along the rivers courses.

According to an estimate made by **S.P. Dasgupta**, the annual yield of water in the rivers of the country is 1,858,100 million cubic metres of which more than one third (33.8%) is contributed by the Brahmaputra, followed by the Ganga (25.2%), the Godavari (6.4%), Indus (4.3%), the Mahanadi (3.6%), the Krishna (3.4%), and the Narmada (2.9%). The remaining 20.4 is contributed by other rivers (percentages are calculated for basin areas in Indian territory only).

Drainage Systems of India

There are several bases for classifying drainage systems of India. The main types of drainage systems are briefly described below :

1. Size of the Catchment area. River systems of India are divided into three categories depending on their size. *Major river basins* have catchment area of 20,000 sq km and above. *Medium river basins* have catchment are between 2,000 and 20,000 sq km and river basins with catchment area less than 2,000 sq km are known as *minor river basins*.

2. Origin. Depending upon the origin of rivers two broad drainage systems of India are generally recognised, (*a*) The Himalayan rivers including the Indus, the Ganga, the Brahmaputra and their tributaries and (*b*) The Peninsular rivers which include along with their tributaries, a large number of rivers such as the Mahanadi, the Godavari, the Krishna, the Cauvery, the Narmada and the Tapi.

3. Orientation to the sea. The Indian drainage is divided into two major drainage systems on the basis of orientation to the sea. These include : (*i*) the Bay of Bengal drainage and (*ii*) Arabian sea drainage. About

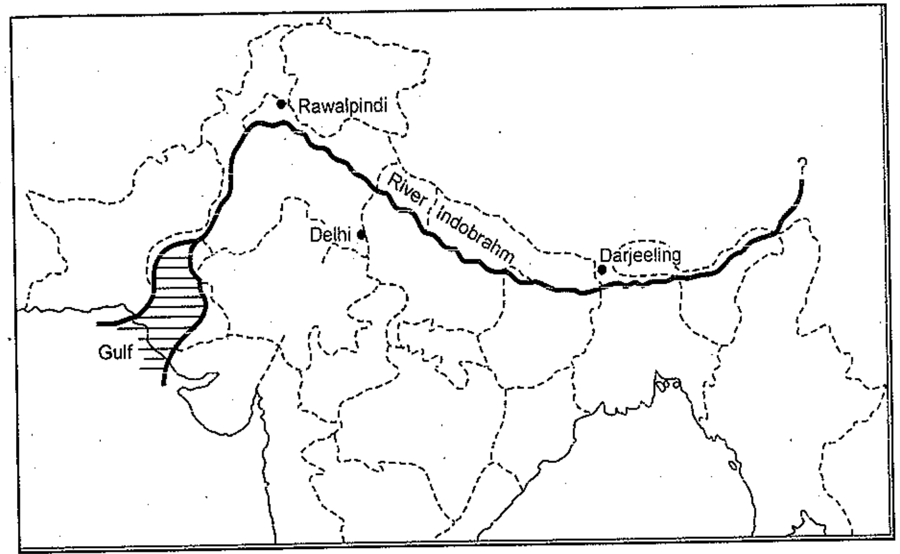

FIG. 4.1. The supposed course of the Indo-Brahm River (According to Pascoe)

77 per cent of the drainage area of the country is oriented towards the Bay of Bengal. It consists of a large number of rivers like the Ganga, the Brahmaputra, the Mahanadi, the Godavari, the Krishna, the Cauvery, the Penneru, the Penneiyar, the Vaigai, etc. The Arabian Sea drainage spreads over 23 per cent of the country's surface flow area which commands river basins like the Indus, the Narmada, the Tapi, the Sabarmati, the Mahi and the large number of swift flowing western coast rivers descending from the Sahyadris.

It may be mentioned here that the area covered by the above mentioned drainage systems differs markedly from the amount of water carried by them.

Over 90 per cent of the water carried by the Indian rivers is housed into the Bay of Bengal; the rest is drained into the Arabian Sea or forms inland drainage. This lop sided distribution is due to the location of the watershed separating the drainage systems falling into the Bay of Bengal and the Arabian Sea. This 2,736 km long watershed runs from Kanniyakumari through the Western Ghats, the Ajanta, the Maikala, the Vindhayas and the Aravalis ranges to the Shiwalik hills near Haridwar (**Fig. 4.3**).

THE HIMALAYAN RIVER SYSTEMS

Three Major river systems *viz.* the Indus, the Ganga and the Brahmaputra comprise the Himalayan river systems. Many of the Himalayan rivers existed even before the Himalayan ranges were uplifted. These rivers originate in the Tibetan side beyond the mountain ranges of the Himalayas. The gorges of the Indus, the Satluj, the Alaknanda, the Gandak, the Kosi and the Brahmaputra clearly indicate that these rivers are older than the mountains themselves. It is believed that they continued to flow all through the building phase of the Himalayas; their banks rising steeply while the beds went lower and lower, thus cutting deep gorges through the rising Himalayan ranges. Thus, many of the Himalayan rivers are typical examples of *antecedent drainage*. The evolution and flow of the Himalayan rivers is described as under :

Evolution of the Himalayan Rivers

1. The Indo-Brahm or Shiwalik River Theory

Some of the unwarranted features of the Himalayan rivers such as the longitudinal courses of the Indus, the Satluj and the Brahmaputra; deep gorges cut by the rivers across the Himalaya; and still westerly flowing tributaries in their upper reaches are a great puzzle and require proper explanation. This

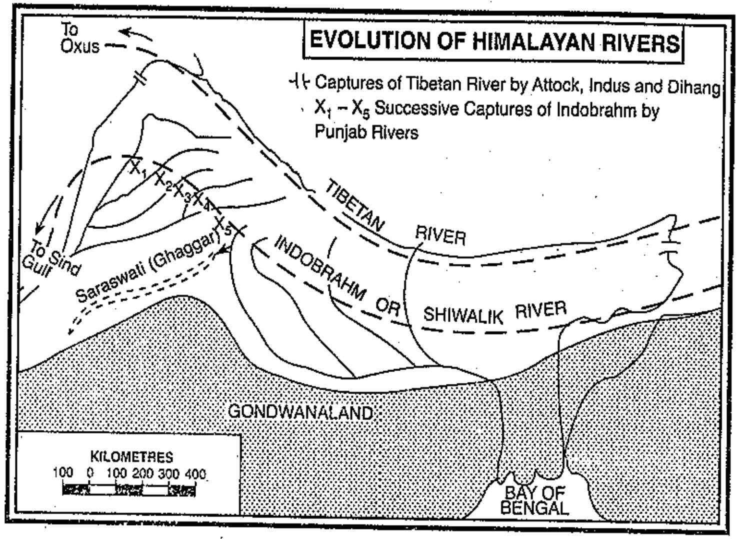

FIG. 4.2. Evolution of the Himalayan Rivers

has been partly done by assuming a mighty river which flowed from Assam to Punjab and even beyond upto Sind. This hypothetical ancient river was called the ***Indo-Brahm*** by **E.H. Pascoe** who thought that the present day Indus and Brahmaputra were the severed parts of the original river. However, it was named as the ***Shiwalik River*** by E.G. Pilgrim who considered that the course of the primitive river is occupied by the present day Shiwalik hills. Pascoe and Pilgrim presented an elaborate and comprehensive hypothesis, independently in 1919, on the assumption that the Shiwalik deposition occurred along this great river. The river came into being due to earth movements which took place in *Tertiary* period and is believed to be successor of the *Himalayan sea*. In the *Eocene Epoch* a gulf extended from Sind to Afghanistan and from there extended eastward and south-eastward through Kohat and Punjab to the neighbourhood of Nainital. This gulf gave place to a great river. With its headwater consisting of portions of the Brahmaputra, this master stream flowed along the foot of the Himalayas first westward and then north-westward as far as north-western Punjab where it turned southward more or less along the course of the modern Indus, and emptied itself into the Arabian Sea. Later, this mighty stream got dismembered into the following systems and sub-systems :

(*a*) the Indus,

(*b*) the five tributaries of the Indus in Punjab,

(*c*) the Ganga and its Himalayan tributaries, and

(*d*) the stretch of the Brahmaputra in Assam and its Himalayan tributaries.

The dismemberment was the result of the following two events :

(*i*) Upheavals in the western Himalayas including the Potwar Plateau in the Pleistocene age and

(*ii*) Headward erosion by the tributaries of the Indobrahma river.

As a result of the above mentioned dismemberment of the Indobrahma river, the Indus and its tributaries, the Ganga and its tributaries and the Brahmaputra and its tributaries came into being. It is supposed that the Yamuna was first a tributary of the Indus. During the late Pleistocene and early Holocene ages, it joined with the Sarswati somewhere near Suratgarh and continued to flow as Ghaggar, finally joining the Indus. Some other scholars believe that it reached upto Rann of Kachchh as an independent river. Later on, it changed its course due to tectonic disturbance along the Aravali axis and was annexed by the Ganga to become its tributary.

Pascoe also envisaged a great '*Tibetan River*' flowing north–westwards along the Tsangpo—

Manasarovar Lakes—Satluj—Gartang —Indus trough. This river might have emptied itself into the Oxus Lake, or might have debouched on to the plains by one of a number of transverse gaps such as Photu Pass. This river also was disrupted by headward erosion by Ayeyarwadi—Chindwin, the Meghna—Brahmaputra, the Satluj and the Indus. According to de Terra, the rivers of Karakoram and Ladakh might have flowed south-eastward or eastward. Its capture in the east might have been executed by Dihang, a tributary of the Brahmaputra.

However, this theory has been challenged on the following grounds :

(*i*) It is not necessary to imagine a stream of the size of Indobrahma flowing all along the length of the Himalayas to explain the occurrence of the Shiwalik deposits. These could be brought down by the rivers flowing down the slopes of the Himalayas. **M.S. Krishnan** and **N.K.N. Iyngar** (1940) found it difficult to accept the existence of such a mighty river on geological as well as physiographical grounds.

(*ii*) The evidences furnished by the depositional history in the Ganga delta and in Assam does not fit well with the concept of Indobrahma stream.

(*iii*) The width, thickness and lithology of the Tipam sand stones of Assam which were deposited in an estuary situated so close to the source of the Indobrahma also speak against this theory.

(*iv*) The upper course and the source of the Satluj river also do not fit in this theory. It is fed by underground water from the Manasarovar lake and it flows in a deep canyon cut in the soft fluviated beds of Nari Khorsum. The upper course of the Satluj is distinctly arid and the river appears to be a *misfit*. This could be explained if it were an old outlet of the '*Tibetan River*'. Pascoe argues that the Satluj captured a part of the '*Tibetan River*' and then lost again to the rejuvenated Tsangpo after the Dihang had cut back into the furrow. This argument has been rejected by many scholars.

E. Ahmad (1965 and 1971) has given his own interpretation of evolution of the Himalayan drainage. He believed that the Tethys remained as a basin of sedimentation from the Cambrian to the Eocene period but the major portion of the Himalayan region was occupied by the Gondwana landmass. During the *first Himalayan upheaval* in Oligocene period, part of the Tethyian geosyncline and probably the Gondwana shield covering the major part of the Himalayan region was uplifted. Most probably, this marks the initiation of the Himalayan drainage. The Tethys was raised into a landmass with a median mass of high Tibetan plateau in the centre and two bordering ranges namely the Kun Lun in the north and the Himadri in the south. The drainage started from the southern edge of the median mass and flowed south towards the foredeep. As the formation of east-west ranges created east-west valleys, the rivers partly flowed along these valleys. This is indicated by the upper course of several rivers such as the Indus, the Sutluj, the Brahmaputra, the Shyok, the Arun, etc. Since the whole of the Tethys was not fully raised to become land surface, there existed patches of sea along the margins and the drainage lines were not fully defined.

The *second Himalayan upheaval* during the mid-Miocene period increased the altitude of the medium mass and the bordering ranges. The remnant sea was also raised to form landmass. The rise in land resulted in greater and more invigorated drainage. Along with these changes, the region to the south of the first Himalayan range was raised as Lesser Himalayan range. Earlier streams on the southern margin of the Tibetan plateau cut down deep valleys to maintain their courses. Along the southern slopes of the lesser Himalayas, a number of consequent streams also emerged which drained into the southern foredeep.

The *third Himalayan upheaval* during the Pleistocene period resulted in the folding of the Shiwalik foredeep into hill ranges. Also the height of earlier ranges and the Tibetan plateau was raised. The rise in the Tibetan plateau blocked the streams that had gone northward into the Tibetan sea. These streams were diverted east or west which probably led to the formation of the trans-Himalayan master stream. This master stream was broken into two (the proto-Indus and the proto-Brahmaputra) by the formation of the Kailas Range. The uplift of the Shiwalik range gave rise to the last set of consequents originating on the crest of the range emptying into older streams.

2. Multiple River Theory

An alternative explanation regarding the evolution of the Himalayan drainage has been offered by the Multiple River Theory. The protagonists of this theory find it difficult to accept the existence of a large river like the Indo-Brahm or Shiwalik on geological and physiographical grounds.

This theory postulates that the Eocene sea extended upto Sind, Rajasthan and from Punjab to Jammu and thereafter Lansdowne and Nainital. This was connected to Tethys. Existence of such a sea is evidenced by the presence of shallow water bodies indicative of coast near Landsdowne. This limit also coincides with the eastern continuation of one of the ridges of the Aravali Range which presumably acted as barrier. At the same time, another ridge extended from the Rajmahal Hills to the Meghalaya or Shillong plateau (Rajmahal—Garo gap) which is now occupied by the Ganga-Brahmaputra basin. The sea was broken by the first upheaval of the Himalayas to form an isolated basin in which sediments were deposited. In the next upheaval, a pronounced foredeep all along the southern border of the Himalayas was formed. This foredeep contained numerous lagoons in which flowed streams from the Peninsula and the newly uplifted Himalayas. These streams brought sediments which later came to be known as Shiwalik deposits. The outlet of this foredeep was through the Rajmahal-Garo gap in the Bay of Bengal and the Arabian Sea in the west. Later on the lagoons got dried up and numerous transverse streams flowing from the Himalayan region formed what is now known as the Himalayan drainage.

THE INDUS RIVER SYSTEM

The Indus (Sanskrit—Sindhu, Greek—Sinthos; Latin—Sindus), along with its tributaries forms one of the largest drainage systems of the world. It is from this river that India got her name. The Indus valley has been the cradle of one of the oldest civilizations in the world—'the Indus Valley Civilization'.

The mighty Indus rises near Manasarovar Lake from the glaciers of the Kailas Range in Western Tibet (31°15′ N and 81°40° E) at an elevation of 5,182 metres. Starting from its source, it flows for a distance of 257 km in the north west direction in the trans-Himalaya region under name of *Singge Khabab* until it is joined by the Dhar. A short distance lower down, it enters India at an elevation of 4,206 m and continues to flow in the same north-west direction between the Ladakh and the Zaskar Ranges. The gradient of the river in this course is very gentle (about 30 cm per km). Here it encircles the town of Leh and is joined by the Zaskar river. About 50 km before Skardu, it is joined by the Shyok at an elevation of about 2,700 m. The *Gilgit*, *Gortang*, *Dras*, ***Shiger***, ***Hunza*** are the other Himalayan tributaries of the Indus. After passing through a 480 km long antecedent and very deep gorge (5,181 metres at Bunji north of Nanga Parbat), it takes a sharp southerly bend and reaches Attock at an altitude of about 610 m. Here it ends its mountainous journey and is joined by the Kabul river from Afghanistan. Thereafter it flows through the Potwar plain and crosses the Salt Range. Some of the important tributaries below Attock include the Kurram, Toch and the Zhob-Gomal. Just above Mithankot, about 805 km from the sea, at an elevation of 79 m the Indus receives from *Panjnad* (*Panchnad*), the accumulated waters of the five eastern tributaries—the Jhelum, the Chenab, the Ravi, the Beas and the Satluj. The river finally empties itself into the Arabian Sea, south of Karachi after forming a big delta. The total length of the Indus river from its source to its mouth is about 2,880 km out of which only 709 km length falls in India. The average annual flow of water in the Indus river is 110,450 million cubic metres at Kalabagh.

The left bank tributaries are big rivers in themselves and deserve a brief mention here. These rivers join together one by one before they ultimately meet the main river.

The Jhelum rises in a spring at Verinag in the south-eastern part of the Kashmir Valley. It flows northwards from its source to Wular Lake and further down south-westwards. The river flows through the Kashmir Valley and forms a 200 m deep defile with almost vertical walls through Pir Panjal Range below Baramula. A number of tributaries notably the Lidar, the Sind and the Pohru, which rise in Kashmir, join the main river. At Muzaffarabad, the river takes a sharp hairpin swing southward and the Kishaganga joins it on its right bank. Thereafter, it forms the India-Pakistan boundary for 170 km and emerges at the Potwar Plateau near Mirpur. After skirting the outlying spurs of the Salt Range it debouches on the plains near the city of Jhelum about 402 km from its source. About 322 km lower, it joins the Chenab at Trimmu. The river is navigable for about 160 km out

TABLE 4.1. The Indus Drainage System

Name of the river	Source	Length in km	Area drained (sq km)	Volume of average annual flow (in million cubic metres)
Indus	Near Manasarovar Lake (31°15′N, 81°40′E at 5,182 m elevation	2,880 (709 in India)	1,178,440 (321,284 in India)	1,10,450 at Kalabagh in Pakistan
Jhelum	Verinag	724	34,775 upto Indo-Pak Border	27,890 at Mangla in Pakistan
Chenab	Bara Lacha Pass	1,180	26,155 upto Indo-Pak Border	29,000 at Marala in Pakistan
Ravi	Near Rohtang Pass	725	14,442 (5,957 in India)	8,000 at Madhopur
Beas	Near Rohtang Pass at 4,062 m height	460	20,303	15,800 at Mandi
Satluj	Manasarovar-Rakas Lakes at 4,570 m altitude	1,450 (1,050 in India)	25,900	16,600 at Rupnagar

of a total length of 724 km. The average annual flow of water in the river at Mangla is 27,890 million cubic metre. The catchment area upto the Indo-Pakistan border is 34,775 sq km.

The Chenab originates from near the Bara Lacha Pass in the Lahul-Spiti part of the Zaskar Range. Two small streams on opposite sides of the pass, namely ***Chandra*** and ***Bhaga***, form its headwaters at an altitude of 4,900 m. The united stream, called the ***Chandrabhaga*** flows in the north-west direction through the Pangi valley, parallel to the Pir Panjal range, and enters Jammu and Kashmir as the Chenab river at an elevation of 1,838 m. Near Kistwar, it cuts a deep gorge, at places 1,000 m deep. Here, it flows for 290 km between steep cliffs of high mountains and turns southwards and flows in this direction for a short distance. Further, it turns to the west and enters the plain area near Akhnur in Jammu and Kashmir after traversing a distance of about 330 km. From here it swings to the south-west through the plains of Pakistani Punjab for a distance of 644 km to reach Panchnad where it joins the Satluj after receiving the waters of Jhelum and Ravi rivers. The total length of the river is 1,180 km. Its catchment area upto the Indo-Pakistan border is 26,155 sq km. Its annual flow at Marala is 29,000 million cubic metres.

The Ravi has its source in Kullu hills near the Rohtang Pass in Himachal Pradesh. Flowing in a northwest direction from its source, it drains the area between the Pir Panjal and the Dhaola Dhar ranges. After crossing Chamba, it takes a south-westerly turn and cuts a deep gorge in the Dhaola Dhar range. It enters Punjab Plains near Madhopur and later enters Pakistan 26 km below Amritsar. It debouches into the Chenab a little above Rangpur in Pakistani Punjab after flowing for a distance of 725 km from its source. Its total catchment area is 14,442 sq km of which only 5,957 sq km lies in India. The annual flow of water in this river at Madhopur is 8,000 million cubic metres.

The Beas originates near the Rohtang Pass, at a height of 4,062 m above sea level, on the southern end of the Pir Panjal Range, close to the source of the Ravi. Fairly steep in its upper portion (24 metres per km) it crosses the Dhaola Dhar range through a deep gorge 900 m deep from Lorji to Talwara. On meeting the Shiwalik hills the river sweeps sharply northward, then bending round the base of the hills it takes a southerly direction and debouches on the plain. Thereafter, it takes a south-westerly direction and meets the Satluj river at Harike in Punjab. It is a comparatively small river which is only 460 km long but lies entirely within the Indian territory. Its total catchment area is 20,303 sq km. The river carries about 15,800 million cubic metres of water at Mandi.

The Satluj rises from the Manasarovar-Rakas Lakes near Darma Pass in western Tibet at a height of

4,570 m within 80 km of the source of the Indus. Like the Indus, it takes a north-westerly course upto the *Shipki La* on the Tibet-Himachal Pradesh boundary. Here the river flows at an altitude of about 3,000 m above sea level. It cuts deep gorges where it pierces the Great Himalaya and the other Himalayan ranges. In Nari Khorsan province of Tibet, it has created an extraordinary canyon, comparable to the Grand Conyon of Colorado; the channel here is 900 m deep. Its tributaries in Himachal Pradesh are short in length except the Spiti, which drains a large trans-Himalayan area and joins it at Namgia near the Shipki La. Before entering the Punjab plain, it cuts a gorge in Naina Devi Dhar, where the famous Bhakra dam has been constructed. After entering the plain at Rupnagar (Ropar), it turns westwards and is joined by the Beas at Harike. From near Ferozepur to Fazilka it forms the boundary between India and Pakistan for nearly 120 km. During its onward journey it receives the collective drainage of the Ravi, Chenab and Jhelum rivers and about 70 km further downstream, it joins the Indus a few kilometres above Mithankot. Out of its total length of 1,450 km, it flows for 1,050 km in Indian territory. It drains an area of 25,900 sq kms and its average annual flow at Rupnagar (Ropar) is 16,660 million cubic metres.

The water assets of the Indus river system are shared by India and Pakistan according to the Indus Water Treaty signed between the two countries on 19th September, 1960. According to this treaty, India can utilize only 20 per cent of its total discharge of water.

THE GANGA RIVER SYSTEM

The Ganga river system consists of the master river Ganga and a large number of its tributaries. This system drains a very large area comprising the middle part of the Himalayas in the north, the northern part of the Indian Plateau in the south and the Ganga Plain in-between.

The Ganga originates as Bhagirathi from the Gangotri glacier in Uttar Kashi District of Uttarakhand at an elevation of 7,010 m. Alaknanda joins it at Devaprayag. But before Devaprayag is reached, the Pindar, the Mandakini, the Dhauliganga and the Bishenganga rivers pour into the Alaknanda and the Bheling flows into the Bhagirathi. The Pindar river rising from Nanda Devi and East Trisul (6,803 m) joins Alaknanda at Karan Prayag and Mandakini or Kali Ganga meets at Rudra Prayag. The combined water of the Bhagirathi and the Alaknanda flows in the name of the Ganga below Devaprayag. After travelling 280 km from its source, the Ganga reaches Haridwar, debouches from the hills and enters plain area. From here it flows in south and south-east direction for a distance of 770 km to reach Allahabad. Here it is joined by the Yamuna which is its most important tributary. It sweeps another 300 km eastwards to reach the Bihar plain. Near Rajmahal Hills it turns to the south-east and south of Farraka, it ceases to be known as the Ganga. It bifurcates itself into Bhagirathi-Hugli in West Bengal and Padma-Meghna in Bangladesh. After traversing 220 km further down in Bangladesh, the Brahmaputra (or the Jamuna as it is known here) joins it at Goalundo and after meeting Meghna 100 km downstream the Ganga joins the Bay of Bengal.

Before entering the Bay of Bengal, the Ganga, along with the Brahmputra, forms the largest delta of the world between two arms : the Bhagirathi / Hugli and the Padma / Meghna covering an area of 58,752 sq km. The delta front of the Ganga is a highly indented area of about 400 km length extending from the mouth of the Hugli to the mouth of the Meghna. The delta is made of a web of distributaries and islands and is covered by dense forests called the ***Sunderbans***. A major part of the delta is a low-lying swamp which is flooded by marine water during high tide.

The total length of the Ganga river from its source to its mouth (measured along the Hugli) is 2,525 km, of which 310 km in Uttarakhand, 1,140 km is in Uttar Pradesh, 445 km is in Bihar and 520 km in is West Bengal. The remaining 110 km stretch of the Ganga forms the boundary between Uttar Pradesh and Bihar. The river flows majestically from Gangotri to Bay of Bengal with an average gradient of 2.77 m per km.

The Ganga is joined by a large number of tributaries both from the left as well as from the right. Majority of them originate in the Himalayan ranges but some of them have their sources in the Peninsular plateau.

The Yamuna is the largest and the most important tributary of the Ganga. It originates from the Yamnotri glacier on the Bandarpunch Peak in

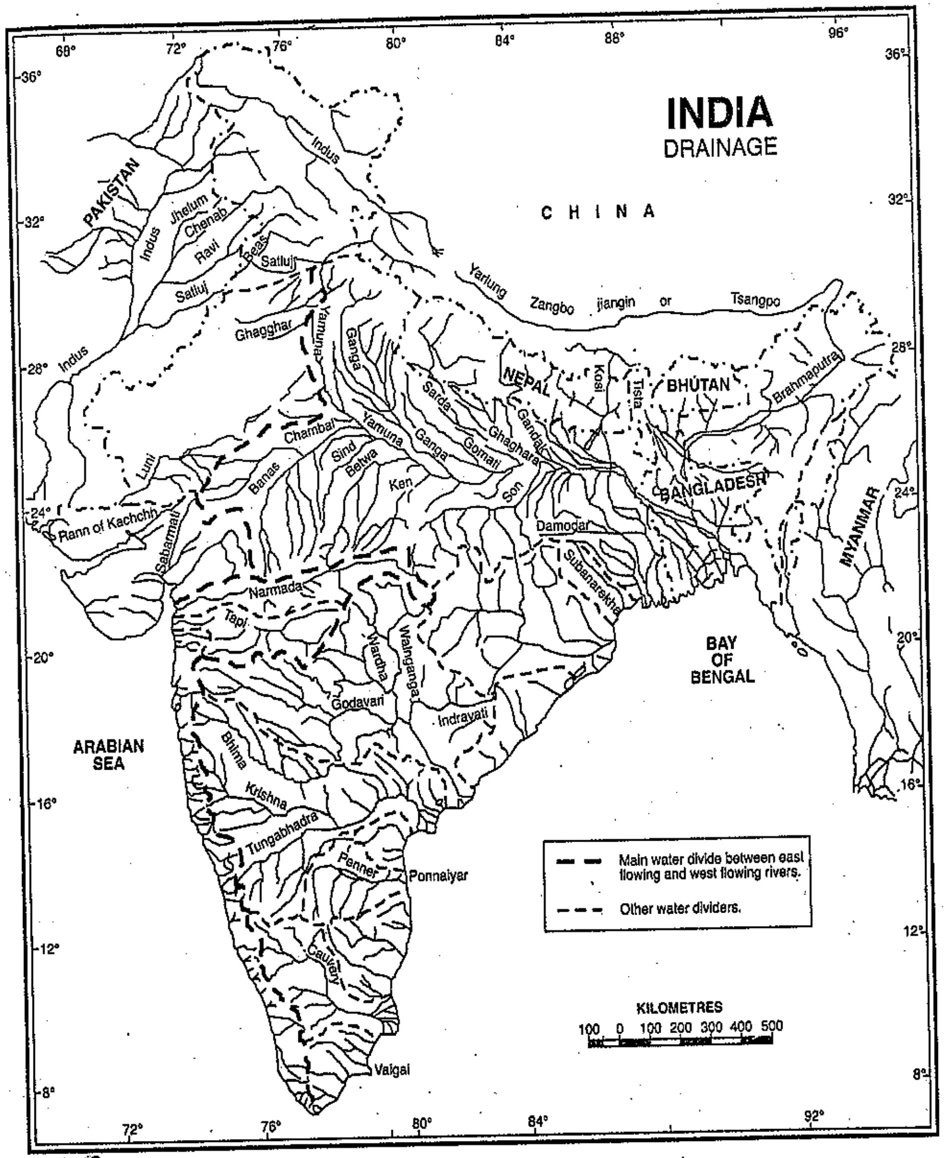

FIG. 4.3. India : Drainage

Garhwal in Uttarakhand at an elevation of 6,330 m, a source which is very close to that of the Ganga itself. After cutting across the Nag Tibba, the Mussoorie and the Shiwalik ranges it emerges out of the hilly area and enters plains near Tajewala. Many small streams such as the Rishiganga, the Uma and the Hanuman Ganga join it in the mountains. Its main affluent in the upper reaches is the *Tons* which also rises from the Bandarpunch glacier at an altitude of 3,900 m and joins Yamuna below Kalsi before the latter leaves the hills. At this site, the water carried by the *Tons* is twice the water carried by the Yamuna. After completing a journey of about 300 km in the plain area, it is joined by the 256 km long Hindon near Ghaziabad in Uttar Pradesh. The Yamuna takes a southerly course upto Mathura and south-easterly in its onward journey upto Allahabad where it unites with the Ganga. Between Agra and Allahabad, the Yamuna receives some important tributaries originating from the Peninsular Plateau. These are the Chambal, the Sind, the Betwa and the Ken. The total length of the Yamuna from its origin to its confluence with the Ganga at Allahabad is 1,376 km.

The Chambal rises 15 km south-west of Mhow in the highlands of Janapao Hills (700 m) in the Vindhya Range in Madhya Pradesh and takes a north-westerly course through the Malwa Plateau. It then enters a gorge at Chaurasigarh, 312 km from its source. The gorge is 96 km long and stretches upto Kota city. Below Kota, it turns to north-east and after reaching Pinahat, it turns to the east and runs nearly parallel to the Yamuna before joining it in Etawah district of Uttar Pradesh. The river flows much below its banks due to severe erosion because of poor rainfall and numerous deep ravines have been formed in the Chambal Valley, giving rise to **badland topography**. The total length of the river is 1,050 km. *The Banas* is an important tributary of the Chambal. It originates in the southern part of the Aravali Range, and takes a north-eastern course to join the Chambal near Sawai Madhopur. **The Sind** originates in Vidisha Plateau of Madhya Pradesh at an elevation of 543 m. It flows for a distance of 415 km before it joins the Yamuna. It drains an area of 25,085 sq km. **The Betwa** rises at an elevation of 470 m in Bhopal district and joins the Yamuna near Hamirpur. It has a total length of 590 km and a catchment area of 45,580 sq km. **The Dhasan** is its important tributary. The 360 km long **Ken river** rising from the Barner Range of Madhya Pradesh is another tributary which joins the Yamuna near Chila; some 60 km downstream from the mouth of the Betwa.

The Son river springs from the Amarkantak Plateau, not far from the origin of the Narmada, at an elevation of about 600 m. After flowing for some distance to the north, it meets the Kaimur Range which turns its course to the north-east. It passes over the cascades in the hill reaches and further beyond through the Palamau district of Jharkhand. It joins the Ganga about 16 km upstream of Danapur in Patna district of Bihar after flowing for a distance of 784 km from its source. It has a total catchment area of 71,259 sq km in which there are wide fluctuations of water flow changing with the change of season. The important tributaries of the Son are the *Johilla*, the *Gopat*, the *Rihand*, the *Kanhar* and the North *Koel*. Almost all the tributaries join it on its right bank.

The Damodar river rises in the hills of the Chotanagpur plateau and flows through a rift valley. It used to cause devastating floods as a result of which it earned the dubious name of ***'Sorrow of Bengal'***. After flowing through Bankura and Burdwan districts of West Bengal, it joins the Hugli 48 km below Kolkata. The total length of the river is 541 km and its catchment area is 25,820 sq km.

Still more important tributaries of the Ganga originate in the Himalayas and join it on its left bank. The major tributaries of this category, apart from the Yamuna, are the Ramganga, the Gomati, the Ghaghra, the Gandak, the Burhi Gandak, the Bagmati, and the Kosi.

The Ramganga river rises in the Garhwal district of Uttarakhand at an altitude of 3,110 m and enters the Ganga Plain near Kalagarh. It joins the Ganga at Kannauj after traversing a distance of 596 km. The Khoh, the Gangan, the Aril, the Kosi, and the Deoha (Gorra) are important tributaries which join the Ramganga. Its basin covers 32,493 sq km.

The Ghaghra river originates near the Gurla Mandhata peak, south of Manasarovar in Tibet. Obviously it is a river of the trans-Himalayan origin and carries sufficient water. It is known as the *Karnaili* in Western Nepal. It first flows south-east and then south-southwest cutting across the Great Himalaya through a succession of steep defiles. Its important tributaries are the *Sarda*, the *Sarju* on the bank of which Ayodhya is located and the *Rapti*. The Ghaghara joins the Ganga a few kilometres downstream of Chhapra in Bihar after a 1,080 km long journey from its source. Soon after reaching the plain area, its stream gets divided into many branches of which, *Koriyab* and *Garwa* are important. These two streams meet again in Bahraich district of Uttar Pradesh. From here, the river bed is sandy and sudden bends start occurring in the stream. Flowing over a wide sandy expanse, this river crosses Gorakhpur, Deoria, Azamgarh and Balia districts of Uttar Pradesh

as a divided stream. The total catchment area of the river is 127,950 sq km out of which 45% is in India and the rest lies in Nepal and Tibet. The river has a high flood frequency and has shifted its course several times. Its average annual flow is 94,000 million cubic metres.

The Kali river also rises in the high glaciers of snow covered region of the trans-Himalaya. It has several feeders in the high ranges and forms the boundary between Nepal and Kumaon for most of its transit across the mountains. It is known as the *Sarda* or *Chauka* after it reaches the plains near Tanakpur. Below this point it takes a south-easterly course and joins the Ghaghara.

The Gandak which originates near the Tibet-Nepal border at a height of 7,620 m receives a large number of tributaries in Nepal Himalaya, the most outstanding being the *Kali Gandak*, the *Mayangadi*, the *Bari* and the *Trishuli*. It debouches into the plains at Tribeni and pours into the Ganga at Hajipur in Bihar after flowing for a distance of 425 km in India. Its drainage area is 46,300 sq km out of which 7,620 sq kms, is in India. The average annual flow is 52,200 million cubic metres.

The Burhi Gandak originates from the western slopes of Sumesar hills near the India-Nepal border and flows in south-east direction. It joins the Ganga opposite Monghyr town. Its length is 610 km and its drainage area is 12,200 sq km.

The Kosi river consists of seven streams namely ***Sut Kosi, Tamba Kosi, Talkha, Doodh Kosi, Botia Kosi, Arun*** and ***Tamber*** and is popularly known as ***Saptkaushiki***. These streams flow through a large part of eastern Nepal which is known as the ***Sapt Kaushik*** region. *Arun* is the main stream which rises to the north of Gosainthan. The sources of seven streams of the Kosi are located in snow covered areas which also receive heavy rainfall. Consequently, huge volume of water flows with tremendous speed. Coming out of the Saptakosi region, the streams flow in south-west direction. Seven streams mingle with each other to form three streams named the ***Tumar, Arun*** and ***Sun Kosi***. These three streams contribute respectively 44%, 37% and 19% of the total water flow in the river. They unite at Triveni north of the Mahabharata Range to form the Kosi. The river enters the *Tarai* of Nepal after cutting a narrow gorge for 10 km in the Mahabharata Range at Chatra. The Kosi flows for a distance of 730 km in India and joins the Ganga near Kursela. The total drainage area of the river is 86,900 sq km out of which 21,500 sq km lies in India.

Soon after debouching onto the plain the river becomes sluggish and large scale deposition of eroded

TABLE 4.2. The Ganga Drainage System

Name of the river	Source	Length (in km)	Area drained (sq km)	Volume of average annual flow (in million cubic metres)
Ganga	Gangotri Glacier at 7,010 m	2,525	861,404	1,52,000 at Allahabad, 4,59,040 at Patna
Yamuna	Yamnotri Glacier at 6,330 m	1,376	366,223	93,020 at Allahabad
Chambal	Near Mhow (Madhya Pradesh)	1,050	139,468	30,050 at confluence with the Yamuna
Ramganga	Garhwal district at 3,110 m	596	32,493	15,258
Ghaghara	Near Gurla Mandhota peak south of Manasarovar	1,080	127,950	94,400
Gandak	Tibet-Nepal border at 7,620 m	425 in India	46,300 (7,620 in India)	52,200
Kosi	Sikkim-Nepal-Tibet Himalaya	730 in India	86,900 (21,500 in India)	61,500

material takes place. The river channel is braided and it shifts its course frequently. This has resulted in frequent devastating floods and has converted over 10,000 sq km cultivable land into waste land in Bihar. Thus the river is often termed as the '*Sorrow of Bihar*'. In order to tame this river, a barrage was constructed in 1965 near Hanuman Nagar in Nepal. Embankments for flood control have been constructed as a joint venture of India and Nepal.

THE BRAHMAPUTRA RIVER SYSTEM

The Brahmaputra (meaning the *son of Brahma*) rises in the great Chemayungdung glacier in the Kailas Range of the Himalayas a little south of the Lake Konggyu Tsho at an elevation of about 5,150 m located at 30° 31′ N latitude and 82° 10′ E longitude. This source is about 150 km away from the source of the Indus and only 35 km from the birth place of the Satluj. Both these rivers flow westwards while the Brahmaputra flows eastwards from this region. *Mariam La* separates the source of the Brahmaputra from the Manasarovar Lake. With a total length of 2,900 km the Brahmaputra is one of the longest rivers of the world and passes through Tibet, India and Bangladesh.

Known as the ***Tsangpo*** (meaning 'The Purifier'), in Tibet and ***Yarlung Zangbo Jiangin*** in Chinese language, the Brahmaputra flows eastwards in Southern Tibet for about 1,800 km and for most part of this journey it passes through the depression formed by the *Indus-Tsangpo Structure Zone* between the Great Himalayas in the south and the Kailas Range in the north. Inspite of the exceptionally high altitude of the land through which the Tsangpo flows, it has a gentle slope and the river is sluggish and has a wide navigable channel for about 640 km from Lhatse Dzong down-stream. This is one of the most remarkable navigable waterways of the world where boats sail at an altitude of 3,000 metres and above. Its bed is 3,525 m high at Tradom (Teladuomu) and 3,300 m at Shigatse. It receives a large number of tributaries in Tibet. The first major tributary is the Raga Tsangpo from the north meeting the Tsangpo near Lhatse Dzong. The river Ngangchu flows through the trade centre of Gyantse in the south and joins the main river near Zhikatse. Further east, the Kyichu (Gya Chhu) from the north runs past the sacred town of Lhasa and joins it near Chushul Dz. At Tsela Dz, the river is joined by the Griamda from the north.

Towards the end of its journey in Tibet, it abruptly turns to north-east and north and then traverses in a succession of rapids between high mountains of Gyala Peri (7,151 m) and Namcha Barwa (7,756 m). Further, it turns to the south and south-west and cuts across the eastern Himalaya through the Dihang or Siang Gorge and emerges from the mountains near Sadiya in the Assam Valley. Here it first flows under the name of Siong and then as the Dihang. The Dihang gorge is only 50 metres wide at places but is 5,485 m below Namcha Barwa. The steepness of its slope can be judged from the fact that its altitude falls suddenly from 2,450 m north of Namcha Barwa to only 135 m at Sadiya. Here it is joined by two important tributaries *viz*. the Dibang (or Sikang) from the north and Lohit from the south forming what looks like a '*delta in reverse*'.

From Sadiya onwards, this mighty river is known as the ***Brahmaputra*** and flows majestically in the Assam Valley for a distance of about 720 km. Here also, a large number of tributaries, both from the north and from the south, pay their tribute to the master river. The main streams merging with the Brahmaputra from the north are, Subansiri, Kameng, Belsiri, Dhansiri (north), Nyera Ama, Manas—Mora—Manas, Champaman, Gangadhar, Raidah, Dharla and Tista. The Tista was a tributary of the Ganga prior to the devastating floods of 1787 after which it diverted its course eastwards to join the Brahmaputra. Those pouring in the main river from the south are the Dibru, Burhi Dihing, Noa Dihing, Dikhu, Dhansiri (south) and Kalang.

The Brahmaputra has a braided channel for most of its passage through Assam. There is a constant shifting of the river channels and the sandy shoals. Its southward shift in the Assam plains has been quite conspicuous in the recent years. It carries a lot of silt and there is excessive meandering. The river is nearly 16 km wide at Dibrugarh and forms many islands, the most important of which is *Majuli*. It is 90 km long and measures 20 km at its widest, having an area of 1,250 sq km. This island has 144 villages with a population of over 1,50,000. With rainfall concentrated during the monsoon months only the river has to carry enormous quantities of water and silt which results in disastrous floods in the rainy

season. The floods caused by the Brahmaputra in Assam Valley affect on an average an area of 8 to 10 lakh sq km. The Brahmaputra is thus truly a *River of Sorrow*. However, the river is navigable for a distance of 1,384 km upto Dibrugarh from its mouth and serves as an excellent inland water transport route.

Traversing round the stairs of the Garo Hills, the Brahmaputra bends southwards and enters Bangladesh near Dhubri. It flows for a distance of 270 km in the name of Jamuna river and joins the Ganga at Goalundo. The united stream of the Jamuna and the Ganga flows further in the name of Padma. About 105 km further downstream, the Padma is joined on the left bank by the Meghna, originating in the mountainous region of Assam. From the confluence of Padma and Meghna, the combined river is known as the ***Meghna*** which makes a very broad estuary before pouring into the Bay of Bengal.

THE PENINSULAR DRAINAGE

The Indian Peninsula is traversed by a large number of rivers which have existed for a much longer period than the Himalayan rivers. As such the peninsular rivers have reached mature stage and have almost reached the base level of their erosion. This is characterised by broad, shallow and largely graded valleys. The beds have very subdued gradient except for a limited tract of river where faulting has allowed steepening of the gradient. Almost the entire peninsula presents a senile topography showing features of mature drainage.

The velocity of water in the rivers and the load carrying capacity of the streams is low due to low gradient and the rivers form big deltas at their mouths. This is especially observed in the east flowing rivers pouring into the Bay of Bengal. But the west flowing rivers of Narmada and Tapi as well as those originating from the Western Ghats and falling in the Arabian Sea form estuaries in place of deltas.

However, there are instances of superimposed and rejuvenated drainage represented by waterfalls. The Jog on the Sharvati (289 m), Yenna of Mahabaleshwar (183 m), Sivasamundram on the Cauveri (101 m), Gokak on the Gokak (55 m), Kapildhara (23 m) and Dhuandar (15 m) on the Narmada are the major waterfalls in the Peninsular India.

Evolution of the Peninsular Drainage

Geologists believe that the Sahyadri-Aravali axis was the main water divide in the geological past. One hypothesis assumes that the existing peninsula is the remaining half of bigger landmass. The Western Ghats were located in the middle of this landmass dividing the entire drainage into two symmetrical parts—one flowing in the east and the other flowing in the west. But the western part of the Peninsula cracked and submerged in the Arabian Sea and disturbed the symmetrical plan of the rivers on either side of the watershed during the early Tertiary period. During the collision of the Indian plate, a second major distortion was introduced in the Peninsular block and it was subjected to subsidence and consequent trough faulting through which now flow main west flowing rivers of the Peninsula, namely the Narmada and the Tapi. This is amply proved by the straight coastline, steep western slope of the Western Ghats, and the absence of delta formations on the western coast.

Another view is put forward keeping in view the exceptional behaviour of the Narmada and the Tapi. It is believed that these two rivers do not flow in the valleys formed by the rivers themselves. Rather they have occupied two fault planes or alluvium filled rifts in rocks running parallel to the Vindhyas. These faults are supposed to be caused by bend or 'sagging' of the northern part of the Peninsula at the time of upheaval of the Himalayas. According to **D.N. Wadia** (1975) the Peninsular block, south of the cracks, tilted slightly eastwards thus giving new orientation to the entire drainage towards the Bay of Bengal. While this line of thought explains the present drainage system of the Peninsular India with greater satisfaction, it still leaves some questions to which there is no satisfactory answer. **R.C. Mehdiratta** (1962) argues that tilting should have increased the gradient of the river valleys and caused some rejuvenation of the rivers. This type of phenomenon is absent in the Peninsula, barring a few exceptions such as waterfalls, as mentioned earlier.

The Peninsular River Systems

Although the general direction of flow of the Peninsular rivers is from west to east, a careful study reveals at least three main directions of flow :

(*i*) The Mahanadi, the Godavari, the Krishna, the Cauvery and several smaller rivers draining south-east into the Bay of Bengal.

(*ii*) The Narmada and the Tapi flowing west as well as several small streams originating from the Western Ghats flow westwards into the Arabian Sea.

(*iii*) Tributaries of the Ganga and the Yamuna such as the Chambal, the Betwa, the Ken, the Son and the Damodar flow in the north-easterly direction.

The East Flowing Rivers of the Peninsula

The Mahanadi (literally meaning big river) is an important river of the Peninsular India. It has its source in the northern foothills of Dandakaranya near Sihawa in Raipur District of Chhattisgarh at an elevation of 442 m. Its upper course lies in the saucer-shaped basin called the 'Chhattisgarh Plain'. This basin is surrounded by hills on the north, west and south as a result of which a large number of tributaries join the main river from these sides. The main tributaries are the *Ib* (251 km), the *Mand* (241 km), the *Hasdo* (333 km) and the *Sheonath* (383 km) on the left bank and the *Ong* (204 km), the *Jonk* (196 km), and the *Tel* (295 km) on the right bank. From its source, the river takes a north easterly course. Beyond Seorinarayan it flows eastwards and after entering Odisha, it turns southwards below the Hirakud Dam. Further below it turns eastwards near Sonepur. On reaching the Eastern Ghats, the river flows through a narrow Gorge for 23 km near Tikkarpara Range and finally emerges in a delta at Naraj 11 km west of Cuttack. The Mahanadi finally empties itself in the Bay of Bengal after flowing for a distance of 857 km. The delta of Mahanadi spreads over an area of 9,500 sq km and is over 150 km broad.

The Godavari is the largest river system of the Peninsular India and is next only to the Ganga and the Indus Systems regarding sanctity, picturesqueness and utility and is held in reverence as *Vridha Ganga* or *Dakshina Ganga*. Its total length is 1,465 kilometres. The source of this river is in the Trimbak Plateau of North Sahyadri near Nashik in Maharashtra which is only 80 km from the shore of the Arabian Sea. From its source it flows eastwards in a narrow rocky bed upto Nashik but the river valley opens out below this point. It receives a large number of tributaries both from the left as well as from the right. But the left bank tributaries are more in number and larger in size than the right bank tributaries. The *Manjra* (724 km) is the only important right bank tributary. It originates from Jamkhed Hill in Central Maharashtra and joins the Godavari near Kondalwadi after passing through the Nizam Sagar. The *Penganga*, the *Wardha*, the *Wainganga*, the *Indravati* and the *Sabari* are important left bank tributaries. The *Penganga* (676 km) rises from the Buldana Range and joins the Wardha River (483 km) near Ghughus. The Wardha in its turn joins the Wainganga. The united Wardha and Wainganga rivers become the short span *Pranhita* river which joins the Godavari below Sironcha. The *Indravati* river from the Kondhan Hills of Eastern Ghats joins the master river about 48 km downstream from Sironcha. Below its confluence with Indravati, the Godavari flows in a gorge, 60 km long and 200 m wide through the Eastern Ghats. It is located about 100 km from the mouth of the river and is supposed to be formed due to faulting. Below Rajahmundry, the river divides itself into two main streams, the *Gautami Godavari* on the east and the *Vashishta Godavari* on the west and forms a large delta before it pours into the Bay of Bengal. The current at Rajahmundry is not rapid and varies from 1.2 to 3.3 metres per second. The delta has a front of 120 km and projects about 35 km into the sea. The delta of the Godavari is of *lobate type* with a round bulge and many distributaries. The Godavari causes heavy floods in its lower course below Polawaram. The Godavari is navigable upto a distance of 300 km from its mouth.

The Krishna is the second largest east flowing river of the Peninsula. It rises in the Western Ghats just to the north of Mahabaleshwar, about 64 km from the Arabian Sea and flows for a distance of 1,400 km to the Bay of Bengal in a general easterly direction. The *Koyna*, the *Ghataprabha*, the *Malprabha*, the *Bhima*, the *Tungabhadra*, the *Musi* and the *Muneru* are its important tributaries. **The Koyna** is a small tributary but is very famous for Koyna Dam. This dam was perhaps the main cause of the devastating earthquake in 1967. **The Bhima** originates from the Matheron Hills and joins the Krishna 26 km from Raichur after flowing in the south-easterly direction for a distance of 861 km. Mula, Mutha Ghod and Nora are its sub-tributaries. **The Tungabhadra** is formed by the unification of the *Tunga* and the

Bhadra originating from Gangamula in the Central Sahyadri. Its total length is 531 km. At Wazirabad, it receives its last important tributary, the *Musi*, on whose banks the famous city of Hyderabad is located. The Krishna forms a large delta spreading over an area of 4,600 sq km with a shoreline of about 120 km. The Krishna delta appears to merge with that formed by the Godavari and extends about 35 km into the sea.

Kaveri (Cauvery) is the most revered and sacred river of south India and is designated as the '*Dakshina Ganga*' or '*the Ganga of the South*'. The Source of this river lies at Taal Cauvery on the Brahmagiri range of hills in the Western Ghats at 1,341 m elevation (12° 25′ N and 75° 34′ E) situated in the Coorg Plateau (Coorg district of Karnataka). It flows eastwards for a distance of about 800 km before it empties in the Bay of Bengal. This river is unique in the sense that its upper catchment area receives rainfall during summer by the south-west monsoon and the lower catchment area during winter season by the retreating north-east monsoon. It is, therefore, almost a perennial river with comparatively less fluctuations in flow and is very useful for irrigation and hydroelectric power generation. Thus the Cauvery is one of the best regulated rivers and 90 to 95 per cent of its irrigation and power production potential already stands harnessed.

The Cauvery river falls rapidly by 450 m from its source of origin within a short distance of 8 km. The middle course of the river over the 750 m high Mysore Plateau is characterised by broad and sweeping meanders. The river descends from the South Karnataka Plateau to the Tamil Nadu Plains through the Sivasamudram waterfalls (101 m high). The river which was more than one kilometre wide above the Sivasamudram Falls, narrows down considerably below it and enters a long, picturesque gorge, 200 m deep at places, cut through the Eastern Ghats. The river divides itself into two distinct channels at Srirangam. The northern channel is called Kollidam (Coleroon) while the southern one retains the name Cauvery. The delta formation starts from a point about 16 km away from Tiruchchirappalli. The Cauvery has formed a quadrilateral delta spreading over an area of 8,000 sq km. It has almost a straight front which runs for a distance of 130 km along the coast of Bay of Bengal.

The water flowing in the Cauvery is supplemented by a large number of tributaries which join the master river at different places. The main tributaries are the *Herangi*, the *Hemavati*, the *Lokpavani*, the *Srimsha* and the *Arkavati* from the north and the *Laksmantirtha*, the *Kabani*, the *Suvarnavati*, the *Bhavani* and the *Amravati* from the south.

Among the other east flowing rivers of the Peninsular India are, from north to south, the Subarnarekha, the Brahmani, the Penneru, the Ponnaiyar and the Vaigai. **The Subarnarekha** originates from he Ranchi Plateau in Jharkhand at an elevation of 600 m and flows in south-east direction forming the boundary between West Bengal and Odisha in its lower course. It joins Bay of Bengal forming an estuary between the Ganga and Mahanadi deltas. Its total length is 395 km. **The Brahmani** river comes into existence by the confluence of the *Koel* and the *Sankh* rivers near Rourkela. It has a total length of 800 km. Its main tributaries are the *Kura*, the *Sankhad* and the *Tikra*. Its mouth becomes the northern end of the Mahanadi delta. **The Penneru** river springs from the *Nandi Durg* peak in Karnataka and flows in northward direction. It then enters Andhra Pradesh and takes an easterly course. It forms a narrow estuary before it joins the Bay of Bengal. The total length of the river is 597 km. The principal tributaries of this river are the *Jayamangali*, the *Kunderu*, *Saigileru*, *Chitravari*, *Papagni* and *Cheyyeru*. The *Ponnaiyar* is a small stream which is confined to the coastal area only. South of the Cauvery delta, there are several streams, of which the *Vaigai* is the longest. This flows through dry channels and tends to get lost intermittently and appear again on the surface.

The west flowing rivers of the Peninsula

The west flowing rivers of the Peninsular India are fewer and smaller as compared to their east flowing counterparts. The two major west flowing rivers are the *Narmada* and the *Tapi*. This exceptional behaviour of these two rivers is explained by the supposition that they do not flow in the valleys formed by themselves but have usurped for their channels two fault planes running parallel to the Vindhyas. These faults are supposed to have originated with the bending or '*sagging*' of the northern part of the Peninsula at the time of upheaval of the Himalayas. It is interesting to note that the Peninsular rivers which fall into the Arabian Sea do not form *deltas*, but only *estuaries*. This is due to the fact that the west flowing rivers, especially the Narmada and the Tapi flow through hard rocks and are not able to form distributaries before they enter the sea. The Sabarmati, Mahi and Luni are other rivers of the Peninsular India which flow westwards. Hundreds of small streams originating in the Western Ghats flow swiftly westwards and join the Arabian Sea.

The Narmada is the largest of all the west flowing rivers of the Peninsular India. It rises from the western flanks of the Amarkantak plateau about 22°40′N and 81°45′E at an elevation of 1,057 m in Shahdol district of Madhya Pradesh and flows westwards through a rift valley between the Vindhyan Range on the north and the Satpura Range on the south. Its total length from its source in Amarkantak to its estuary in the Gulf of Khambhat is 1,310 km. For 1,078 km, it flows through Madhya Pradesh. For the next 32 km, it forms the boundary between Madhya Pradesh and Maharashtra and for another 40 km between Maharasthra and Gujarat. The remaining 160 km of its course is in Gujarat. After flowing for 400 km from the source, the river slopes down Jabalpur, where it cascades 15 m into a gorge to form the most spectacular and world famous *Dhuan Dhar (Cloud of Mist) Falls*. Since the gorge is composed of marble, it is popularly known as the *Marble Rocks*. The average descent of the river in its upper basin is 7-9 metres per kilometre. Below Jabalpur, it flows in a narrow elongated and well defined basin and forms a few rapids. It makes two waterfalls of 12 m each at Mandhar and Dardi. Near Maheshwar the river again descends from another small fall of 8 m, known as the Sahasradhara Falls. Emerging from the hills near Gardeshwar, it meanders through an alluvial plain past Bharuch and makes an estuary before entering the Gulf of Khambhat. There are several islands in the estuary of the Narmada of which Aliabet is the largest. At its confluence with the sea, the mouth of the river is about 28 km wide. The Narmada is navigable upto 112 km from its mouth.

Since the river flows through a narrow valley confined by precipitous hills, it does not have many tributaries. The absence of tributaries is especially noted on the right bank of the river where the *Hiran* is the only exception. It is 188 km long and flows parallel to the Bhanru Range in Jabalpur district before falling into the Narmada, north-east of Chhindwara. The other right bank tributaries are the *Orsang*, the *Barna* and the *Kolar*. A few left bank tributaries drain the northern slopes of the Satpura Range and join the Narmada at different places. The important tributaries joining the Narmada on its left bank are the *Burhner* (177 km), the *Banjar* (184 km), the *Shar* (129 km), the *Shakkar* (161 km) the *Tawa* (172 km) and the *Kundi* (169 km).

The Tapi (also known as the *Tapti*) is the second largest west flowing river of the Peninsular India and is known as ***'the twin'*** or ***'the handmaid'*** of the Narmada. It originates from the sacred tank of Multai on the Satpura Plateau in Betul district of Madhya Pradesh at an elevation of 730 m above sea level. It first traverses on open plain and then plunges into a rocky gorge of the Satpura hills between the Kalibhit Range in Nimar and Chikalda in Berar. At a distance of 192 km from its source, the river enters the Nimar region. After crossing the Nimar region of Madhya Pradesh it enters the Khandesh Plain of Maharashtra, lying between the Satpura and the Ajanta Ranges. On entering the Khandesh Plain, it receives the *Purna* river on the left bank. This is the main tributary of the Tapi which originates in the Gawilgarh Hills and joins the main river near Bhusawal. Further west it crosses the Western Ghats through a deep and narrow valley, passes through the alluvial plain of Surat and makes an estuary before falling into the Gulf of Khambhat.

The total length of the river is 730 km. About 48 km stretch of its course is tidal and the river is navigable for only about 32 km from the sea. The important tributaries of this river apart from the Purna River, are the Betul, Patki, Ganjal, Dathranj, Bokad, Bokar Suki, More, Kanki, Guli, Aner, Arunavati, Gomai and Valer on right bank and Ambhora, Khursi, Khandu, Kapra, Sipra, Garja, Khokri, Utaoli, Mona, Vaghur, Girna, Bori, Panjhara, Buray and Amravati on the left bank.

The Sabarmati is the name given to the combined streams the *Sabar* and *Hathmati*. It rises from the hills of Mewar in the Aravali Range and is 320 km long. It flows through a gorge at Dharoi and falls into the Gulf of Khambhat. The important

TABLE 4.3. Major Rivers of the Peninsular India

Name of the river	Source	Length in km	Area drained (sq km)	Volume of average annual flow (million cubic metres)	Important tributaries
Mahanadi	Dandakaranya near Sihawa in Raipur district of Chhattisgarh	857	141,600	67,000	Ib, Mand, Hasdo, Sheonath, Ong, Jonk, Tel
Godavari	Trimbak Plateau near Nashik in Maharashtra	1,465	312,812	105,000	Manjra, Penganga, Wardha, Wainganga, Indravati, Sabari, Pranhita
Krishna	Near Mahabaleshwar in Maharashtra	1,400	258,948	67,670	Koyna, Ghatprabha, Malprabha, Bhima, Tungabhadra, Musi, Muneru
Cauvery	Taal Cauvery Western Ghats	800	87,900	20,950	Herangi, Hemavati, Lokpavani, Shimsha, Arkavati, Lakshmanatirtha, Kabani, Suvanavati, Bhavani, Amaravati
Narmada	Amarkantak Plateau	1,310	98,795	40,700	Hiran, Orsang, Barna, Kolar, Burhner, Banjar, Shar, Shakhar, Tawa, Kundi
Tapi	Multai in Betul Distt. of M.P.	730	65,145	17,980	Purna, Betul, Patki, Ganjal, Dathranj, Bokad, Amravati

tributaries of this river are the *Hathmati*, the *Sedhi*, the *Wakul*, the *Harnav*, the *Meshwa* and the *Vatrak*. The average annual flow of this river is 3,200 million cubic metres.

The **Mahi** river rises in the Vindhyas at an elevation of 500 m and empties itself into the Gulf of Khambhat after flowing for a distance of 533 km. The main tributaries of this river are the *Som*, the *Anas* and the *Panam*.

The **Luni** or the **Salt River** (*Lonari or Lavanavari* in Sanskrit) is named so because its water is brackish below Balotra. Its source lies to the west of Ajmer in the Aravalli at an elevation of 550 m and it flows in a south-west direction. It is a small stream but has got the distinction of flowing through the Thar Desert. The river is known as the *Sagarmati* in its upper course. It is joined by the Sarsuti after passing Govindgarh and it is from this confluence that the river gets its proper name as the Luni. It traverses for a distance of 482 km and is finally lost in the marshy grounds at the head of the Rann of Kachchh. The river has a low gradient and flows through a wide plain without a well marked valley.

West flowing Rivers of the Sahyadris

About six hundred small streams originate from the Western Ghats and flow westwards to fall into the Arabian Sea. The western slopes of the Western Ghats receive heavy rainfall from the south-west monsoons and are able to feed such a large number of streams. Although only about 3% of the areal extent of the basins of India is drained by these rivers, they contain about 18% of the country's water resources. The important rivers falling in this category are the Mandovi, Zuari and Rachol in Goa; Kalinadi, Gangavalli-Bedti, Sharavati, Tadri and Netravati in Karnataka, and Beypore, Pannam, Bharatapuzha, Periyar and Pamba in Kerala. Most of the streams flow swiftly down the steep slope and some of them make waterfalls. The *Jog* or *Gersoppa Falls* (289 m) made by the Sharavati river is the most famous waterfall of India.

Inland Drainage

Some rivers of India are not able to reach the sea and constitute inland drainage. Large parts of the Rajasthan desert and parts of Aksai Chin in Ladakh have inland drainage. The *Ghaggar* is the most important river of inland drainage. It is a seasonal stream which rises on the lower slopes of the Himalayas and forms boundary between Haryana and Punjab. It gets lost in the dry sands of Rajasthan near Hanumangarh after traversing a distance of 465 km. Earlier, this river was an affluent of the Indus, the dry bed of the old channel is still traceable. Its main tributaries are the Tangri, the Markanda, the Saraswati and the Chaitanya. It contains a lot more water in rainy season when its bed becomes 10 km wide at places. Most of the streams draining western slopes of the Aravalli Range dry up immediately after they enter the sandy arid areas to the west of this range.

Differences between the Himalayan and the Peninsular River Systems

The Himalayan rivers are quite different from the rivers of the Peninsular India from the point of view of the drainage features and hydrological characteristics. A brief summary of these differences is given below :

Basis	The Himalayan River System	The Peninsular River System
1. Name	These rivers originate from the lofty Himalayan ranges and are named as the Himalayan rivers.	These rivers originate in the Peninsular Plateau and are named as Peninsular rivers.
2. Basins	These rivers have large basins and catchment areas. The total basin area of the Indus, the Ganga and the Brahmaputra is 11.78, 8.61 and 5.8 lakh square kilometres respectively.	These rivers have small basins and catchment areas. The Godavari has the largest basin area of 3.12 lakh square kilometres only which is less than one-third the basin area of the Indus.
3. Valleys	The Himalayan rivers flow through deep I-shaped valleys called gorges. These gorges have been carved out by down cutting carried on side by side with the uplift of the Himalayas. These are examples of *antecedent drainage*.	The Peninsular rivers flow in comparatively shallow valleys. These are more or less completely graded valleys. The rivers have little erosional activity to perform. These are examples of *consequent drainage*.
4. Water Flow	The Himalayan rivers are perennial in nature, *i.e.*, water flows throughout the year in these rivers. These rivers receive water both from the monsoons and snow-melt. The perennial nature of these rivers makes them useful for irrigation.	The Peninsular rivers receive water only from rainfall and water flows in these rivers in rainy season only. Therefore, these rivers are seasonal or non-perennial. As such these rivers are much less useful for irrigation.
5. Stage	These rivers flow across the young fold mountains and are still in a youthful stage.	These rivers have been flowing in one of the oldest plateaus of the world and have reached maturity.
6. Meanders	The upper reaches of the Himalayan rivers are highly tortuous. When they enter the plains, there is a sudden reduction in the speed of flow of water. Under these circumstances these rivers form meanders and often shift their beds.	The hard rock surface and non-alluvial character of the plateau permits little scope for the formation of meanders. As such, the rivers of the Peninsular Plateau follow more or less straight courses.
7. Deltas and Estuaries	The Himalayan rivers form big deltas at their mouths. The Ganga-Brahmaputra delta is the largest in the world.	Some of the Peninsular rivers, such as the Narmada and the Tapi form estuaries. Other rivers such as the Mahanadi, the Godavari, the Krishna and the Cauvery form deltas. Several small streams originating from the Western Ghats and flowing towards the west enter the Arabian Sea without forming any delta.

RIVER BASINS OF INDIA

River basin is the area drained by the main river and its tributaries. For example, Ganga basin is the area drained by the main Ganga river and its tributaries like Yamuna, Ghaghara, Gondak, Kosi and their sub-tributaries. In a large country like India, it is natural to have different types of river basins. Depending on the size of their catchment area : **Dr. K.L. Rao** (1977), divided the Indian river basins into following three categories :

(*i*) **Major river basins** with catchment area of 20,000 sq km and above account for 85 per cent of the total run-off of all the rivers of India. They are fourteen in all and are in high rainfall areas (*i.e.* 63 million cubic metre per 100 sq km). There are three river systems to the north of Tropic of Cancer, seven between Tropic of Cancer and 20°N latitude and four in the Peninsular India.

(*ii*) **Medium river basins** with a catchment area between 2,000 sq km and 20,000 sq km account for 7% of the total run off of all the rivers. They are 44 in all and have medium rainfall (*i.e.* 45 million cubic metres per 100 sq km). The medium river basins are divided into three sub-groups depending upon their direction of flow. Of them 19 are west flowing, 21 are east flowing and the remaining 4 flow in other directions.

(*iii*) **Minor river basins** with a catchment area below 2,000 sq km account for 8 per cent of the total run off of all the rivers of India. There are 55 such river basins. They are located either in dry areas or in the coastal areas, especially on west coast where the rivers are much shorter due to narrow coastal plain between the coast and the Western Ghats.

Major River Basins

India has 14 major river basins. They are Indus, Ganga, Brahmaputra, Mahanadi, Godavari, Krishna, Kaveri, Narmada, Tapi, Penneru, Brahmani, Mahi,

TABLE 4.4. Surface Flow in Major River Basins of India

Sl. No.	River basins	Basin area*		Annual water yield		Rate of flow	Storage capacity
		(km^2)	%	(million m^3)	%	(m^3/km^2)	(million m^3)
	Major rivers						
1.	Ganga	861,404	26.2	468,700	25.2	442,170	33,467
2.	Indus	321,284	9.8	79,500	4.3	247,441	14,419
3.	Godavari	312,812	9.5	118,000	6.4	377,223	14,859
4.	Krishna	258,948	7.9	62,800	3.4	243,403	29,860
5.	Brahmaputra	258,008	7.8	627,000	33.8	1,081,034	142
6.	Mahanadi	141,589	4.3	66,640	3.6	470,658	7,926
7.	Narmada	98,795	3.0	54,600	2.9	970,658	2,550
8.	Kaveri	87,900	2.7	20,950	1.1	237,770	5,428
9.	Tapi	65,145	2.0	17,982	0.9	267,770	8,140
10.	Penneru	55,213	1.7	3,238	0.2	58,646	1,978
11.	Brahmani	39,033	1.2	18,310	1.0	202,701	3,953
12.	Mahi	34,481	1.0	11,800	0.6	388,681	4,140
13.	Subarnarekha	19,296	0.6	7,940	0.4	411,484	283
14.	Sabarmati	21,895	0.7	3,800	0.2	173,556	1,017
	Medium & minor rivers	711,833	21.6	296.840	16.0	417,008	18,452
	Total (India)	**3,287,782**	**100.0**	**1,858,100**	**100.0**	**565,153**	**146,826**

*Area means basin area in India

Source : S.P. Das Gupta, 1989.

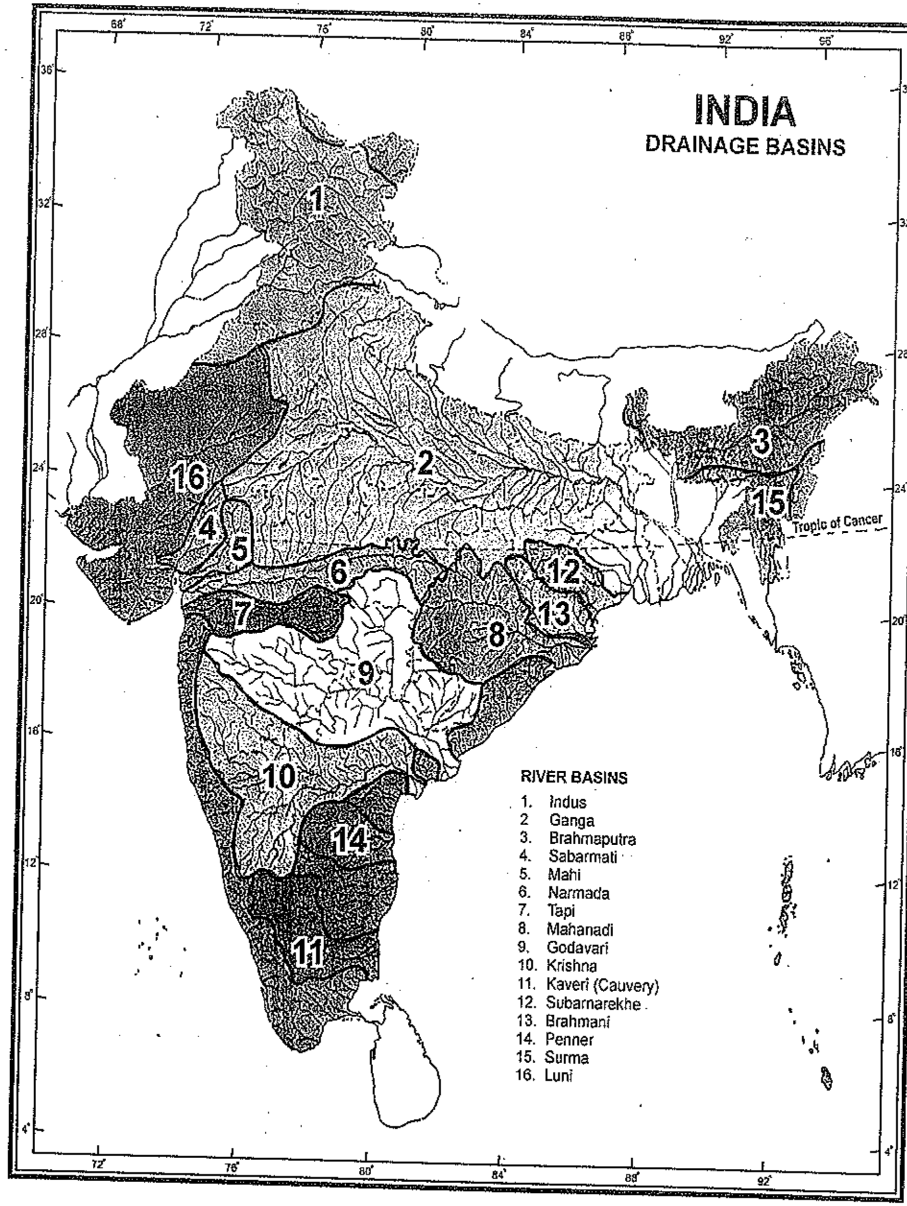

Fig. 4.4. India : Drainage Basins

Sabarmati and Luni. S.P. Das Gupta has treated Subarnarekha also as the major river basin although its basin area is less than 20 thousand sq km (**Table 4.4**). Some other geographers tend to treat Surma and Luni also as major river basins as is indicated in **Fig. 4.4.**

A brief description of some of the important river basins is given as under :

1. The Indus River Basin. The Indus river originates near Manasarover Lake from the glaciers of the Kailas Range in the western part of Tibet, enters India at the border of Jammu and Kashmir with China and traverses this state between the Ladakh and the Zaskar Ranges. The whole of Jammu and Kashmir state excepting its northern and the north-eastern tips is included in this basin. It receives a large number of tributaries on its right bank and its five left bank tributaries *viz.* the Satluj, the Beas, the Ravi, the Jhelum and the Chenab are big rivers in themselves. The Indus has a total drainage area of 1,178,440 sq km out of which about 453,250 sq km lies in the Himalayan mountains and foothills, the rest lies in the Indus plain of India and Pakistan. As a result of partition, Indus drainage basin has been divided between India and Pakistan with major portion going to Pakistan and India has to content with only 321,284 sq km which is about 26.2 per cent of the total drainage area. Apart from Jammu and Kashmir, the whole of Punjab, almost the whole of Himachal Pradesh, northern fringe of Haryana and northern tips of Rajasthan are included in this basin.

2. The Ganga River Basin. Originating from the Gangotri glacier in the Western Himalayas, the Ganga flows towards the south in Uttarakhand and then turns towards the east, flowing through Uttar Pradesh and Bihar and then turn towards the south-east to empty itself in the Bay of Bengal. This mighty river is joined by a large number of tributaries like Yamuna, Ghaghara, Gondak, Kosi, Son etc. In fact, the Ganga has the largest basin in India which stretches over an area of 861,404 sq km and amounts to 26.2% of the total river basin area of India. This basin is shared by ten states. These states are Uttarakhand and Uttar Pradesh (34.2%), Madhya Pradesh and Chhattisgarh (23.1%), Bihar and Jharkhand (16.7%), Rajasthan (13.0%), West Bengal (8.3%), Haryana (4.0%) and Himachal Pradesh (0.5%). The Union Territory of Delhi accounts for 0.2% of the total area of the Ganga Basin.

3. The Brahmaputra River Basin. Like the Indus, the Brahmaputra river also has its source in the western part of Tibet and it flows from west to east in a depression between the Great Himalayas and the Kailas Range. On reaching the extreme east, it takes a sharp turn in the south-west direction and enters India after cutting through the Himalayan range. Its total basin area is 2,58,008 sq km, in India, which is about 7.8 per cent of the total basin area of the country. Most of the drainage area of this river lies in Assam, Arunachal Pradesh and Sikkim. The northern parts of Nagaland and Meghalaya are also included in this basin.

4. The Mahanadi River Basin. Originating from the foothills of Dandakaranya in Chhattisgarh, this river flows in to the east and joins the Bay of Bengal after traversing over a distance of 857 km. The total basin area of this river is 141,589 sq km which is about 4.3% of the total basin area of India. Its major tributaries are Ib, Mand, Hasdo, Seomath, Org, Jonk and Tel. This basin spreads over a large part of Chhattisgarh and middle of Odisha.

5. The Godavari River Basin. The Godavari has the largest basin area of 3,12,812 sq km (9.5% of India) which is larger than even that the great Brahmaputra in Indian territory. Originating in the Trimbak Plateau in Maharashtra, it is joined by a large number of tributaries like Manjra, Penganga, Wardha, Wainganga, Indravati, Sabari and Pranhita. 48.6 per cent is in Maharashtra, 23.8 per cent in Andhra Pradesh and Telangana, 20.7 per cent in Madhya Pradesh and Chhattisgarh, 5.5 per cent in Odisha and only 1.4 per cent in Karnataka.

6. The Krishna River Basin. The Krishna has the second largest basin area of 258,948 sq km (7.9% of all India) after that of the Godavari in the Peninsular India. Originating from the north of Mahabaleshwar, it flows in the east and joins the Bay of Bengal. Its important tributaries are Koyna, Ghataprabha, Malprabha, Bhima, Musi, Tungabhadra and Muneru. Its basin area is quite wide in the west in the states of Maharashtra and Karnataka and narrows down considerably in Telengana and Andhra Pradesh and it is narrowest in the delta region.

7. The Kaveri (Cauvery) River Basin. Originating in the Western Ghats, it traverses 800 km in the eastern direction before joining the Bay of Bengal. The tributaries joining the main river from the north are the Herangi, the Hemavati, the Lakpavani, the Srimsha and the Arkawali while those joining from the south are the Lakshmantirtha, the Kabani, the Suvarnavati, the Bhavani and the

Amravati. Its total basin area is 87,900 sq km (2.7% of the India) which is shared by two states of Karnataka and Tamil Nadu.

8. The Narmada River Basin. This river originates from the Amarkantak Plateau and flows westward to join the Arabian sea in the Gulf of Khambhat after forming an estirary. Since it flows through a rift valley, it does not receive any tributary worth the name as a result of which its basin is elongated, quite long in the east and west direction and quite narrow in the north-south direction. The total area of this basin is 98,795 sq km (3.0% of all India), most part of which lies in Madhya Pradesh with small part lying in Gujarat.

9. The Tapi River Basin. South of the Narmada river flows the Tapi river in the east-west direction. It originates from the Maltai Tank in Betul district of Madhya Pradesh and traverses a distance of 730 km before entering the Arabian sea. Its total basin area of 65,145 sq km which is about 2.0% of the all India basins. Like the Narmada, the Tapi river also does not have large tributaries and its basin area is alongated with its long side in east-west direction.

10. The Penneru River Basin. The Penneru river originates from the Nandi Durg in Karnataka and enters Andhra Pradesh where its flows in an easterly direction to join the Bay of Bengal after forming a small estuary. This is a comparatively small river basin covering an area of 55,213 sq km (1.7%).

11. The Brahmani River Basin. The Brahmani river takes its birth at the confluence of the Koel and the Sankh rivers near Rourkela. Tributaries like Kura, Sankhad and Tikra join the main river enabling the Brahmani river basin to spread over an area of 39,033 sq km (1.2%) in the state of Odisha.

12. The Mahi River Basin. This 533 km long river originates in the Vindhyas and empties itself in the Gulf of Khambat. The Son, the Anas and the Panam are its main tributaries. Its total basin area is 34,481 sq km which is shared by Rajasthan (47%), Gujarat (34%) and Madhya Pradesh (19%).

13. The Sabarmati River Basin. This 320 km long river is the combined name of the Sabar and the Hathmati which originate in the hills of Mewar in the Aravali range and empties itself in the Gulf of Khambhat. Its main tributaries are the Hathmati, the Sedhi, the Wakul, the Harnav, the Mehswa and the Vatrak. The total basin area is 21,895 (0.7%), which entirely lies in Gujarat.

14. The Luni River Basin. Part of this river has salty water as a result of which it is known as the Luni river. It originates in the west of Ajmer and flows through the Thar Desert and is lost in the marshy grounds at the head of the Ranu of Kachchh. It flows through a wide plain without a well marked valley. This river has a vast basin which spreads over Rajasthan and Gujarat.

River Regimes

River regime is the seasonal fluctuation in the volume of water in a river. The climatic differences in the sources of the Himalayan and the Peninsular rivers lead to the differences in the drainage patterns of these two areas. The Himalayan rivers are perennial because their regimes depend upon water supply both from rainfall and snow-melt. Thus, the regimes of the Himalayan rivers are both monsoonal as well as glacial. On the other hand, the Peninsular rivers receive water from rainfall only and their regimes are only monsoonal.

Fig. 4.5 shows hydrographs of two Himalayan and two Peninsular rivers depicting their regimes. These graphs show the monthly discharge of water flowing in these rivers. This discharge is measured in *cusecs* (cubic feet per second) or *cumecs* (cubic metres per second).

The Ganga has minimum flow from January to June. The maximum is attained in August or September. The rate of flow steadily falls after September. The Ganga has, thus, a typical monsoonal regime. However, there is enough water in this river before the monsoon rains mainly because of snow-melt in the Himalayas. Another Himalayan river, the Jhelum attains its maximum flow in June or even in May mainly because of Himalayan snow-melt. An interesting difference between the regimes of the two rivers is seen in the range of variation between the maximum and the minimum flow. This difference is sharper in the case of the Ganga than the Jhelum. The mean maximum discharge of the Ganga at Farakka is about 45,000 cusecs, while the mean minimum is only 1,300 cusecs. The Jhelum, however, has a less voluminous discharge, the respective mean maximum

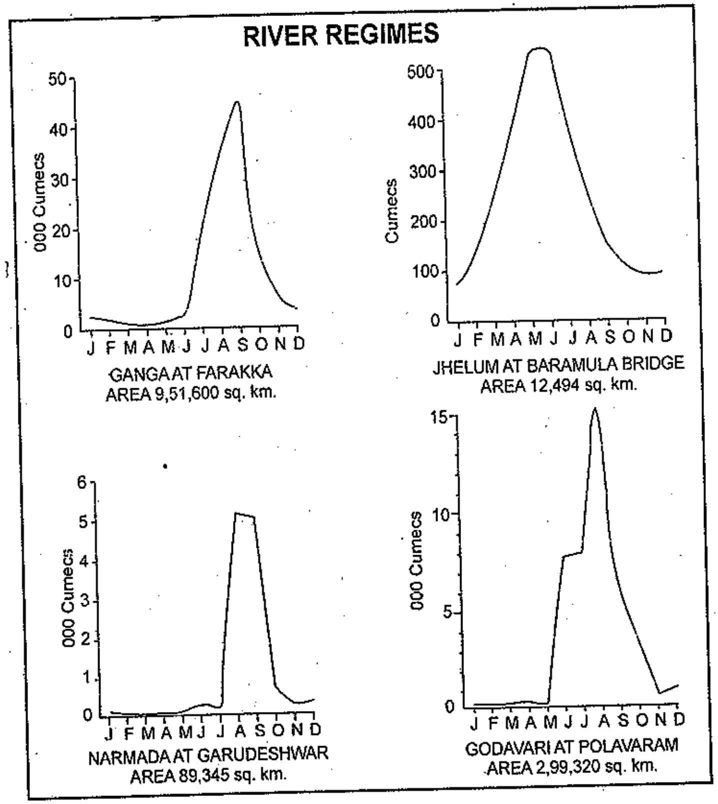

FIG. 4.5. River Regimes

flow being 600 cusecs and the mean minimum 50 cusecs.

The two Peninsular rivers display interesting differences from the Himalayan rivers in their regimes. The Narmada has a very low volume of discharge from January to July which suddenly rises in August when the maximum is attained. The river, however, maintains its fall as spectacular as the rise in August. The Godavari flows at a low level until May. It has a double maxima—one in May-June and other in July-August. After August, there is a sharp fall in discharge, although the volume of flow in October and November is higher than in any of the months from January to May. The mean maximum discharge of the Godavari at *Polauaram* is 3,200 cusecs, while the mean minimum flow is only 50 cusecs. The respective values for the Narmada, as recorded at Garudeshwar, are 2,300 cusecs and 15 cusecs.

Usability of Rivers

Rivers are of great use for us because they comprise a great source of fresh water. In fact most of our requirements of fresh water are met by rivers. The volume of annual precipitation in the country is estimated at about 37,00,400 million cubic metres. A large part of it seeps into the ground and some part is lost by evaporation and transpiration. We use river waters for a variety of purposes such as irrigation, hydro-electric production navigation etc. Large quantity of water is supplied to cities and villages for domestic consumption. A large number of industries also depend upon water.

1. Irrigation. The largest amount of river water is used for irrigation. Indian rivers carry about 18,58,100 million cubic metres of water per year. Due to uneven topography and seasonal flow of the rivers, all this amount is not usable. About 5,55,166 million cubic metres river waters are actually used for irrigation through canals. This amounts to about 30 per cent of the annual flow of the Indian rivers.

2. Hydro-electric Production, Large rivers have great water power potential. The Himalayas in the north, the Vindhyas, the Satpura and the Aravalli in the west, the Maikala and Chhotanagpur in the east, the Meghalaya plateau and Purvachal in the northeast, and Western and the Eastern Ghats of the Deccan plateau offer possibilities of large scale water power development. Sixty per cent of the total river flow is concentrated in the Himalayan rivers, 16 per cent in the Central Indian rivers (the Narmada, the Tapi, the Mahanadi, etc.), and the rest in the rivers of the Deccan plateau. Dependable power generation from the peninsular rivers requires impounding of water during the monsoon months. The Himalayan rivers do not have such problem as their flow is appreciable even during the critical winter months. They, however, have other kind of problems, namely, difficulty in construction of large storage on account of narrow valleys, high seismicity of the region and vast alluvial plain with no variation of relief. The country has an exploitable power potential of about 41 million KW at 60 per cent load factor from these rivers.

3. Navigation. The Ganga and the Brahmaputra in the north and northeastern part of the country, the Mahanadi in Odisha, the Godavari and the Krishna in Andhra and Telangana the Narmada and the Tapi in Gujarat, and the lakes and tidal creeks in coastal states possess some of the important and useful waterways of the country. In the past they were of great importance, which suffered a great deal with the advent of rail and roads. Withdrawal of large quantities of water for irrigation resulted in dwindling flow of many rivers. The most important navigable risers are the Ganga, the Brahmaputra and the Mahanadi. The Godavari, the Krishna, the Narmada and the Tapi are navigable near their mouths only.

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CHAPTER 5

Climate

INTRODUCTION

Climate of a country includes the study of temperature, rainfall, atmospheric pressure, as well as the direction and velocity of winds over a long period of time. These elements of climate are largely influenced by latitudinal extent, relief, and a real distribution of land and water. The *Tropic of Cancer* passes through the middle of the country. In the north, the Indian subcontinent is separated from the rest of Asia by the Himalayan ranges as a result of which the cold air masses from Central Asia cannot enter India. During winter, the northern half of India is warmer by 3°C to 8°C than other areas located on these latitudes. Thus the whole of India, south of the Himalayas is climatically treated as a tropical country. According to **L.D. Stamp**, "India is basically a tropical country although its northern part is situated in the temperate belt." In the south, the Indian coasts are washed by the Arabian Sea and the Bay of Bengal branches of the Indian Ocean which give it a typical tropical monsoon climate. *India is par excellence, a tropical monsoon country.*

DIVERSITY IN THE UNITY OF INDIAN MONSOON CLIMATE

Notwithstanding its broad climatic unity, the climate of India has many regional variations, expressed in the pattern of winds, temperature and rainfall, rhythm of seasons and the degree of wetness or dryness. These climatic differences are due to location, altitude, distance from sea and relief. The vast size of the country, coupled with its topographical variations is responsible for a great variety of climatic conditions in India. **Blanford** was highly impressed by climatic diversities of India and stated "We may speak of climates but not the climate of India, for the world itself affords, no greater contrast than is to be met with at one and the same time within its limits." ***Marsden*** too believed that India possesses all types of climate found in the world. The main examples of diversities in the monsoonal unity of Indian climate are briefed as under :

1. The day temperature in the month of June may soar to 48°-50°C at Barmer in Rajasthan while it may hardly reach 22°C at

Gulmarg or Pahalgam in Kashmir at the same time.

2. On a December night, the temperature may dip to –40°C at Dras or Kargil in J&K while it may be as high as 20°C-22°C at Thiruvananthapuram or Chennai at the same time.
3. Mawsynram in Meghalaya receives as high as 1,221 cm of annual rainfall while at Jaisalmer (Rajasthan) the annual rainfall rarely exceeds 12 cm. Tura, in the Garo Hills, may sometimes receive as much rainfall in a single day as is received by Jaisalmer in 10 years.
4. The Ganga delta and the coastal plains of Odisha are hit by strong rain storms almost every third or fifth day in July and August, while the Coromandel Coast, a thousand kilometres to the south, goes dry during these months.
5. The people of Mumbai and the Konkan Coast do not have to suffer the extremes of climate but these extremes affect the life of people of interior parts of the country such as Delhi and Agra.
6. Places like Goa, Hyderabad, Bhubaneshwar and Patna get rains by the first quarter of June while the rains are awaited till the end of June or early July at places like Agra, Delhi and Chandigarh.

FACTORS INFLUENCING THE CLIMATE OF INDIA

The climate of India is a complex phenomenon and is influenced by a large number of geographical factors. Some of the important factors are briefly discussed as under :

1. Location and Latitudinal Extent. The mainland of India extends roughly from 8°N to 37°N and the Tropic of Cancer passes through the middle of the country. Areas south of the Tropic of Cancer are closer to the equator and experience high temperature throughout the year. The northern parts on the other hand lie in the warm temperate zone. Hence they experience comparatively lower temperatures. Some places record considerably low temperatures particularly in winter. Water bodies comprising the Arabian sea and the Bay of Bengal surround the peninsular India and make climatic conditions mild along the coastal areas.

2. Distance from the Sea. Areas near the coast have equable or *maritine climate*. On the contrary, interior locations are deprived of the moderating influence of the sea and experience extreme or *continental climate*. For example the annual range of temperature at Kochi does not exceed 3°C whereas it is as high as 20°C at Delhi. Similarly, the amount of annual rainfall at Kolkata is 119 cm which falls to a low of 24 cm at Bikaner.

3. The Northern Mountain Ranges. As mentioned earlier, India is separated from the rest of Asia by the impenetrable wall of the Himalayan mountain ranges. These ranges protect India from the bitterly cold and dry winds of Central Asia during winter. Further, these mountain ranges act as an effective physical barrier for rain bearing south-west monsoon winds to cross the northern frontiers of India. Thus, the Himalayan mountain ranges act as a climatic divide between the Indian Sub-continent and Central Asia.

4. Physiography. Physiography of India has a great bearing on major elements of climate such as temperature, atmospheric pressure, direction of winds and the amount of rainfall. In fact, physical map of India is very closely related to the climatic conditions of the country. Places located at higher altitude have cool climate even though they are located in the peninsular India, *e.g.*, Ooty. Several hill stations and the Himalayan ranges are much cooler than the places located in the Great Plain of North India. The greatest control of physiography in the peninsular India is seen in the distribution of rainfall. The south-west monsoon winds from the Arabian sea strike almost perpendicular at the Western Ghats and cause copious rainfall in the Western Coastal plain and the western slopes of the Western Ghats. On the contrary, vast areas of Maharashtra, Karnataka, Telangana, Andhra Pradesh and Tamil Nadu lie in *rainishadow* or *leewood* side of the Western Ghats and receive scanty rainfall. The physiographic control of the mighty Himalayas over the climate of the country goes without saying. The monsoon winds from the Bay of Bengal are bifurcated into two branches by the physiographic features. One branch goes to the

Brahmaputra valley through the Meghalaya plateau. Here the funnel shaped Cherrapunji valley forces the moisture laden monsoon winds to rise along the steep slope and make this area the wettest place in the world. The other branch of monsoons from the Bay of Bengal enters the Ganga valley. Its northward-movement is obstructed by the Himalayan ranges and it advances westwards up the Ganga plain. Initially this branch causes heavy rainfall but the amount of rainfall decreases as the monsoons loose much of the moisture content while advancing westwards.

5. Monsoon Winds. The most dominating factor of the Indian climate is the 'monsoon winds' as a result of which it is often called the *monsoon climate*. The complete reversal of the monsoon winds brings about a sudden change in the seasons—the harsh summer season suddenly giving way to eagerly awaited monsoon or rainy season. The south-west summer monsoons from the Arabian sea and the Bay of Bengal bring rainfall to the entire country. The north-eastern winter monsoon travel from land to sea and do not cause much rainfall except along the Caromandel coast after getting moisture from the Bay of Bengal.

6. Upper Air Circulation. The changes in the upper air circulation over Indian landmass influences the climate of India to a great extent. Jet streams in the upper air system influence the Indian climate in the following ways :

(i) Westerly Jet Stream. Westerly jet stream blows at a very high speed during winter over the sub-tropical zone. This jet stream is bifurcated by the Himalayan ranges. The northern branch of this jet stream blows along the northern edge of this barrier. The southern branch blows eastwards south of the Himalayan ranges along 25° north latitude. Meteorologists believe that this branch of jet stream exercises a significant influence on the winter weather conditions in India. This jet stream is responsible for bringing western disturbances from the Mediterranean region in to the Indian sub-continent. Winter rain and heat storms in north-western plains and occasional heavy snowfall in hilly regions are caused by these disturbances. These are generally followed by cold waves in the whole of northern plains.

(ii) Easterly Jet Stream. Reversal in upper air circulation takes place in summer due to the apparent shift of the sun's vertical rays in the northern hemisphere. The westerly jet stream is replaced by the easterly jet stream which owes its origin to the heating of the Tibet plateau. This leads to the development of an easterly cold jet stream centered around 15°N latitude and blowing over peninsular India. This helps in the sudden onset of the south-west monsoons.

7. Tropical Cyclones and Western Disturbances. Tropical cyclones originate in the Bay of Bengal and Arabian Sea and the influence large parts of the peninsular India. Majority of the cyclones originate in the Bay of Bengal and influence the weather conditions during the south-west monsoon season. Some cyclones are born during the retreating monsoon season, *i.e.*, in October and November and influence the weather conditions along the eastern coast of India.

The western disturbances originate over the Mediterranean sea and travel eastward under the influence of westerly jet stream. They influence the winter weather conditions over most of Northern-plains and Western Himalayan region.

8. El-Nino Effect. El-Nino is a narrow warm current which occasionally appears off the coast of Peru in December (See **Fig. 5.9**). It is a temporary replacement of the cold Peru current which normally flows along the coast. This current is responsible for wide spread floods and droughts in the tropical regions of the world. Sometimes it becomes more intense and increases the surface water temperatures of the sea by 10°C. This warming of tropical Pacific waters affects the global pattern of pressure and wind systems including the monsoon winds in the Indian Ocean. Meteorologists believe that the severe droughts of 1987, 2009 and 2014 in India were caused by El-Nino.

9. La Nina. After an El-Nino, weather conditions return to normal. However, some times trade winds become so strong that they cause abnormal accumulation of cold water in the central and eastern Pacific region. This event is called *La Nina*, which in effect is the complete reversal of El Nino. A La Nina also marks an active hurricane season. But in India, the presence of La Nina portends exceptionally good news. It is the harbinger of heavy monsoon showers in India.

La Nina usually follows a strong El Nino. How the two weather pattern anomalies compare :

El Nino the little boy	La Nino the little girl
• Trade winds weaken, warm waters move east	• Strong Pacific trade winds blow from surface water westward.
• Pacific jet stream is pulled further south than normal; picks up storms the jet stream could normally miss	• Cold water rises to the surface
• Weakens Indian monsoons	• Strengthens Indian monsoons
• El Nino occurs after 3 to 5 years	• La Nino occurs roughly half as often as El Nino; lasts from 1 to 3 years.

10. Southern Oscillation. There is a strange linkage of meteorological changes often observed between the Indian and the Pacific Oceans. It has been noticed that whenever the surface level pressure is high over the Indian Ocean, there is low pressure over the Pacific Ocean and *vice-versa*. This inter-relation of high and low pressure over the Pacific and the Indian Ocean is called ***Southern Oscillation***. When the winter pressure is high over the Pacific Ocean and low over the Indian ocean, the south-west monsoons in India tend to be stronger. In the reverse case, the monsoons are most likely to be weaker.

THE MONSOON WINDS

The term monsoon has been derived from the Arabic *mausin* or from the Malayan *monsin* meaning '*season*'. Thus the monsoons are seasonal winds which reverse their direction of flow with the change of season. They flow from sea to land during the summer and from land to sea during winter. In other words, the monsoon is a double system of seasonal winds, that is, the sum of summer and winter winds. There seems to be a lack of agreement on a precise definition of the monsoon and different scholars have tried to define the monsoon winds in different ways.

According to **A.A. Rama Sastry**, "*Monsoons are large scale seasonal wind systems flowing over vast areas of the globe, persistently in the same direction, only to be reversed with the change of season.*" H.G. **Dobby** is of the opinion that "*reversal of wind system is the key-note of the monsoonal climate*". The reversal of the monsoon wind system is fully emphasised by **Conrad**. According to him, "*a true thermal monsoon demands a complete reversal of winds, that is an angle of about 180° between the dominant winds at extreme seasons*". This is further elaborated by **P.A. Menon**, when he expressed the opinion that "*the main criterion used in demarcating the monsoon areas is the reversal of wind systems between summer and winter*". Thus between July and January there should be a shift of nearly 180° in the prevailing wind direction with seasonal wind showing high degree of steadiness. The reversal of monsoon winds take place in a definite manner keeping rhythm with change of season. Therefore, it is often said that *rhythm is the key-note of the monsoonal climate*. Some scholars tend to treat the monsoon winds as land and sea breezes on a large scale. **Koppen** (1923), **Hann** (1932) and **Angot** (1943) believe that the "*monsoons represent simply a land and sea breezes on a large scale, and that the annual period of the monsoon corresponds to the diurnal period of the breezes.*"

While discussing the monsoon winds **C.S. Ramage** (1971) suggested the following four features of monsoon winds :

(*i*) The prevailing wind direction should shift by at least 120° between January and July.

(*ii*) The average frequency of prevailing wind directions in January and July should exceed 40 per cent.

(*iii*) The mean resultant wind velocity in at least one of the months should exceed 3 m/s.

(*iv*) There should be fewer than one cyclone-anticyclone alternation every two years, in either month, over a five degree latitude/longitude grid.

On the basis of above criteria he demarcated the area of the monsoon region as a rectangle roughly extending from 35° N to 25° S latitudes and 30° W to 173° E longitudes.

Mechanism of the Monsoons

The origin of monsoons is still shrouded in mystery. Several attempts have been made to explain the mechanism of the monsoons but no satisfactory

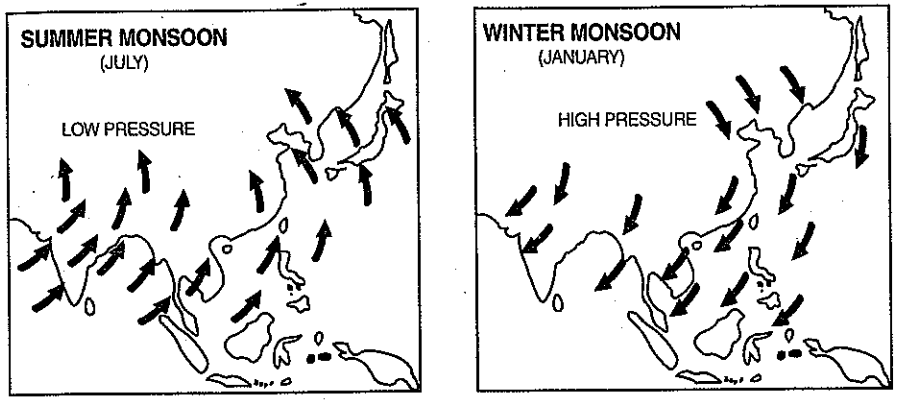

FIG. 5.1. Summer and Winter Monsoon

explanation is available till date. Over the years many mysteries of the monsoons have been unravelled but still much remains to be done. The theories regarding the monsoons are generally divided into following two broad categories :

1. Classical Theory, and
2. Modern Theories.

1. Classical Theory. Although monsoons are mentioned in our old scriptures like the *Rig Veda* and in the writings of several Greek and Buddhist scholars, the credit for first scientific study of the monsoon winds goes to the Arabs. Near about the tenth century, Al Masudi, an Arab explorer from Baghdad, gave an account of the reversal of ocean currents and the monsoon winds over the north Indian Ocean. Date of commencement of monsoons at several places was reported by Sidi Ali in 1554 A.D.

In 1686 the famous Englishman Sir Edmund Halley explained the monsoon as resulting from thermal contrasts between continents and oceans due to their differential heating. Accordingly, Halley conceived summer and winter monsoons depending upon the season.

(a) *Summer Monsoon.* In summer the sun shines vertically over the *Tropic of Cancer* resulting in high temperature and low pressure in Central Asia while the pressure is still sufficiently high over Arabian Sea and Bay of Bengal. This induces air flow from sea to land and brings heavy rainfall to India and her neighbouring countries.

(*b*) *Winter Monsoon.* In winter the sun shines vertically over the Tropic of Capricorn. The north western part of India grows colder than Arabian Sea and Bay of Bengal and the flow of the monsoon is reversed (**Fig. 5.1**).

Halley's ideas are basically the same as those involved in land and sea breeze except that in the case of the monsoon day and night are replaced by summer and winter, and the narrow coastal strip and adjacent sea are replaced by large portions of continents and oceans.

2. Modern Theories. Halley's classical theory based on differential heating of land and water as the main driving force of the monsoon winds dominated the scene for about three centuries. However, the monsoons do not develop equally everywhere and the thermal concept of Halley fails to explain the intricacies of the monsoons. Besides differential heating, the development of monsoon is influenced by the shape of the continents, orography, and the conditions of air circulation in the upper troposphere. Therefore, Halley's theory has lost much of its significance and modern theories based on air masses and jet stream are becoming more relevant. Although Halley's ideas have not yet been outrightly rejected, studies during the last six decades have thrown much light on the genesis of the monsoons. During these years, Flohn, Thompson, Stephenson, Frost, M.T. Yin, Hwang, Takahashi, E. Palmen, C. Newton and Indian meteorologists including P. Koteswaram, Krishnan, Raman, Ramanathan, Krishna Murti, Rama

Rattan, Ramaswami, Anant Krishnan, etc. have contributed a lot to the study of the monsoon winds.

Air Mass Theory. The southeast trade winds in the southern hemisphere and the northeast trade winds in the northern hemisphere meet each other near the equator. The meeting place of these winds is known as the ***Inter-Tropical Convergence Zone (ITCZ)***. Satellite imagery reveals that this is the region of ascending air, maximum clouds and heavy rainfall. The location of ITCZ shifts north and south of equator with the change of season. In the summer season, the sun shines vertically over the *Tropic of Cancer* and the ITCZ shifts northwards. The southeast trade winds of the southern hemisphere cross the equator and start blowing from southwest to northeast direction under the influence of *coriolis force* (**Fig. 5.2**). These displaced trade winds are called ***south-west monsoons*** when they blow over the Indian sub-continent. The front where the south-west monsoons meet the north-east trade winds is known as the ***Monsoon Front***.

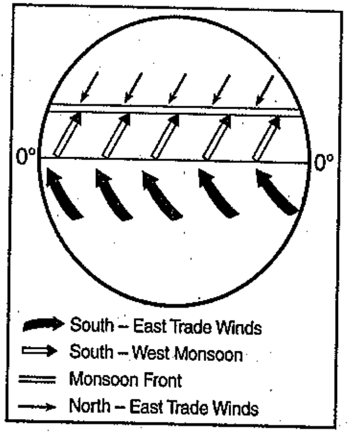

FIG. 5.2. Northward shifting of ITCZ and the wind system in summer season of northern hemisphere.

In the month of July the ITCZ shifts to 20°- 25° N latitude and is located in the Indo-Gangetic Plain and the south-west monsoons blow from the Arabian Sea and the Bay of Bengal (**Fig. 5.3**). The ITCZ in this position is often called the ***Monsoon Trough***.

H. Flohn of the German Weather Bureau, while rejecting the classical theory of origin of monsoons suggested that the tropical monsoon of tropical Asia is simply a modification of the planetary winds of the tropics. He thinks of the thermal low of northern India and the accompanying monsoon as simply an unusually great northward displacement of the Northern Inter-Tropical Convergence Zone (NITCZ). The seasonal shift of the ITCZ has given the concept of Northern Inter-Tropical Convergence Zone (NITCZ) in summer (July) and Southern Inter-Tropical Convergence Zone (SITCZ) in winter (Jan.). The fact that the NITCZ is drawn to about 30° latitude may be associated with the unusually high temperature over north India. According to this interpretation the main westerly current of the monsoon is simply the expanded equatorial westerlies which lie embedded in the great mass of tropical easterlies or the trade winds. NITCZ is the zone of clouds and heavy rainfall.

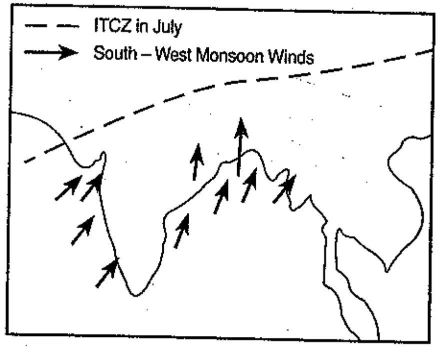

FIG. 5.3. ITCZ and S.W. Monsoon winds

Jet Stream Theory. Jet stream is a band of fast moving air from west to east usually found in the middle latitudes in the upper troposphere at a height of about 12 km. The wind speeds in a westerly jet stream are commonly 150 to 300 km p.h. with extreme values reaching 400 km p.h. Jet stream is the latest theory regarding the origin of the monsoons and has earned world wide acceptance and acclaim from the meteorologists.

M.T. Yin (1949), while discussing the origin of the monsoons expressed the opinion that the burst of monsoon depends upon the upper air circulation. The low latitude upper air trough shifts from 90° E to 80° E longitude in response to the northward shift of the western jet stream in summer. The southern jet becomes active and heavy rainfall is caused by south-west monsoons.

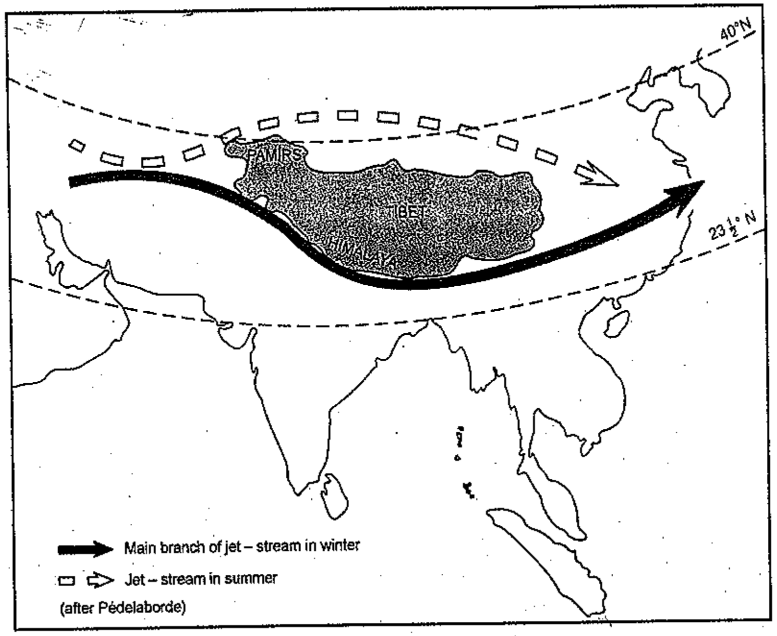

FIG. 5.4. Jet Stream (After Pedelaborde)

Yin's ideas are well recognised by **Pierre Pedelaborde** (1963), in his book entitled ***'The Monsoon'***. The map, showing the seasonal shift of the westerly jet stream, has been reproduced in **figure 5.4**. It shows that in winter the western jet stream flows along the southern slopes of the Himalayas but in summer it shifts northwards, rather dramatically, and flows along the northern edge of the Tibet Plateau. The periodic movements of the Jet stream are often indicators of the onset and subsequent withdrawal of the monsoon.

P. Koteswaram (1952), put forward his ideas about the monsoon winds based on his studies of upper air circulation. He has tried to establish a relationship between the monsoons and the atmospheric conditions prevailing over Tibet Plateau. Tibet is an ellipsoidal plateau at an altitude of about 4,000 m above sea level with an area of about 4.5 million sq km This plateau is surrounded by mountain ranges which rise 6,000-8,000 m above sea level. It gets heated in summer and is 2°C to 3°C warmer than the air over the adjoining regions. Koteswaram, supported by Flohn, feels that because the Tibet Plateau is a source of heat for the atmosphere, it generates an area of rising air. During its ascent the air spreads outwards and gradually sinks over the equatorial part of the Indian Ocean. At this stage, the ascending air is deflected to the right by the earth's rotation and moves in an anti-clockwise direction leading to anticyclonic conditions in the upper troposphere over Tibet around 300-200 mb (9 to 12 km). It finally approaches the west coast of India as a return current from a south-westerly direction and is termed as equatorial westerlies (**Fig. 5.5**). It picks up moisture from the Indian Ocean and causes copious rainfall in India and adjoining countries.

The south-west monsoon in southern Asia is overlain by strong upper easterlies with a pronounced jet at 100 to 200 mb. These easterly winds, which often record speeds exceeding 100 knot are known as the ***Easterly Jet Stream of the tropics***. The Easterly Jet Stream was first inferred by P. Koteswaram and P.R. Krishna in 1952 and aroused considerable interest among tropical meteorologists. A careful study of the jets would suggest that the core of the easterly jet is at 13 km (150 mb) while that of the westerly jet is at 9 km. Over India, the axis of the strongest winds in the easterly jet may extend from

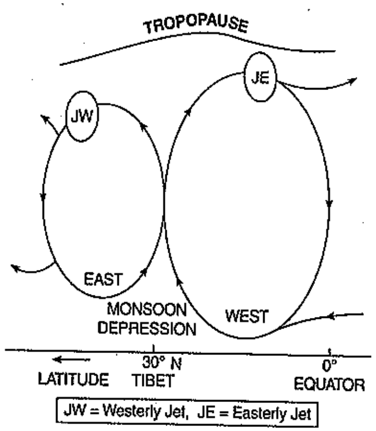

FIG. 5.5. Monsoon as Thermal Engine (After P. Koteswaram)

the southern tip of the peninsula to about 20° N latitude. In this jet stream wind speeds exceeding 100 knot may be recorded. **Figure 5.6** shows the axis of the easterly jet at 12 km (200 mb). The figure shows that there is the subtropical westerly jet to the north of the Himalayas besides the easterly jet over the peninsular India. It has already been made clear in **Fig. 5.4** that the westerly jet stream is located along the southern slopes of the Himalayas in winter but it suddenly shifts to the north with the onset of the monsoon. The periodic movements of the sub-tropical jet stream provide a useful indication of the onset and subsequent withdrawal of the monsoon. In fact, northward movement of the subtropical jet is the first indication of the onset of the monsoon over India.

Recent observations have revealed that the intensity and duration of heating of Tibet Plateau has a direct bearing on the amount of rainfall in India by the monsoons. When the summer temperature of air over Tibet remains high for a sufficiently long time, it helps in strengthening the easterly jet and results in heavy rainfall in India. The easterly jet does not come into existence if the snow over the Tibet Plateau does not melt. This hampers the occurrence of rainfall in India. Therefore, any year of thick and widespread snow over Tibet will be followed by a year of weak monsoon and less rainfall.

Thomson (1951), Flohn, (1960) and Stephenson (1965) have expressed more or less similar views but Flohn's concept is widely accepted. These ideas can be explained by considering the winter and the summer conditions over large parts of Asia.

Winter. This is the season of outblowing surface winds but aloft the westerly airflow dominates. The upper westerlies are split into two distinct currents by the topographical obstacle of the Tibet Plateau, one flowing to the north and the other to the south of the plateau. The two branches reunite off the east coast of China (**Fig. 5.7**). The southern branch over northern India corresponds with a strong latitudinal thermal gradient which, along with other factors, is responsible for the development of southerly jet. The southern branch is stronger, with an average speed of about 240 km p.h. at 200 mb compared with 70 to 90 km p.h. of the northern branch. Air subsiding beneath this upper westerly current gives dry outblowing northerly winds from the subtropical anticyclone over northwestern India and Pakistan. The surface winds blow from northwest over most parts of northern India.

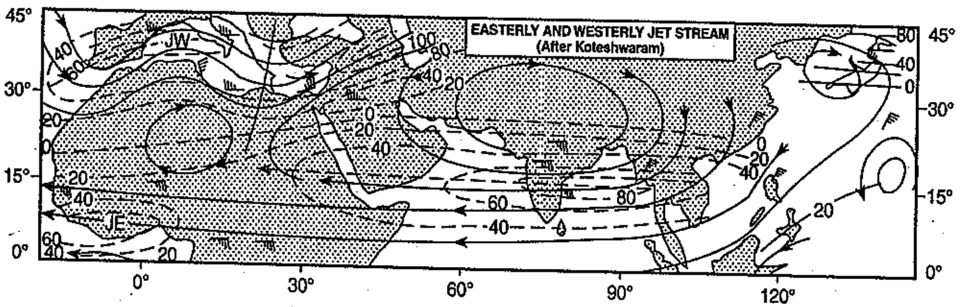

FIG. 5.6. Axis of the Easterly and Westerly Jet stream at 12 km (after Koteswaram) Jet axis are shown by thick broken lines

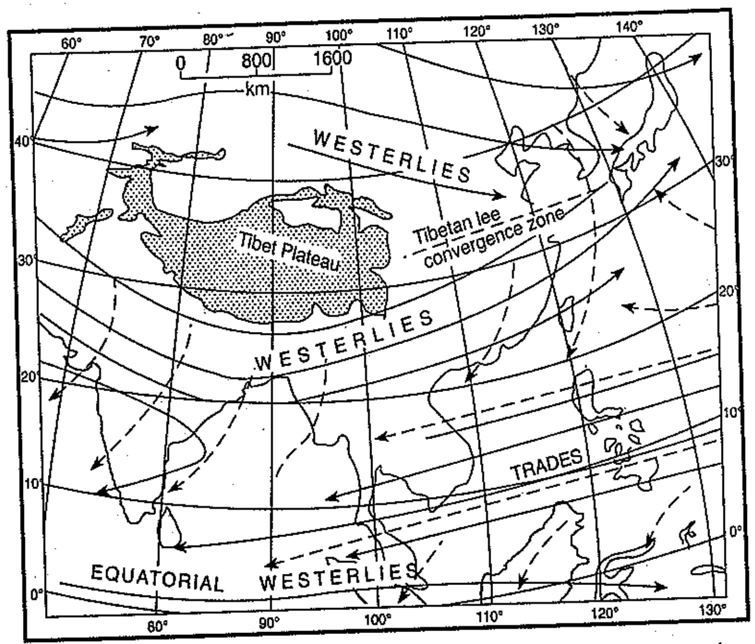

FIG. 5.7. The characteristic air circulation over southern and eastern Asia in winter. Solid lines indicate air flow at about 3000 m and dashed lines that at about 600 m. The names refer to the wind systems aloft.

The upper jet is responsible for steering of the western depressions from the Mediterranean Sea. Some of the depressions continue eastwards, redeveloping in the zone of jet stream confluence about 30° N, 105° E beyond the area of subsidence in the immediate lee of Tibet.

Summer. With the beginning of summer in the month of March, the upper westerlies start their northward march, but whereas the northerly jet strengthens and begins to extend across central China and into Japan, the southerly branch remains positioned south of Tibet, although weakening in intensity. The weather over northern India becomes hot, dry and squally due to larger incoming solar radiation. By the end of May the southern jet begins to break and later it is diverted to the north of Tibet Plateau. Over India, the Equatorial Trough pushes northwards with the weakening of the upper westerlies south of Tibet, but the burst of the monsoon does not take place until the upper-air circulation has switched to its summer pattern (**Fig. 5.8**). The low level changes are related to the high level easterly jet stream over southern Asia about 15° N latitude.

T.N. Krishnamurti used data of the upper atmosphere to calculate the patterns of divergence and convergence at 200 mb for the period of June-August, 1967. He observed an area of strong divergence at 200 mb over northern India and Tibet, which coincides with the upper-level divergence associated with the easterly jet. Similarly he found a northerly component to the flow from this region which represents the upper branch of the *Hadley cell*. These happenings are closely related to the Indian monsoon. **S. Rama Rattan** opined that the development of monsoon winds is deeply connected with the jet stream in addition to the differential heating of land and sea. The upper air circulation in summer has anticyclonic pattern between 40° N and 20° S whereas cyclonic conditions prevail at the surface. Western and eastern jets flow to the north and south of the Himalayas respectively. The eastern jet becomes powerful and is stationed at 15° N latitude. This results in more active south-west monsoon and

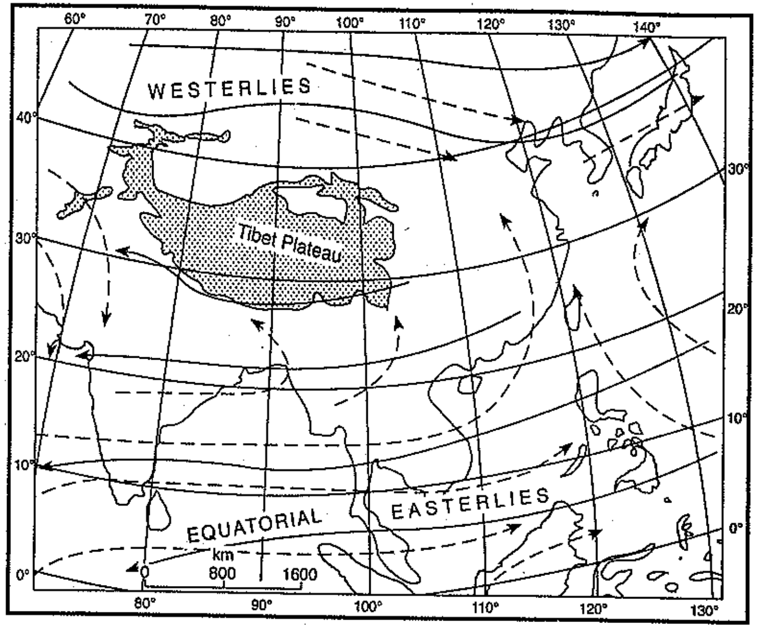

FIG. 5.8. The characteristic air circulation over southern and eastern Asia in summer. Solid lines indicate air flow at about 6,000 m and dashed lines that at about 600 m. Note that the low-level flow is very uniform between about 600 and 3,000 m.

heavy rainfall is caused. **Raman** and **Ramanathan** while discussing the tropical easterly jet stream suggested that the easterly winds become very active in the upper troposphere after the beginning of the rainy season. The latent heat produced due to cloud cover results into *inversion of temperature* and causes rainfall. **Ananth Krishnan** is of the opinion that the south-west monsoons are deeply influenced by the subtropical cyclones in the upper troposphere between 20° and 25° N latitudes. These winds start developing in the beginning of the summer season and shift to 30° N about 5-6 weeks later. Besides intensive heat between 20° and 40° N latitudes gives further strength to the south-west monsoons. **S. Parthasarthy** in his essay on *'Trying to solve the Monsoon Riddle'* expressed the view that the monsoons are influenced by the north-east trade winds. A weak north-east trade wind results in weak monsoon and leads to drought conditions.

The Indian monsoons, particularly the south-west monsoons, have generated a lot of interest among the meteorologists all over the world. Concerted efforts on data collection and of intensive studies of monsoon regimes by various meteorological services and organisations from different nations have been made during the last six decades. Much has been done but much more is yet to be done. The first attempt was made during International India Ocean Expedition (IIOE) from 1962 to 1965. It was organised jointly by the International Council of Scientific Unions. (ICSU), Scientific Committee on Ocean Research (SCOR) and UNESCO with World Meteorological Organisation (WMO) joining the meteorology programme. Special oceonographic and atmospheric studies were carried out with the aid of research vessels, instrumented aircrafts, rockets as well as special upsonde and dropsonde soundings. Two more experiments were conducted, jointly, by India and the former USSR in 1973 and 1977, with limited participation from other countries. These experiments are known as the ***Indo-Soviet Monsoon Experiment (ISMEX)*** and Monsoon-77 respectively. It was observed from these experiments that there is a specific zone off the coast of Kenya where the

monsoons from the southern hemisphere crossed the equator on their way to India. It was also observed that the fluctuations in the intensity of low-level across the equator resulted in the fluctuations of rainfall over Maharashtra. Upper air observations over the Bay of Bengal were also made in 1977.

More intensive data collection effort was made under the aegis of another international experiment—the Monsoon Experiment in 1979. It is popularly known as ***MONEX-1979***. It was organised jointly by Global Atmospheric Research Programme (GARP) of the International Council of Scientific Unions (ICSU) and the World Meteorological Organisation (WMO) under their World Weather Watch (WWW) programme. It is so far the largest scientific effort made to extend the frontiers of our knowledge of the monsoons by the international scientific community. As many as 45 countries pooled their talents and resources under the aegis of the United Nations for this great venture. Some idea of the dimensions of this experiment may be had from the fact that in May 1979 as many as 52 research ships were deployed over the tropical oceans between 10° N and 10° S latitudes. Besides 104 aircraft missions were successfully completed over different parts of the Pacific, the Atlantic and the Indian Ocean.

The great MONEX was designed to have three components considering the seasonal characteristics of the monsoon :

(*i*) Winter Monex from 1 December 1978 to 5 March 1979 to cover the eastern Indian Ocean and the Pacific along with the land areas adjoining Malaysia and Indonesia.

(*ii*) Summer Monex from 1 May to 31 August 1979 covering the eastern coast of Africa, the Arabian Sea and the Bay of Bengal along with adjacent landmasses. It also covered the Indian Ocean between 10° N to 10° S latitudes.

(*iii*) A West African Monsoon Experiment (WAMEX) over western and central parts of Africa from 1 May to 31 August 1979.

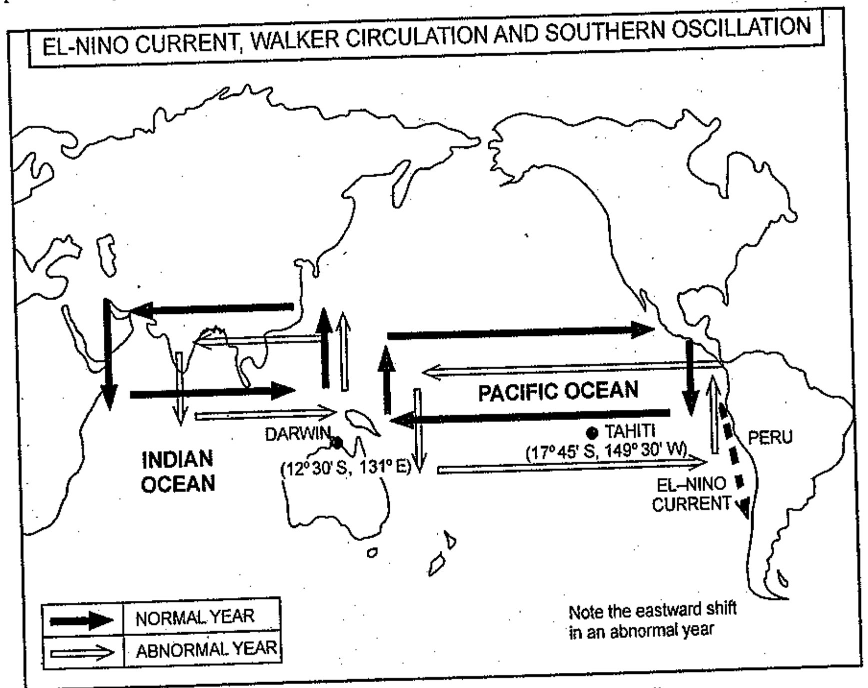

FIG. 5.9. El Nino, Walker Circulation and Southern Oscillation

International MONEX Management Centres (IMMC) were set up in Kuala Lumpur and New Delhi to supervise the winter and summer components of the experiment.

MONEX-1979 suffered some setback due to abnormal behaviour of the monsoons in that year. None of the cold surges was intense in China Sea during the winter MONEX. A strong anticyclone developed in the Arabian Sea in summer of 1979. The southwest monsoon was deflected southwards before touching the Kerala coast under the influence of this anticyclone and started blowing parallel to the coast. Consequently the onset of southwest monsoon over Kerala was delayed by 12 days. Moreover, July was characterised by several weak or break-monsoon occurrences and there was only one monsoon depression. Therefore, 1979 was not a normal monsoon year and MONEX failed to study the normal behaviour of the monsoons. But the vagaries of the monsoon are proverbial and in a scientific and analytical understanding of the monsoons, a study of anomalies is perhaps more important. It is in this context that MONEX-1979 assumes unparalled significance.

Teleconnections, the Southern Oscillation and the El Nino. Recent studies have revealed that there seems to be a link between meteorological events which are separated by long distances and large intervals of time. They are called ***meteorological teleconnections***. The one which has aroused considerable interest among the meteorologists is the difference between an El Nino and the Southern Oscillation. ***El Nino*** (EN) is a narrow warm current which appears off the coast of Peru in December. In Spanish, it means *The Child Christ* because it appears around Christmas. In some years this warm current is more intense than usual.

The El Nino phenomenon, which influences the Indian monsoon, reveals that when the surface temperature goes up in the southern Pacific Ocean, India receives deficient rainfall. However, there had been some years during which the El Nino phenomenon did not occur, but India still got deficient rainfall, and conversely, India received sufficient rainfall during an El Nino year. A study of the one hundred years from 1870 to 1970 of the Indian monsoons shows that out of 43 deficient monsoon years, 19 were associated with an El Nino. On the other hand, there were 6 El Nino years which were also years of good monsoon rain. Analysis of meteorological data for three decades from 1972-73 to 2013-14 shows that out of 14 draught years 9 had been El Nino years and 5 were non El Nino years. Years 1972-73, 1979-80, 1987-88, 2009-10 and 2013-14 were the years of severe drought and witnessed strong El Nino. On the other hand, years 1991-92, 1994-95, 1997-98, 2004-095 and 2006-07 were no El Nino year and India still had to face drought conditions (**Fig. 5.10**). Thus, although there is a tendency for poor monsoons to be associated with an El Nino, there is no one-to-one correspondence.

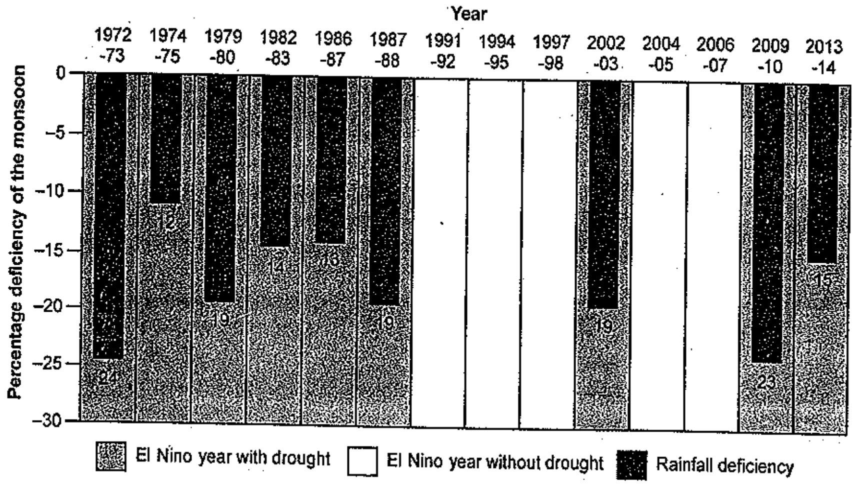

FIG. 5.10. El Nino and monsoon rainfall in India (Based on data from IMD)

Southern Oscillation (S.O.) is the name ascribed to the curious phenomenon of ***sea-saw pattern*** of meteorological changes observed between the Pacific and Indian oceans. This great discovery was made by Sir Gilbert Walker in 1920. While working as the head of the Indian Meteorological service, he noticed that when the pressure was high over equatorial south Pacific, it was low over the equatorial south Indian Ocean and vice versa. The pattern of low and high pressures over the Indian and Pacific Oceans (S.O.) gives rise to vertical circulation along the equator with its rising limb over low pressure area and descending limb over high pressure area. This is known as ***Walker Circulation***. The location of low pressure and hence the rising limb over Indian Ocean is considered to be conductive to good monsoon rainfall in India. In other words when there is low pressure over the Indian Ocean in winter months, the chances are that the coming monsoon will be good and will bring sufficient rainfall. Its shifting eastward from its normal position, such as in El Nino years, reduces monsoon rainfall in India. Due to the close association between an El Nino (E.N.) and the Southern Oscillation (S.O.), the two are jointly referred to as an ENSO event. Some of the predictors used by Sir Gilbert Walker are still used in long-range forecasting of the monsoon rainfall.

The main difficulty with the Southern Oscillation is that its priodicity is not fixed and its period varies from two to five years. Different indices have been used to measure the intensity of the Southern Oscillation, but the most frequently used is the Southern Oscillation Index (SOI). This is the difference in pressure between Tahiti (17°45′S, 149°30′W) in French Polynesia, representing the Pacific Ocean and Port Darwin (12°30′S, 131°E), in northern Australia representing the Indian Ocean. The positive and negative values of the SOI *i.e.* Tahiti minus the Port Darwin pressure are pointers towards good or bad rainfall in India (see the following table)

TABLE 5.1. Southern Oscillation Index (SOI) and associated weather phenomena

Positive SOI :	Negative SOI :
(*i*) Tahiti pressure greater than that of Port Darwin. (*ii*) Pressure high over east Pacific and low over Indian Ocean. (*iii*) Low rainfall over eastern Pacific and prospects of good monsoon rain over India and Indian Ocean.	(*i*) Port Darwin pressure exceeds that of Tahiti. (*ii*) Pressure high over Indian Ocean and low over east Pacific. (*iii*) Low rainfall or poor monsoon over Indian Ocean and higher than usual rain over east Pacific.

Scientists of India Meteorological Department (IMD) joined an international study programme called the Tropical Oceans and Global Atmosphere (TOGA) in 1985. This is an interesting and ambitious programme which investigates both teleconnections effects and the internal variability. As a follow up to TOGA, the climate variability (CLIVAR) was set up in January 1995, to develop an internationally operational climate forecasting system.

Another major programme is the Indian Middle Atmospheric Programme (IMAP) initiated by the Department of Space. This programme has been launched to augment the existing weather prediction scheme.

After the severe drought of 1987, parametric and power regression models have been developed to forecast monsoon rainfall by utilising signals from 15 parameters. Some of the parameters are global while others are regional. These parameters are divided into four broad categories, *viz:* (*a*) temperature, (*b*) pressure (*c*) wind pattern and (*d*) snow cover and are listed below :

(*a*) *Temperature related parameters*

1. El Nino in current year
2. El Nino in previous year
3. Northern India (March)
4. East coast of India (March)
5. Central India (May)
6. Northern hemisphere (Jan. and Feb.)

(*b*) *Wind related parameters*

7. 500 hPa (1 hecta pascal, equals 1 mb) ridge (April)
8. 50 hPa ridge-trough extent (Jan. and Feb.)
9. 10 hPa (30 km) westerly wind (Jan.)

(c) *Pressure anomaly (SOI)*

10. Tahiti-Darwin (Spring)
11. Darwin (Spring)
12. South America, Argentina (April)
13. Indian Ocean Equatorial (Jan.-May)

(d) *Snow cover related parameters*

14. Himalayan (Jan.-March)
15. Eurasian (Previous December)

It was observed in late eighties that whenever more than 50% parameters showed favourable signals, the monsoon rainfall in India was normal and when 70% or more parameters were favourable, the monsoon rainfall was above normal.

Somewhat similar set of predictors for monsoon was suggested by H.N. Srivastava and S.S. Singh in 1994 while discussing long range weather forecasting techniques.

One more parameter, *viz.*, surface pressure anomaly of north-eastern hemisphere was also added later on, thus making a total of 16 parameters. These 16 parameters have been used by the IMD to develop the power regression model. Although this model has been forecasting rainfall in India with greater accuracy since 1989, it is far from being an elaborate and foolproof model. A model capable of forecasting area specific rainfall is yet to be built. The study of data flowing from MONEX, TOGA and other experiments is continuing and our meteorologists are hopeful of discovering more parameters which may help in developing better models capable of predicting rainfall more accurately.

SEASONAL RHYTHM

Indian climate is characterised by distinct seasonality. Seasons come and go one after the other with surprising precision. They depict the annual cycle of weather and reflect the changing moods of nature. Each season has its distinct features. India Meteorological Department (IMD) has recognised the following four distinct seasons:

1. The cold weather season or winter season,
2. The hot weather season or summer season,
3. The south-west monsoon season or Rainy season, and
4. The season of the retreating monsoon or cool season.

1. The Cold Weather Season or Winter Season

The cold weather season commences in November and continues till March. Clear sky, pleasant weather, low temperature and humidity, high range of temperature, cool and slow northern winds are the chief characteristics of this season.

(*a*) **Temperature.** The northern two thirds of the country have mean temperatures below 21°C, with afternoon temperatures of 27°C. January is the coldest month when the temperature in the Ganga plain varies from 12.5° to 17.5°C. The mean minimum temperatures are about 5°C over northwest India and 10°C over the Gangetic plains. However, on individual days the temperatures may fall much below the mean values. The night temperature often falls below freezing point in many hilly areas. Dras Valley in Kashmir is the coldest place in India. The minimum temperature recorded at Dras was –45°C on 28th December, 1908.

The southern one-third has rather warm conditions and does not have a distinctly defined winter weather. The isotherm of 20°C runs in east-west direction, roughly parallel to the Tropic of Cancer and divides India climatically in the northern and southern parts. To the south of this isotherm the temperatures are invariably above 20°C. In the extreme south the temperature may be well above 25°C (**Fig. 5.11**). January temperature at Thiruvananthapuram is 31°C. The diurnal range of temperature, especially in interior parts of the country, is very high. It may reach 15°C over western India.

(*b*) **Pressure and Winds.** High air pressure prevails over large parts of north-west India due to low temperature conditions there. Normally the pressure varies from 1015 to 1020 mb. However, pressure is comparatively lower in south India. The isobar of 1019 mb is seen in north-west India while the isobar of 1013 mb touches the southern tip of the country (**Fig. 5.12**). The winds start blowing from high pressure area of north-west to low pressure area of south-east. The wind velocity is low due to low pressure gradient. Depending upon the pressure and

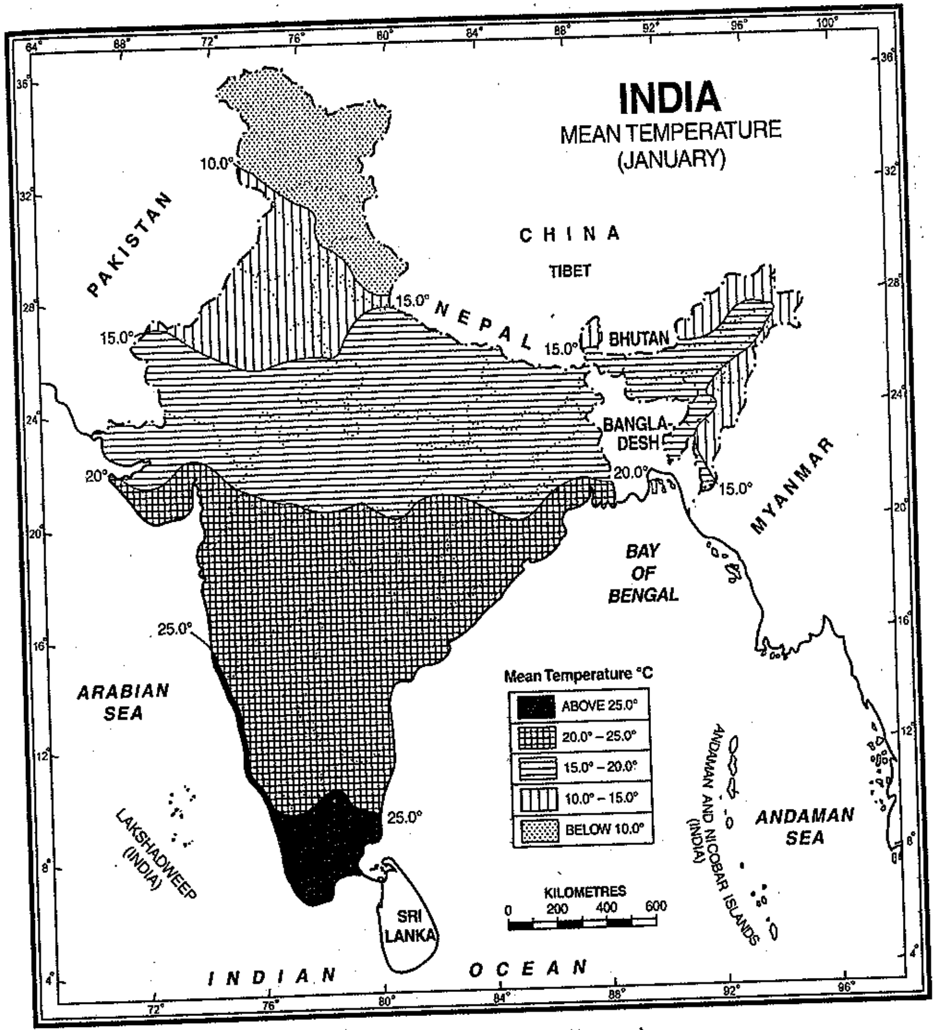

FIG. 5.11. Mean temperature (January)

physiography, the winds blow from west and north-west in Punjab, Haryana, Uttar Pradesh and Bihar, from north-west in Bengal and from north-east in the Bay of Bengal.

Western Disturbances and Tropical Cyclones. Although sky is generally clear, the spell of fine weather is often broken due to inflow of depressions from the west. These low pressure depressions are called ***western disturbances***. They originate in the Mediterranean Sea and enter India after crossing over Iraq, Iran, Afghanistan and Pakistan. On their way, their moisture content is augmented from the Caspian sea and the Persian Gulf. They are often in an occluded form when they reach India. They intensify over Rajasthan, Panjab, and Haryana. They move eastwards across the sub-Himalayan belt and reach right upto Arunachal Pradesh (**Fig. 5.12**), causing light rain in the Indus-Ganga plains and snowfall in the Himalayan belt. After the passage of the disturbance, widespread fog and cold waves lowering

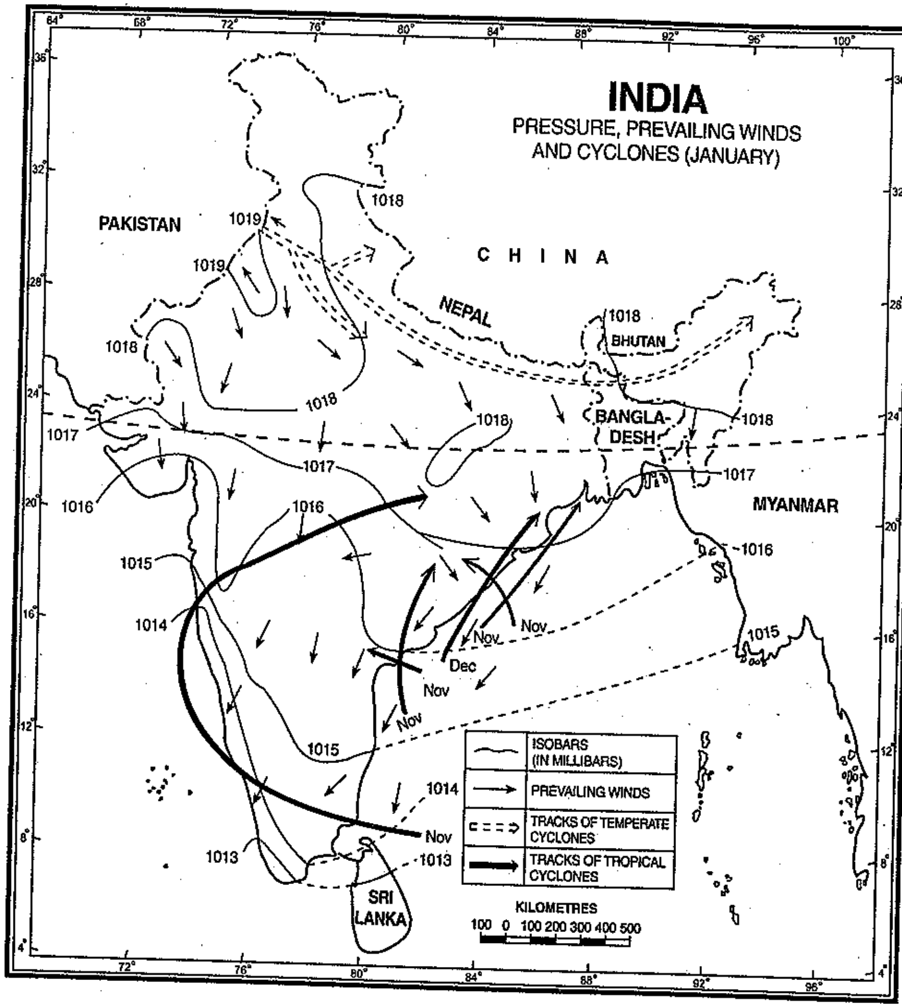

FIG. 5.12. India : Pressure, Prevailing Winds and Cyclones in January

the minimum temperature by 5° to 10°C below normal are experienced. Haze is common in morning and evening.

Fog occurring in this season causes great inconvenience for transport in general and air transport and particular in the northern part of India. According to Met unit at Indira Gandhi International Airport, New Delhi the average duration of occurrence of fog at the airport is 85 hours. However, there are great variations in the foggy hours from year to year as is clear from **table 5.2**. Larger the duration of fog hour, greater the inconvenience for transport.

The frequency of the western disturbances varies from year to year but on an average 3 to 5 disturbances per month are experienced. According to **W.G. Kendrew**, the number of disturbances reaching India are 2 in November, 4 in December, 5 each in January and February and 4 in March. The *jet stream* plays an important role in bringing these disturbances to India.

TABLE 5.2. Hours of dense fog (Visibility below 200 metres)

Season (Year)	Hours of dense fog
2000-01	112
2001-02	78
2002-03	190
2003-04	169
2004-05	100
2005-06	52
2006-07	66
2007-08	16
2008-09	167
2009-10	174
2010-11	50
2011-12	55
2012-13	60

Source : Met. unit at Indira Gandhi International Airport, New Delhi.

This is the season of least tropical cyclone activity and the frequency decreases with the advancement of season. This is due to low sea surface temperature and the location of ITCZ farthest south in this season. The storms which are born in the Bay of Bengal strike Tamil Nadu and some of them cross the southern peninsula over to the Arabian Sea. Some storms originate in the Arabian Sea and move towards either north or west.

(c) Precipitation. The retreating winter monsoons blow from land to sea and do not cause much rainfall. These winds pick up some moisture while crossing the Bay of Bengal and cause winter rainfall in Tamil Nadu, south Andhra Pradesh, south-east Karnataka and south-east Kerala. The highest seasonal rainfall of about 75 cm between October and December occurs along the south-eastern coast of Tamil Nadu and adjoining parts of Andhra Pradesh. Thereafter, it gradually decreases except for a small area towards north-east Kerala.

The western disturbances also cause a little rainfall in north-west India. The amount of rainfall gradually decreases from the north and north-west to east. The average rainfall during three months from December to February is about 60 cm in the Himalayan region, 12 cm in Punjab, 5.3 cm at Delhi and 1.8 cm to 2.5 cm in U.P. and Bihar. Although very small in amount, this rainfall is extremely useful for rabi crops, especially the wheat crop. The north-eastern part of India also gets rainfall during the winter months. Arunachal Pradesh and Assam may get as much as 50 cm of rainfall during these months. The distribution of winter rainfall in India is shown in **Fig. 5.13**.

2. The Summer Season

Period from March to June is called the ***summer season***. High temperature and low humidity are the chief characteristics of this season. Hence it is also known as ***hot weather season*** or ***hot dry summer season***. Sometimes, it is referred to as ***pre-monsoon*** period.

(a) Temperature. As the season advances, sun's vertical rays move northwards and large parts of the country, south of the Satpura range, are heated up. There is a progressive northward march of warmth as the sun proceeds towards the north, the southern parts being distinctly warmer in March and April whereas in June, north India has much higher temperatures. In March, the highest temperatures are nearly 40°C in the southern parts of the Deccan plateau; in April the highest temperature of about 45°C is recorded in the northern parts of Madhya Pradesh; in May the scene of highest temperature shifts to Rajasthan where temperatures as high as 48°C may be recorded and in June the maximum temperature is in Punjab and Haryana. The highest temperatures so far recorded are 50.5°C at Alwar on 10th May, 1956 and 50.6°C at Ganganagar on 14th June, 1935. The highest temperatures are recorded in May but in certain areas June is the month of the highest temperatures. In fact the highest temperatures are recorded just before the onset of the southwest monsoons. Even the minimum temperature at night rarely falls below 20°C mark. It ranges from 20° to 25°C over northern and central India and slightly higher in the south with a pocket of over 27°C over central parts of Deccan. The diurnal range of temperature is also very high. It may be as high as 18°C in Rajasthan and adjoining areas of Madhya Pradesh.

However, the maximum summer temperatures are comparatively lower in the southern parts of the country due to moderating effect of the sea. The mean

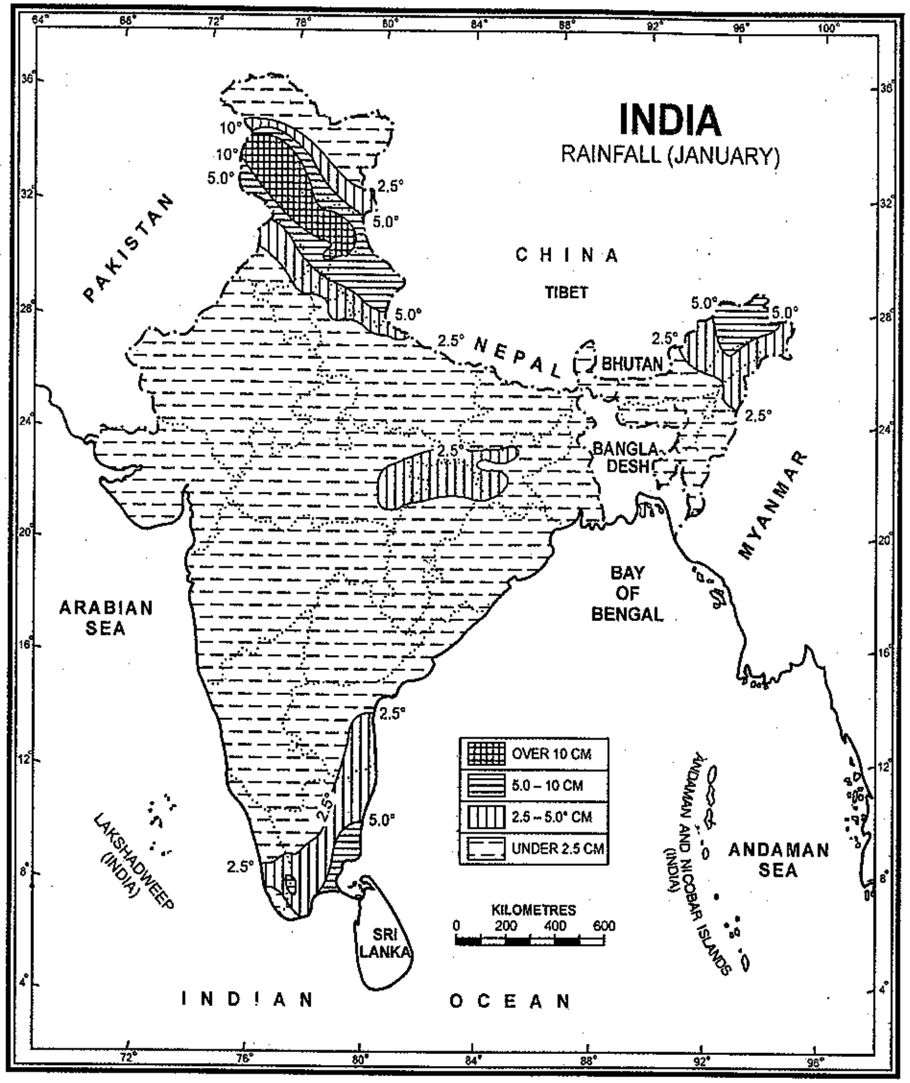

FIG. 5.13. Rainfall (January)

maximum temperature at most places is about 26°–30°C. The temperatures along the west coast are comparatively lower than those prevailing on the east coast due to the prevailing westerly winds. The large contrast between land and sea temperatures is observed from the closely packed isotherms running more or less parallel to the coast (**Fig. 5.14**).

Northern and central parts of India experience *heat waves* in this season. A *heat wave* is generally defined with reference to the normal maximum temperature of a particular region. According to Indian convention, departure of the maximum temperature of the order of 6° to 7°C above normal is termed as '***moderate***' and 8°C and more as '***severe***'

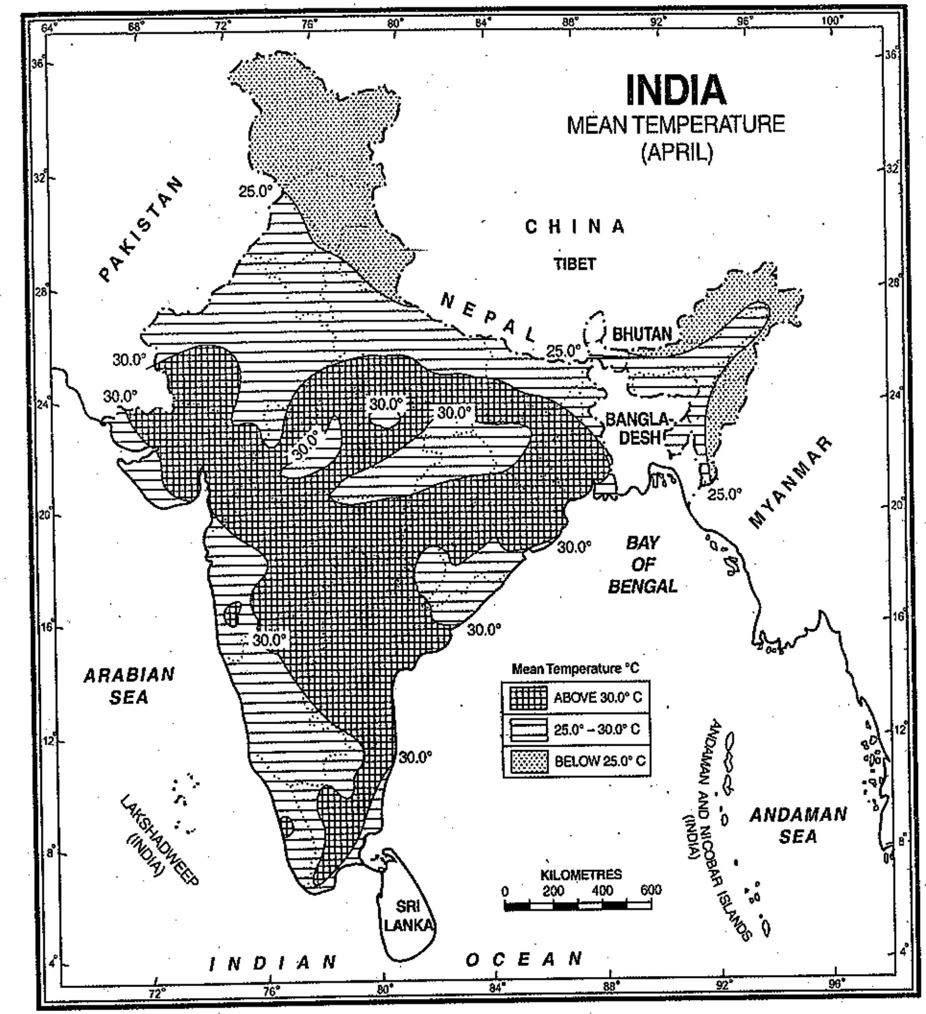

FIG. 5.14. Mean Temperature (April)

heat wave. Most of the heat waves develop over Rajasthan, Punjab and Haryana. This is due to the location of these areas far away from the sea. From here they spread over Uttar Pradesh and Bihar. The strong north westerly winds with a long land trajectory over hot regions check the onward march of the sea breeze over eastern coastal belt and create heat wave conditions over coastal Odisha and Andhra Pradesh. The heat waves start striking by the end of April and their maximum occurrence is in May and June till the onset of southwest monsoon. The normal duration of heat waves is 4 to 5 days. However, heat waves are rare over the peninsula south of 13°N latitude due to maritime conditions prevailing there.

(*b*) Pressure and Winds. The atmospheric pressure is low all over the country due to high temperature. Unusually low pressure is noticed in north-west India where temperatures are exceptionally high. The overall pressure gradient is low. The difference of pressure between the extreme north and south of the country does not exceed 3-4 mb. The isobars run more or less parallel to the coast indicating differences in pressure conditions over land and sea.

There is a marked change in the direction and speed of the winds from the winter conditions. The winds are by and large light and variable. However, there are some exceptions. In May and June, high temperature in northwest India builds steep pressure gradient which is often of the order of 1.0 to 1.5 mb per degree of latitude. Under such conditions, hot, dust laden and strong wind known as ***loo*** blows. Loo normally starts blowing by 9.00 A.M., increases gradually and reaches maximum intensity in the afternoon when the temperature is maximum. It blows with an average speed of 30-40 km per hour and persists for days together; often 3 to 10 days at a stretch. The strong dust storms resulting from the convective phenomena are locally known as ***andhis*** which literally mean ***blinding storms***. They are essentially duststorms, which move like a solid wall of dust and sand. The wind velocity often reaches 50-60 kms. per hour and the visibility is reduced to a few metres ; sometimes the visibility is nil. Such dust storms are common in Rajasthan, Haryana, Punjab, Jammu region, Delhi, Uttar Pradesh, Bihar and Madhya Pradesh. They are invariably short lived but the squall and showers which follow these storms bring down the temperature sharply and afford much needed relief, although temporary, from the scorching heat.

The strong convectional movements with divergence related to the westerly jet stream or westerly disturbances in the upper troposphere lead to thunderstorms in eastern and north-eastern part of the country. They normally originate over Chota Nagpur plateau and are carried eastwards by westerly winds. The areas with highest incidence of thunderstorms are Assam, Arunachal Pradesh, Nagaland, Mizoram, Manipur, Tripura, Meghalaya, West Bengal and the adjoining areas of Odisha and Jharkhand. In West Bengal and the adjoining areas of Jharkhand, Odisha and Assam, the direction of squalls is mainly from the northwest, and they are called ***norwesters***. They are often very violent with squall speeds of 60 to 80 km per hour. Hailstones sometimes accompany showers and occasionally attain the size of a golf ball. They cause heavy damage to standing crops, trees, buildings, livestock and even lead to loss of human lives. However, they are, some times, useful for tea, jute and rice cultivation. In Assam, these storms are known as ***'Barodoli Chheerha***. The period of maximum occurrence of these storms is the month of *Vaisakh* (mid-March to mid-April) and hence, they are locally known as ***Kalabaisakhis***, the *black storms* or a *mass of dark clouds of Vaiasakha*. In the south the thunderstorms occur in Kerala and adjoining parts of Karnataka and Tamil Nadu, particularly during evenings and nights. The highest occurrences are in the extreme south-western tip with seasonal incidence of 38 days over Thiruvananthapuram. This frequency gradually decreases northwards and is only 14 days at Mangalore.

Western Disturbances and Tropical Cyclones. The western disturbances which influence large parts of north-west and north India during the winter season still persist with their frequency and intensity gradually decreasing with advancement of this season. Approximately 4, 3 and 2 western disturbances visit north-west India in March, April and May respectively. These disturbances cause changes in weather conditions by bringing cloudiness and convective activity in this part of the country. They also cause snowfall in higher reaches of the Himalayas.

This is also the season of tropical cyclones originating in the Bay of Bengal and Arabian Sea. A few cyclones are formed in the Bay of Bengal in the month of March but they do not affect the mainland of India. Their frequency rises steeply in April and the number of cyclones originating in May is more than double than those originating in April. About three-fourths of the tropical cyclones are born in the Bay of Bengal and the rest originate in the Arabian Sea. Most of the depressions in April originate to the south of 10°N while those originating in May are born to the north of this latitude. About 60 per cent of the storms of this season initially move west or north-west but later they recurve northeast and strike Bangladesh and the Arakan Coast of Myanmar. About 30 per cent of the storms cross the Indian coast and a few dissipate over the sea itself. The whole of the east coast of India, the coastal areas of Bangladesh and Arakan Coast of Myanmar are liable to be hit by tropical storms in May. Many of them are quite severe and cause heavy damage to life and

property. In the Arabian Sea, major storms are formed in May between 7° and 12° N latitudes. About 75 per cent originate to the west of 70° E longitude and move away from the Indian coast in a north-westerly direction and dissipate in the sea. About 25 per cent originate close to the Indian coast. They move towards the north-east and hit somewhere along the west coast of India.

(c) Precipitation. As mentioned earlier, this is a dry season. But this is not a totally rainless season although only one per cent of the annual rainfall of India is received during this season. In the northeastern parts of the country, dust storms bring little rainfall. Rajasthan, Gujarat and Madhya Pradesh receive less than 2.5 cm rainfall during this season. The precipitation in Kashmir is mainly in the form of snow or sleet in March and early April and is caused by western disturbances. Higher reaches more than 5,000 metre above sea level experience snowfall even in May. These disturbances move eastwards and cause snowfall or thunderstorms in central and eastern Himalayas till the end of April. The *norwesters* bring about 50 cm of rainfall in Assam and about 10 cm in West Bengal and Odisha. The intensity of rainfall is

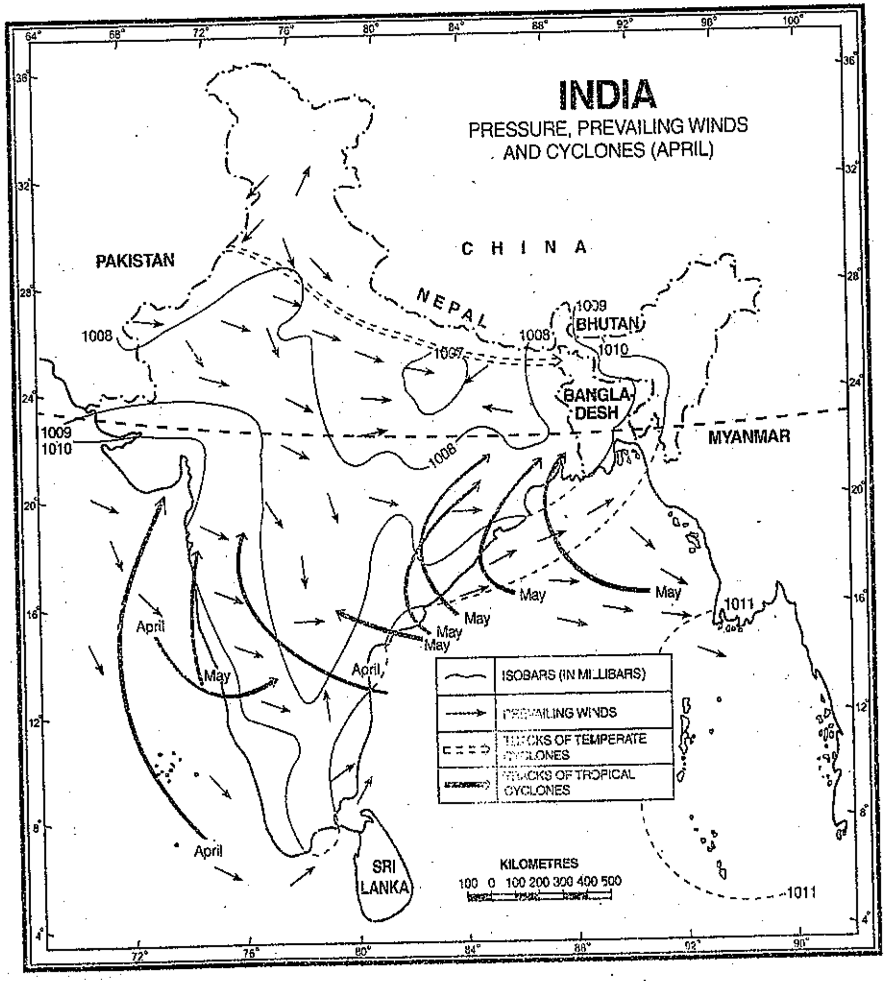

FIG. 5.15. Pressure, Winds and Cyclones (April)

high. Often as much as 5 cm of rain is recorded in one hour but the rainfall is short lived. The rainfall brought by the norwesters is known as the ***spring storm showers***. In Assam the rainfall received in May is about two-thirds of the rainfall received in June. This small amount of rainfall is very useful for the cultivation of tea, jute and rice and is known as ***tea showers*** in Assam. Coastal areas of Kerala and Karnataka receive about 25 cm of rainfall from thunderstorms. These thunderstorms also cause about 10 cm of rainfall in the interior of south India. Such showers are called ***mango showers*** in Tamil Nadu and Andhra Pradesh because they are very beneficial to mango crop. In Karnataka they are called ***cherry blossoms*** due to their salutary effect on the coffee plantations. The distribution of rainfall in April is shown in **Fig. 5.16.**

3. The Rainy Season

The rainy season in India starts with the onset of the southwest monsoon in June and continues till the middle of September. This is also called the ***monsoon season***, the ***southwest monsoon season***, the ***wet season*** and the ***hot-wet season***. The weather conditions all over the country change with the onset of the monsoon winds. High heat, high humidity, extensive clouding and several spells of moderate to heavy rain with strong surface winds are the chief characteristics of this season.

(*a*) **Temperature.** There is a significant fall in temperature with the beginning of rainy season. The June temperature in south India is 3° to 6°C lower than the May temperature.

Similarly July temperature in northwest India is 2° to 3°C lower than the June temperature. But once the temperature falls from its dry summer level, it remains more or less uniform throughout the rainy season. However, the temperature rises again in September with the cessation of rains and secondary maximum temperature period is experienced all over the country. Also there is rise in temperature whenever there is break in the monsoons and rainfall does not occur for a number of days. Night temperatures are more uniform than the day temperatures. The diurnal range of temperature is small due to clouds and rains. It ranges between 4°C and 8°C when the monsoon is fully established.

The highest temperatures of over 32°C are experienced in the Thar desert of Rajasthan. At places especially west of the Aravali the temperature may be as high as 38° to 40°C. This is due to lack of clouds and the predominance of continental airmass. The remaining parts of northwest India also have temperatures above 30°C. The temperatures are quite low over the Western Ghats due to high elevation and also due to heavy rainfall, but the rainshadow area is comparatively warmer on account of low elevation and scanty rainfall. The coastal areas of Tamil Nadu and adjoining parts of Andhra Pradesh have temperatures above 30°C because they receive little rainfall during this season.

(*b*) **Pressure and Winds.** The temperatures in northwest India are still very high as a result of which low pressure conditions prevail there. The most conspicuous feature of the surface pressure distribution during this season is an elongated trough across the Ganga basin right upto the head of Bay of Bengal. This is called the ***monsoon trough***. There are frequent changes in its location and intensity depending upon the weather conditions. The atmospheric pressure in most parts of north India is less than 1,000 mb. It increases steadily southwards where it ranges between 1,008 mb and 1,010 mb. The isobar of 1,009 mb crosses parts of Kerala and Tamil Nadu besides Arabian Sea and the Bay of Bengal.

Under the influence of the above mentioned pressure distribution, winds blow in a southwest to northeast direction from Arabian sea and Bay of Bengal. They maintain this direction throughout peninsular India. But their direction undergoes a change in Indo-Gangetic plain where they move from east to west.

(*c*) **Rainfall.** India's three fourths of the total annual rainfall is received during this season. In some areas it is much more than this average. For example, the average rainfall over the plains of India in this season is about 92 cm, or about 87 per cent whereas during the remaining part of the year only 14 cm of rainfall occurs. This season has the maximum number of rainy days as a result of which it is called the '***wet season***'.

Rainfall during this season all over the country is caused by southwest monsoons coming from the Indian Ocean. **Figure 5.19** shows *isolines* of normal

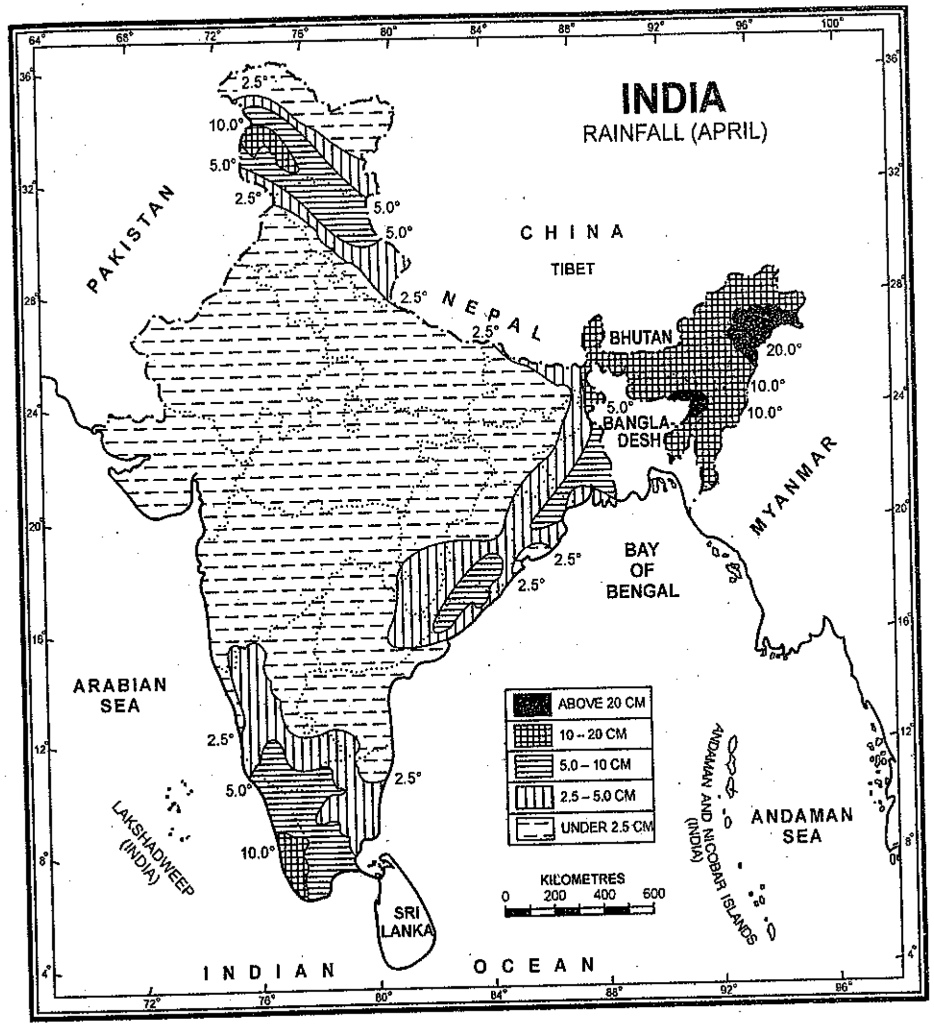

FIG. 5.16. Distribution of rainfall (April)

dates of arrival of the monsoons in different parts of the country. It is clear from this map that the normal date of the arrival of the monsoon is 20th May in Andaman and Nicobar Islands. It is worth mentioning that the advance of the monsoon is much faster in the Bay of Bengal than in the Arabian Sea. This is evident from the pronounced curve shown by isolines of the monsoon onset in **Fig. 5.19**. The monsoon current advances to nearly 20°N latitude in Bay of Bengal by the third week of May, when it is still south of Kerala at about 7°N latitude in the Arabian Sea. The normal date of onset of the southwest monsoon over Kerala *i.e.* the first place of entry in the mainland of India is 1st June. The monsoons advance with startling suddenness accompanied with a lot of thunder, lightning and heavy downpour. This sudden onset of rain is termed as ***monsoon burst***. Although the normal date of onset of the southwest monsoon on the southern tip of the peninsula is 1st June, the actual onset may be earlier or later than this date. On 60%

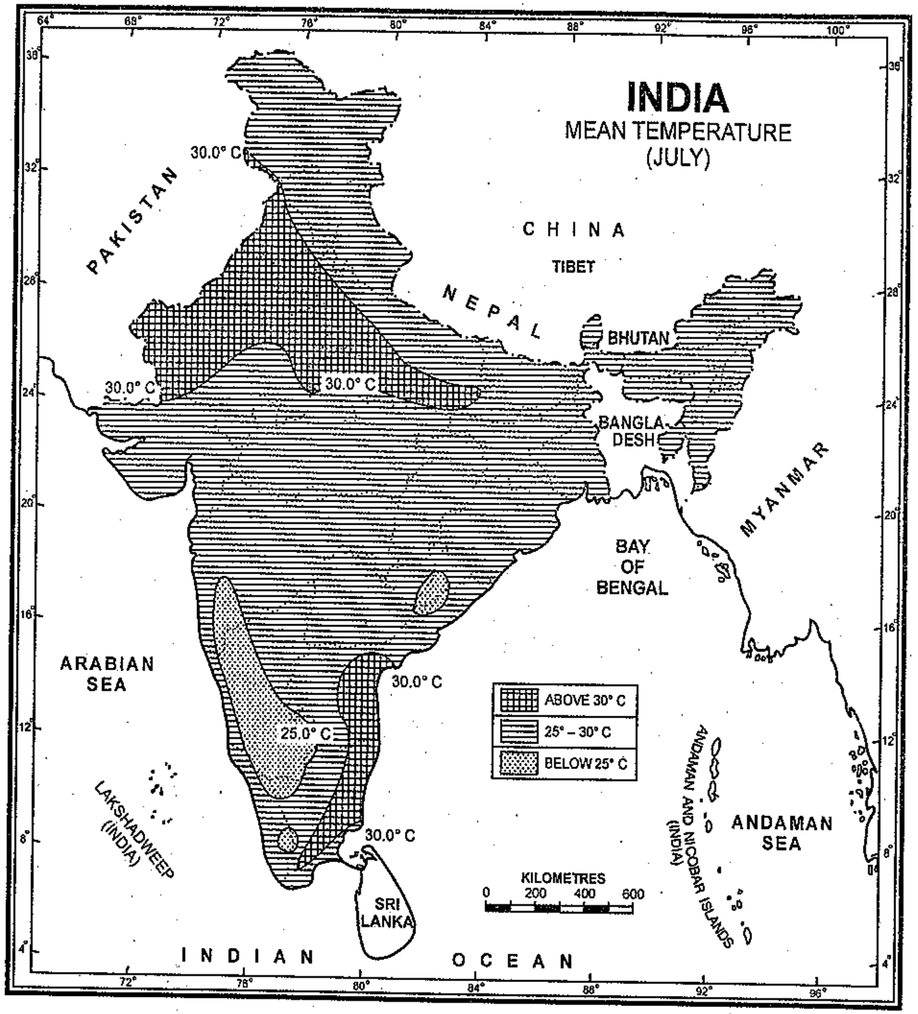

FIG. 5.17. Mean Temperature (July)

occasions, the onset occurs between 29th May and 7th June. The earliest onset was on 11th May in 1918 and 1955, while the most delayed onset was on 18th June in 1972. Satellite imagery is used to identify the advance of the monsoon on a day to day basis.

The progress of the monsoon winds beyond south Kerala is in the form of two branches *viz.* the Arabian Sea branch and the Bay of Bengal branch. The Arabian Sea branch gradually advances northwards. It reaches Mumbai by 10th June and spreads over Saurashtra-Kachchh and central parts of the country by 15th June. The progress of the Bay of Bengal branch is no less spectacular. It spreads rather rapidly over most of Assam. The normal date of its arrival at Kolkata is 7th June. On reaching the foothills of the Himalayas the Bay branch is deflected westward by the Himalayan barrier and it advances up the Gangetic plain. The two branches meet roughly along the line running through Agra and Ferozepur and merge with each other to form a single current. The

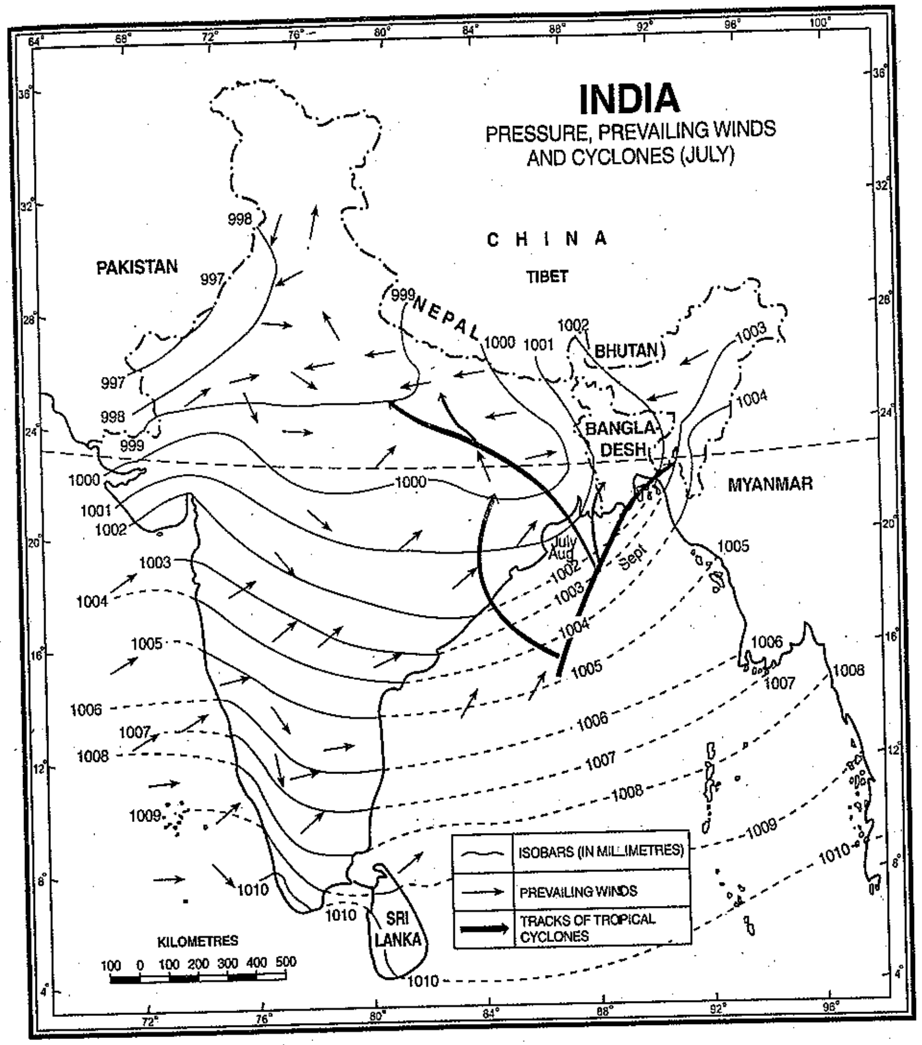

FIG. 5.18. Pressure, Prevailing Winds and Cyclones (July)

combined current gradually extends to west Uttar Pradesh, Haryana, Punjab, Rajasthan and finally to Himachal Pradesh and Kashmir. By the end of June the monsoon is usually established over most parts of the country. By mid-July, the monsoon extends into Kashmir and the remaining parts of the country, but only as a feeble current because, by this time, it has shed most of its moisture. It is often difficult to say whether the Arabian Sea branch or the deflected Bay of Bengal branch will be the first to arrive. For example, at a place like Delhi, the first showers are sometimes brought by the Bay of Bengal branch from the east but on a number of other occasions it is the Arabian Sea branch which brings the first monsoon rain from the south. It is interesting to note that the Arabian Sea branch of the monsoon is much more powerful than the Bay of Bengal branch for two reasons : (*i*) The Arabian Sea is larger than the Bay of

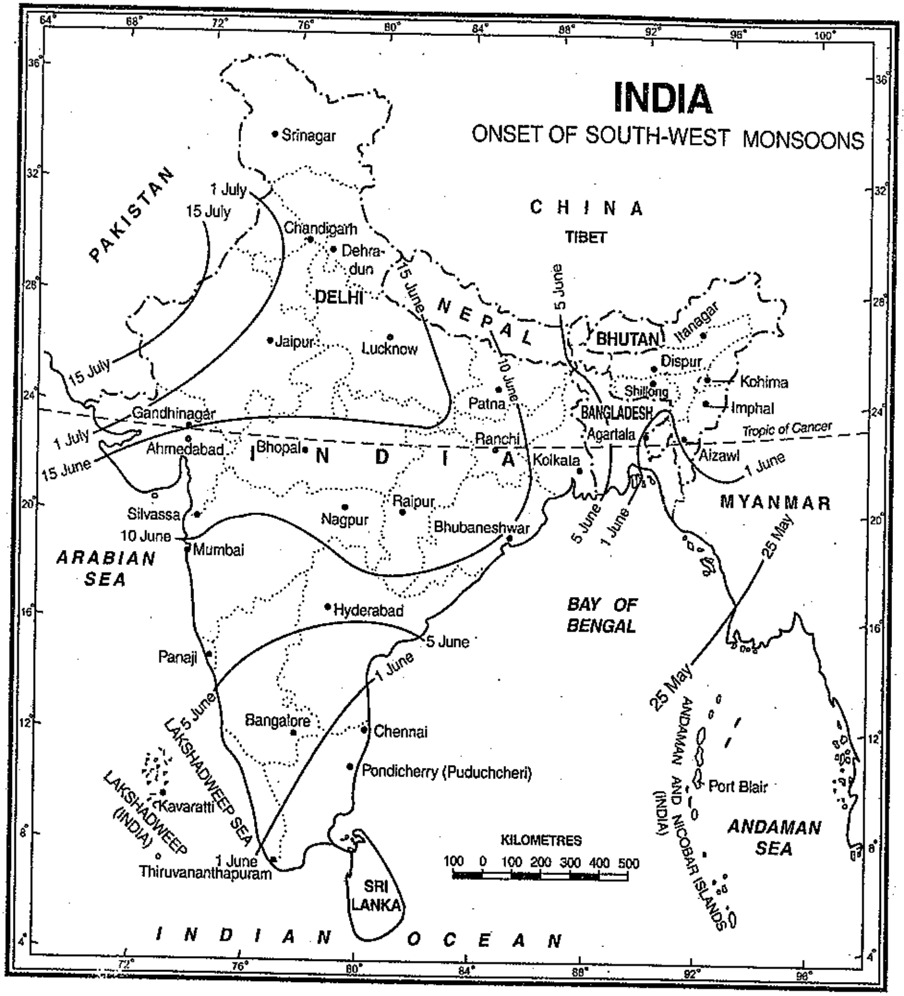

FIG. 5.19. Normal dates of onset of south-west Monsoons

Bengal, and (*ii*) the entire Arabian Sea current advances towards India, whereas only a part of the Bay of Bengal current enters India, the remainder proceeding to Myanmar, Thailand and Malaysia.

The Arabian Sea branch of the southwest monsoons is divided into three distinct streams on arriving in the mainland of India.

The first stream impinges on the west coast of India and gives extremely heavy rainfall of over 250 cm particularly between 10° to 20°N. latitudes where the impinge is perpendicular to the direction of the Western Ghats. The Western Ghats rise abruptly like a wall from the western coastal plains more or less parallel to the coastline. This wall like mountain range forces the moisture laden southwest monsoons from the Arabian Sea to ascend the slope thereby giving heavy rainfall in the west coastal plain and still heavier rainfall on the western slopes of the Western Ghats, *i.e.*, the windward side of the mountain range. But these winds have to descend the

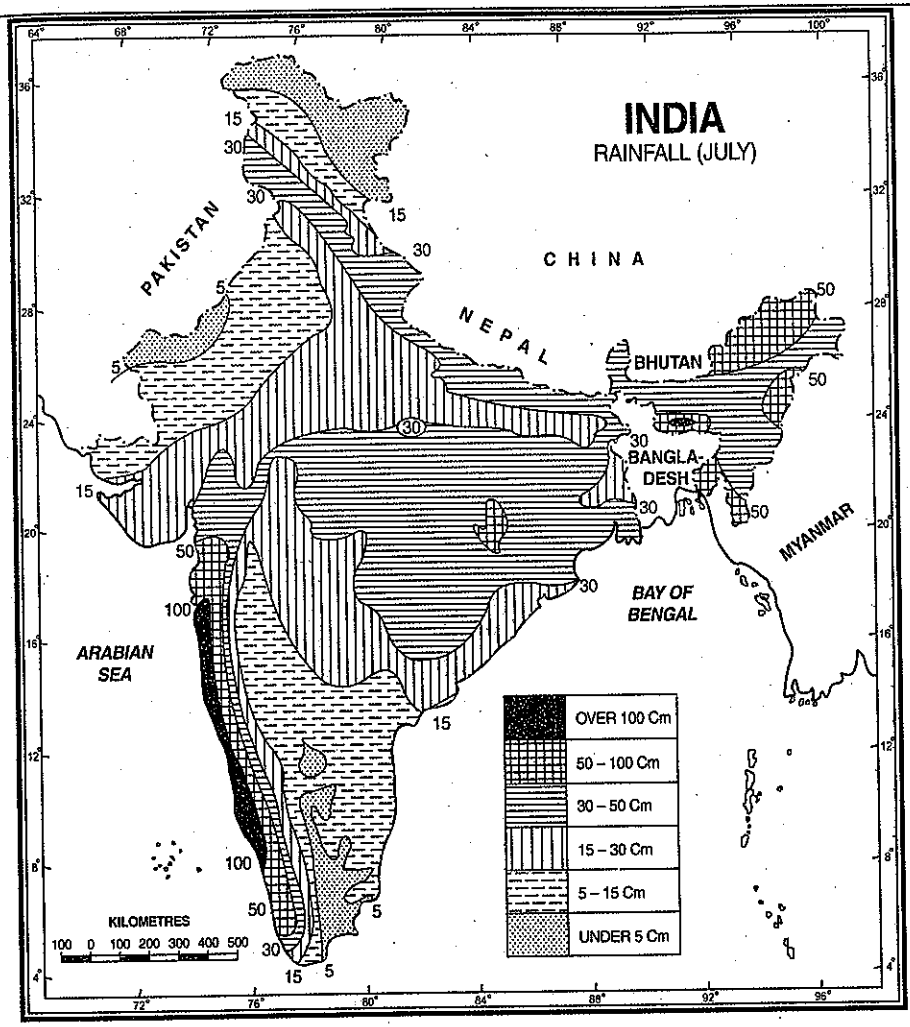

FIG. 5.20. Rainfall (July)

slope after crossing the crest of the ghats. In the process their temperature rises and their humidity decreases. Therefore, they cause little rainfall and the area east of the Ghats is called the '***leeward side***' or the '***rain shadow region***'. Thus while Mumbai on the west coast records about 190 cm, Khandala about 50 km east a bit below the crest gets 60 cm and Pune about 160 km away from Mumbai on the leeward side receives only 50 cm rainfall during the monsoon season. This phenomenon is observed almost all along the Western Ghats. The crest of the Western Ghats receives about 400 to 500 cm annual rainfall which is drastically reduced to about 30-50 cm within a distance of 80-100 km leeward from the crest. This speaks volumes of orographic control of the monsoon rainfall. There is a narrow belt of marked aridity on the immediate leeward side of the Western Ghats. But once it is passed, the air starts rising again and the amount of rainfall increases further east.

The second stream enters Narmada–Tapi troughs and reaches central India. It does not cause much rain near the coast due to the absence of any major orographic obstacle there. Nagpur receives about 60 cm rainfall from this stream.

The third stream moves in a north-easterly direction parallel to the Aravali Range. Since the orientation of the Aravali Range is parallel to the direction of the prevailing monsoon winds, it does not offer major obstacle in the way of the winds and these winds move further without causing much rainfall. Consequently the whole of Rajasthan is a desert area. However, some orographic effect is discernible here as the south-eastern edge of the Aravali Range comes in the way of the monsoon winds and receives reasonably good rainfall. Mt. Abu gets about 170 cm rainfall while the surrounding plains have only 60 to 80 cm rainfall.

The Bay of Bengal Branch of the southwest monsoon is divided into two distinct streams :

The first stream crosses the Ganga-Brahmaputra delta and reaches Meghalaya. It is here that the orographic effect on the monsoon winds and the consequent amount of rainfall is most pronounced. Cherrapunji, a small town (25° 15′ N, 91° 44′ E), located at an elevation of 1,313 m above mean sea level receives an annual rainfall of 1,102 cm, major portion of which occurs from June to August. Till recent times, this has been considered as the highest amount of rainfall for any station in the world. But the recently recorded observations have shown that Mawsynram (25° 18′ N, 91° 35′ E) located at 1,329 m above sea level just 16 km to the west of Cherrapunji records higher annual rainfall of 1,221 cm. Both the stations are located on the southern slopes of the Khasi hills at the northern end of a deep valley running from south to north. When the monsoon winds blow from the south, they are trapped within the funnel shaped valley and strike Cherrapunji and Mawsynram in a perpendicular direction and give copious rains. However, the heaviest rainfall occurs when the winds blow directly on the Khasi hills. Cherrapunji and Mawsynram receive more rainfall in a day than the annual rainfall of many parts of the country. The highest records of rainfall in a day for these two stations are 103.6 cm and 99 cm respectively. The rainfall is well over 200 cm in most parts of the north eastern states. But the amount of rainfall decreases sharply on the leeward side of the Khasis. Guwahati, only 90 km from Cherrapunji gets only 161 cm of rainfall.

The second stream of the Bay of Bengal branch goes to the Himalayan foothills and after reaching there, it is deflected to the west by the size and orientation of the Himalaya and brings widespread rainfall to Ganga plain. The rainfall by this stream is characterised by a steady decline as we move from east to west up the plain. For example, Kolkata gets 119 cm, Patna 105 cm, Allahabad 91 cm, Delhi 51 cm and Bikaner only 24 cm rainfall during the south-west monsoon period.

The eastern coastal belt, particularly in Tamil Nadu, remains relatively dry during the south-west monsoon period. This is because the Tamil Nadu coast lies in the rainshadow area of the Arabian Sea current and is parallel to the Bay of Bengal current.

Break in the Monsoon. During the rainy season, particularly, in July and August, there are certain periods when the monsoons become weak. The cloud formation decreases and rainfall practically ceases over the country outside the Himalayan belt and southeast peninsula. This is known as ***break in the monsoon***. The latest studies have revealed that the breaks are likely to occur more frequently during the second week of August. The normal duration of the break is about a week but on some occasions this could be longer. The longest breaks have been known to persist for two to three weeks, but such occasions are rare. The breaks are believed to be brought about by the collapse of the Tibetan High. This results in the northward shifting of the *monsoon trough*. The axis of the trough lies at the foothills of the Himalayas during the break period. Even when most parts of the country have to content without rainfall during the break period, heavy rainfall occurs over the sub-Himalayan regions and the southern slopes of the Himalayas. This leads to high flooding of the rivers having their catchment areas in the Himalayas. On an average one or two breaks do occur during the rainy season. Statistical studies of the monsoon show that in 85 out of 100 years there is a break in the monsoons.

Monsoon Depressions. A major part of the monsoon rainfall is generated by depressions originating in the Arabian Sea but more so in the Bay of Bengal. Some depressions develop over land also.

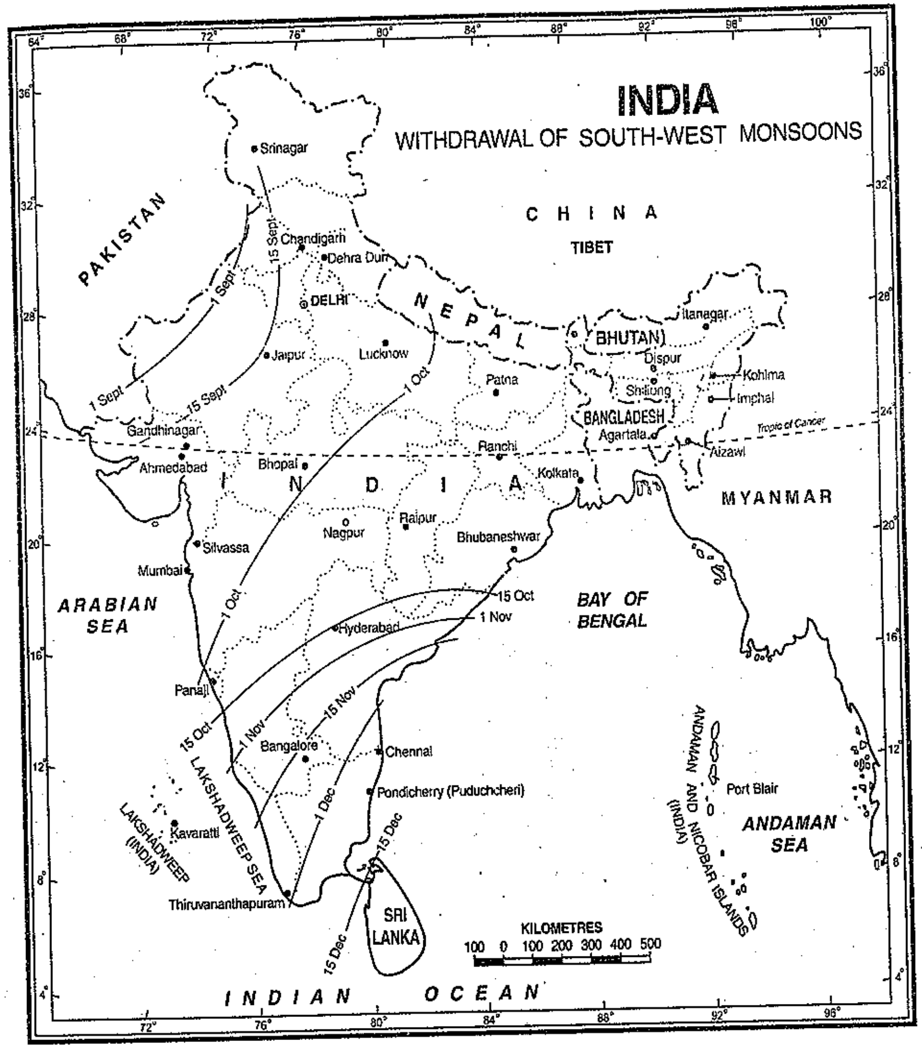

FIG. 5.21. Normal dates of withdrawal of Monsoon

About 3-4 depressions are formed per month from June to September. Almost all of them are sucked inward through the deltas of great rivers, the Ganga, the Mahanadi, the Godavari, the Krishna and the Cauvery and cause heavy rain in these areas.

In June the depressions in the Bay of Bengal originate between 16° N and 21° N and west of 92° E. The majority of them move towards the north-west. During July and August they originate north of 18° N and to the west of 90° E and move generally in a west north-westerly direction. In September the Bay storms originate to the north of 15° N and to the west of 90° E. Majority of the cyclones move along the monsoon trough and most of them merge with the seasonal low over north-west India (**Fig. 5.18**).

In the Arabian Sea the formation of depressions in June is between 17°N and 20°N. They move either in north-west or in northerly direction and may affect

Gujarat or Maharashtra. Storms during August and September are rare and are formed close to Maharashtra-Gujarat coast.

Most of the rainfall in central and northern parts of the country is caused by these depressions. The satellite imagery shows thick clouds associated with these depressions. Sometimes they give excessive rainfall, as much as 60 cm in a single day, resulting in heavy loss of life and property. The absence of depressions or a change in their tracks result in deficit or no rain.

Chief Characteristics of Monsoonal Rainfall

(*i*) Rainfall by the southwest monsoon is seasonal in character, the major part of which is received between June and September.

(*ii*) Monsoonal rainfall is largely orographic in its mode of occurrence and is governed by relief. The Himalayas and the Western Ghats are the main rainfall controlling relief features. The Himalayas obstruct the moisture laiden monsoon winds from the Indian Ocean and cause rainfall in the northeastern States and in the Indus-Ganga-Brahamputra plain. Again the windward side of Western Ghats receive more than 250 cm annual rainfall whereas most parts of the leeward side of the Western Ghats receive less than 60 cm annual rainfall.

(*iii*) The amount of rainfall decreases with increasing distance from the sea. For example Kolkata receives 119 cm during the southwest monsoon period. Patna 105 cm, Allahabad 76 cm and Delhi 56 cm.

(*iv*) The monsoon rains occur in wet spells of a few days interspersed with rainless interval known as ***'breaks'***. The breaks in rainfall are related to tropical cyclones which originate in the Bay of Bengal.

(*v*) The rainfall by the southwest comes in the form of heavy downpour which results in large scale run off and soil erosion.

(*vi*) Indian monsoon rains are vital for agrarian economy of the country.

(*vii*) There are large scale spatial variations in the distribution of rainfall. The amount of annual rainfall varies from about 12 cm in western Rajasthan to over 250 cm in the west coastal plains.

(*viii*) Monsoons often fail to keep date. Sometimes the beginning of rains is delayed considerably over the whole of country or a part thereof.

(*ix*) Sometimes the monsoons withdraw before the scheduled time causing considerable damage to the crops.

4. The Cool Season

The cool season starts with the beginning of the withdrawal of southwest monsoon in the middle of September and continues upto November, after which the winter season starts. The monsoons withdraw from the extreme north-west end of the country in September, from the peninsula by October and from the extreme south-eastern tip by December. Due to retreat of the monsoon, this season is also called the ***season of retreating monsoon.*** Sometimes it is referred to as the ***post monsoon season***.

A simple comparison of **figure 5.19** with **5.21** will show that the south-west monsoons reach north-west India last of all and withdraw from there first of all. Therefore, the duration of the south-west monsoon period is minimum there. In Punjab, for example, the south-west monsoons reach in the first week of July and withdraw from there in the second week of September, giving only two and a half months of monsoon activity. As against this, the south-west monsoons reach Coromandel coast in the first week of June and withdraw from there only in the middle of December. Thus the south-west monsoons remain active for more than six months over the Coromandel coast. Unlike the ***sudden burst*** of the advancing monsoons, the withdrawal is rather gradual and takes about three months.

(*a*) Temperature. With retreat of the monsoons, the clouds disappear and the sky becomes clear. The day temperature rises a little at the initial stage but soon starts falling rather steeply. In October the day temperature over larger parts of Rajasthan is 37°C. It decreases to 33°C in the peninsula and to 30°C in north-east India. Nights are cool with minimum temperature varying from 20° to 25°C. In the

Himalayan region the minimum temperatures reach freezing point. The average temperature in most parts of the country varies from 25° to 30°C. **Figure 5.22** shows the distribution of temperature in the month of October. The diurnal range of temperature increases due to lack of cloud cover.

(*b*) Pressure and Winds. As the monsoons retreat, the elongated trough of the low pressure across the Indus-Ganga plains weakens and gradually shifts southward. By October it reaches the Bay of Bengal and moves further southwards as the season advances. The axis of low pressure roughly runs in an east-west direction along 13°N latitude. The surface pressure in most parts of the country varies from 1,010 to 1,012 mb. Consequently the pressure gradient is low.

This is the season when south-west monsoons yield place to the north-east monsoons. Unlike the south-west monsoon, the onset of the north-east monsoon is not clearly defined. In fact, on many

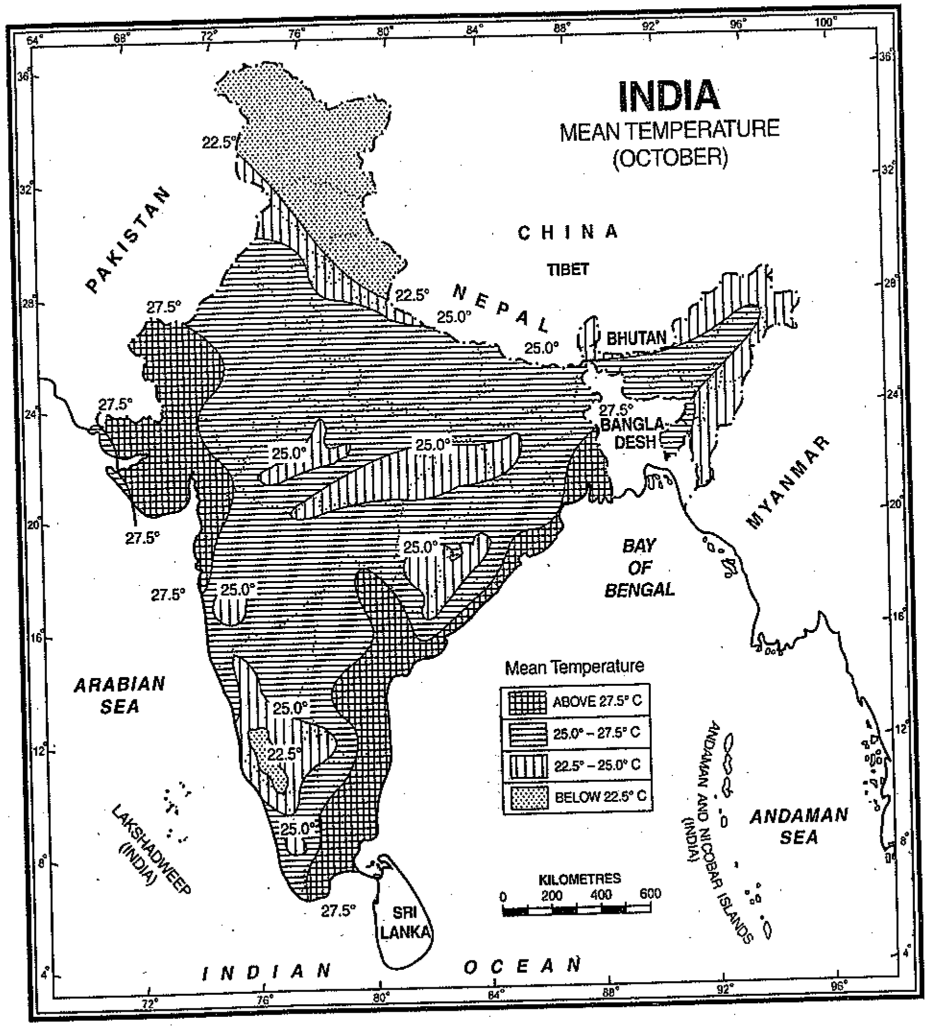

FIG. 5.22. Mean Temperature (October)

occasions, the meteorologists fail to draw a clear demarcation between the withdrawal of the summer monsoon and the onset of winter monsoon over peninsular India. However, the direction of winds over large parts of the country is influenced by the local pressure conditions. (**Fig. 5.23**).

Cyclones. This is the season of the most severe and devastating tropical cyclones originating in the Indian seas especially in the Bay of Bengal. The highest frequency of the cylcones is in the month of October and the first half of November. More cyclones are born in October and then in November and more cylcones originate in the Bay of Bengal than in the Arabian Sea. In October, the Cyclones of the Bay of Bengal originate between 8°N and 14°N. Initially they move in a west or northwesterly direction , but many of them later recurve and move towards the north-east; About 55 per cent of the Bay storms cross or affect the Indian coast. The areas most vulnerable to these storms include the coastal belts of

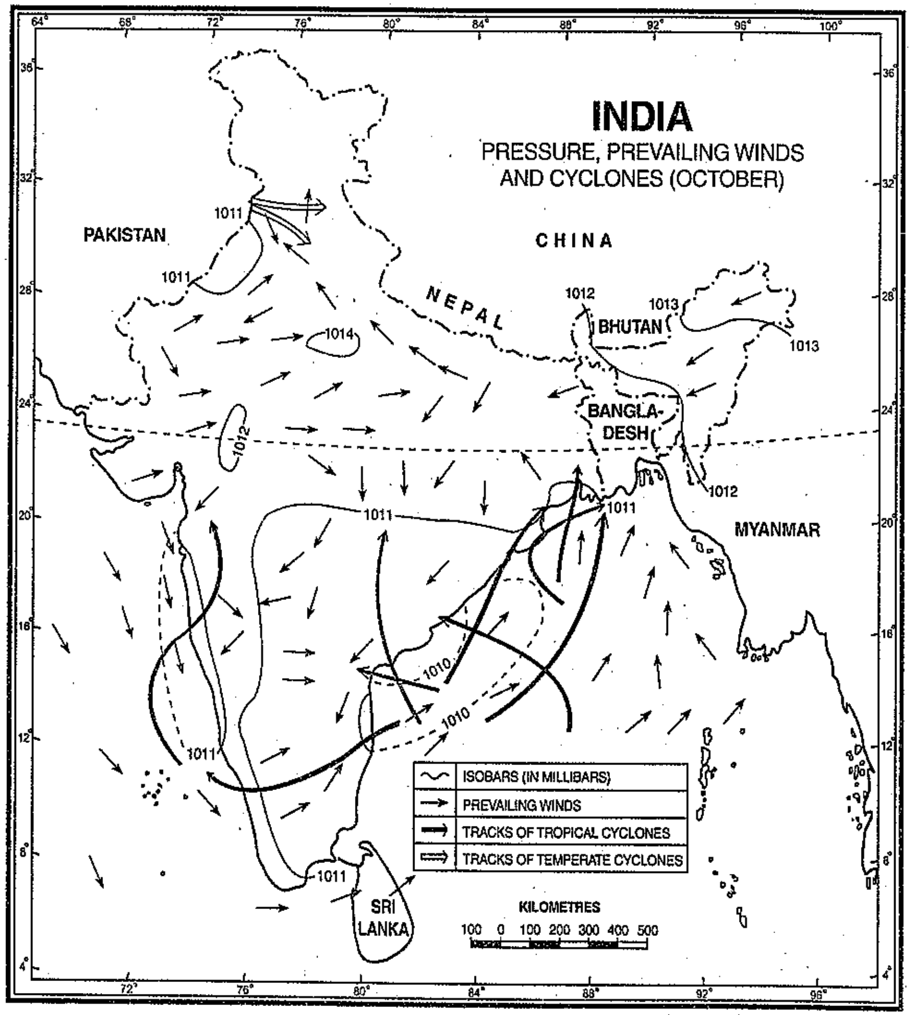

FIG. 5.23. Pressure, Winds and Cyclones (October)

Tamil Nadu, Andhra Pradesh, Odisha and West Bengal. Many of the cyclones which strike the eastern coast of India, south of 15°N latitude cross the southern Peninsula and enter Arabian Sea. During this process, they may weaken, but on re-entry over the Arabian sea they reintensify into cyclonic storms. The storms of Arabian sea originate between 12°N and 17°N latitudes in October and between 8° N and 13° N latitudes in November. Generally they move away from the coast in a north-westerly direction. But about 25% of them later recurve northeast and strike the Maharashtra or Gujarat coast.

The cyclones originating in the Bay of Bengal and the Arabian Sea are accompanied by strong surface winds, dense clouds, thundering and heavy downpours. A rainfall of 50 cm in a day is not uncommon, the highest record being around 86 cm in 24 hours at Purnea in Bihar. The heavy rainfall may continue for 2-3 days.

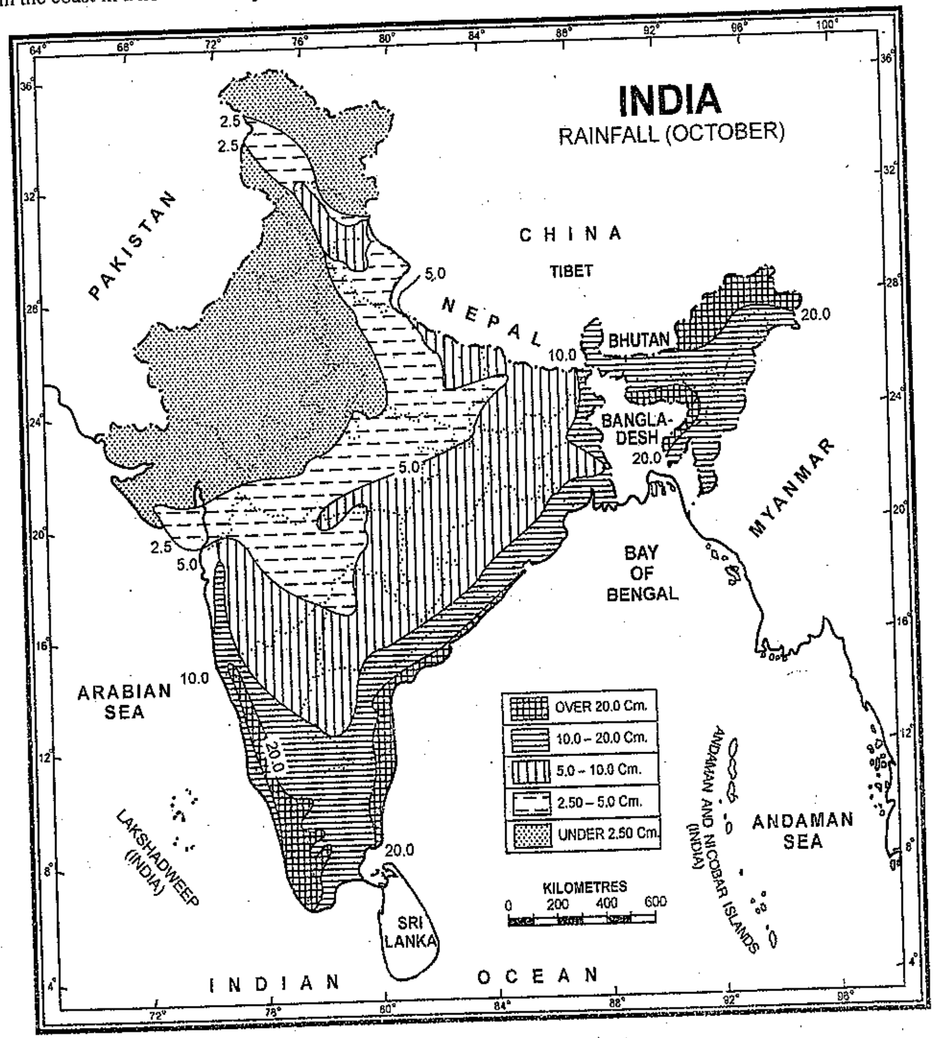

FIG. 5.24. India : Rainfall (October)

In north-west India the western disturbances produce clouding and light rainfall in the otherwise fine weather. The average incidence of western disturbances is 1 to 3, the frequency showing increasing trend with the advance of the season. The precipitation is in the form of snow in higher reaches of Jammu and Kashmir, Himachal Pradesh and in Kumaon Hills.

(*c*) **Precipitation.** The humidity and cloud cover are much reduced with the retreat of the south-west monsoons and most parts of the country remain without much rainfall. However, October-November is the main rainy season in Tamil Nadu and adjoining areas of Andhra Pradesh to the south of the Krishna delta as well as a secondary rainy period for Kerala. In fact Kerala has bi-modal pattern of rainfall with main rains in the south-west monsoon season and subsidiary rains in this season. The retreating monsoons absorb moisture while passing over the Bay of Bengal and cause this rainfall. According to a study conducted by Krishna Rao and Jagannathan the average rainfall in Tamil Nadu in October and November is 38.25 cm which is about 38.73 per cent of the annual rainfall received here. However, the coastal areas receive about 50% of their annual rainfall during this season.

Annual Rainfall

Figure 5.25 shows the distribution of annual rainfall in India. The average annual rainfall of India is about 118 cm which is the highest for a country of such vast dimensions anywhere in the world. But there are large spatial and temporal variations. Large parts of Meghalaya receive about 1,000 cm annual rainfall while on the other end of the scale, some districts in south-west Rajasthan hardly receive annual rainfall of 15 cm. In the extreme south, Kanniyakumari and Nellai Kattabomman districts get less than 30 cm during the south-west monsoon, while heavy rains of 200 cm or more, lash the nearby Kerala Coast. India can conveniently be divided into following regions depending upon the annual average rainfall received by these regions.

Areas of very high rainfall. Areas receiving an annual rainfall of 200 cm and above are termed as areas of very high rainfall. These include the west coast from Thiruvananthapuram in the south to Mumbai in the north. The average annual rainfall in this belt is 200-400 cm with localized areas in between receiving 400-800 cm annual rainfall. Almost the whole of Assam, Nagaland, Meghalaya, Mizoram, Arunachal Pradesh, Sikkim, parts of Manipur, Tripura and north-eastern tip of West Bengal also receive 200 cm or more, with isolated pockets receiving over 400 cm. Meghalaya (*the abode of clouds*) is the wettest part of the country with Mawsynram and Cherrapunji getting 1,221 and 1,102 cm of annual rainfall respectively.

Areas of high rainfall. These areas receive 100-200 cm annual rainfall. They include eastern slopes of the Western Ghats, major part of the northern plain, Odisha, Madhya Pradesh, Andhra Pradesh and Tamil Nadu. The *isohyet* (the line joining places of equal rainfall) of 100 cm rainfall runs southwards from Gujarat coast roughly parallel to the crest of the Western Ghats upto Kanniyakumari. The rainfall to the west of this line is above 100 cm. To the north, the 100 cm isohyet trends eastward passing over the southern parts of Jammu and Kashmir, Himachal Pradesh and northern Uttar Pradesh.

To the east of Allahabad, it bends to the west passing over Bundelkhand in Uttar Pradesh. Turning west-south-westwards, it runs over western Madhya Pradesh, eastern Maharashtra, northern Andhra and Telangana.

Areas of low rainfall. These areas receive 50-100 cm annual rainfall and include large parts of Gujarat, Maharashtra, western Madhya Pradesh, Andhra Pradesh, Karnataka, eastern Rajasthan, Punjab, Haryana and parts of Uttar Pradesh.

Areas of very low rainfall. These are desert and semi-desert areas receiving less than 50 cm of annual rainfall. They include large areas of western Rajasthan, Kachchh and most of Ladakh region of Jammu and Kashmir.a

Variability of Annual Rainfall

Rainfall in India does not change with space only but with time also. There are large variations in the total amount of rainfall from year to year. Variability of annual rainfall is computed with the help of the following formula.

$$\text{Coefficient of Variability (CV)} = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100$$

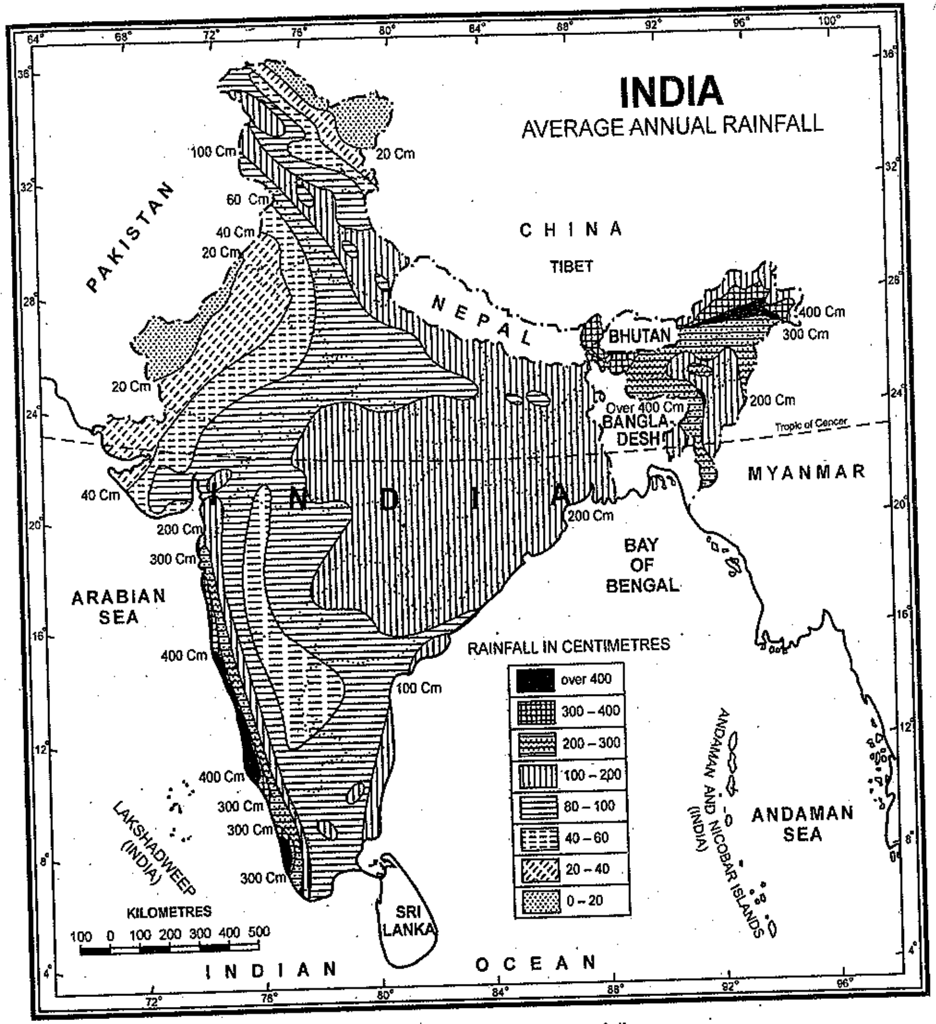

FIG. 5.25. Average Annual Rainfall

The coefficient of variation indicates the amount of fluctuation in rainfall recorded over a long period of time from the mean values. **Figure 5.26** shows the values of the coefficient of variation of monsoon rainfall in India. It generally ranges between 15 and 35 per cent for the country as a whole. The coefficient of variation in large parts of Rajasthan, Gujarat, and parts of Haryana and Panjab is well over 40 per cent. In extreme western parts of Rajasthan and Gujarat, it exceeds 60% and reaches 80% in the extreme west of Rajasthan. Incidentally these are the areas which receive minimum rainfall. The other areas of low rainfall and high coefficient of variation are Leh and Ladakh in the north and Rayalaseema in the south.

The areas of low coefficient of variation include the west coast, the sub-Himalayan belt including Sikkim, Arunachal Pradesh, Assam and West Bengal and the north-eastern hilly regions of Nagaland, Manipur and Mizoram. The coefficient of variation in these areas ranges between 15 and 20 per cent. These areas receive heavy annual rainfall of about 200 cm. In general the variability increases from west into the interior of the plateau as well as from Odisha and West Bengal towards the north and north-west.

A major conclusion that can be drawn from the above description is that the variability is highest where the amount of rainfall is the lowest. In other words, *the rainfall variability is inverse to total*

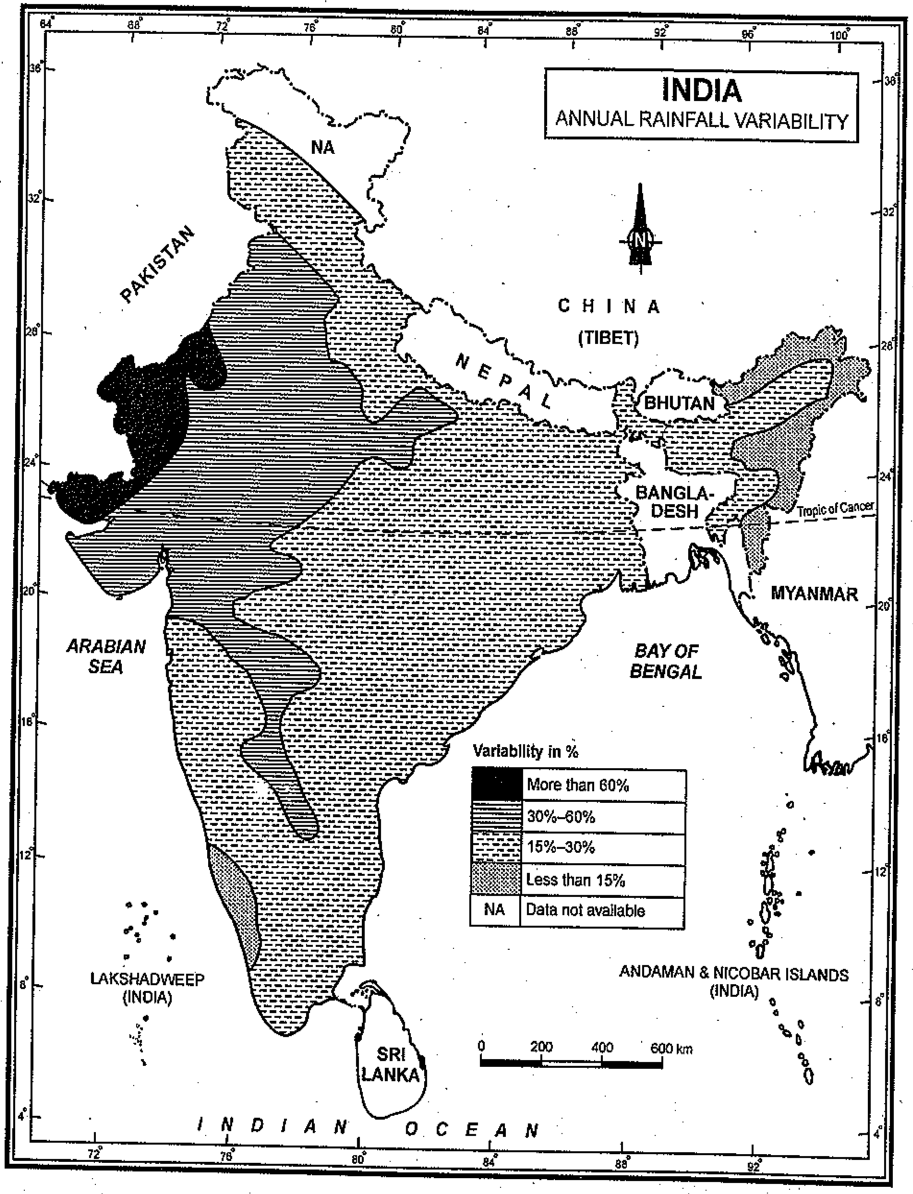

FIG. 5.26. Coefficient of variation of monsoon rainfall

amount of rainfall and reliability of rainfall is inversely proportional to the coefficient of variability. As such the spatial distribution of rainfall variability has a great bearing on Indian agricultural productivity. Since the areas of high variability are also the areas of low rainfall, they suffer from chronic deficiency of water, frequent droughts and crop failures. The areas with marginal rainfall are the worst sufferers.

However, the study of the coefficient of variation helps us in delineating those parts of the country where long range prediction will be useful. This prediction is not much required in areas of small coefficient of variation. For example, we can safely say that the actual rainfall will be within 10 to 15 per cent of the normal rainfall in Assam and West Bengal. But in Rajasthan and adjoining areas of north-west India the rainfall may vary by as much as thirty to fifty per cent or even more from the normal. Similarly the variability of the annual rainfall is high in large part of the Indian Peninsula. Evidently these are the areas where advance information about seasonal rainfall plays a crucial role.

PECULIARITIES AND SIGNIFICANCE OF INDIAN CLIMATE

Indian climate is primarily dominated by south-west monsoons and is peculiar in many ways. The extremes of temperature, rainfall and humidity are well known. The rainfall from the monsoon winds is variable and quite undependable. The monsoon may advance much before its due date or may be considerably delayed. Further, the amount of rainfall may be more than the normal or there may be deficient rains. Some parts of the country may be facing the fury of floods due to heavy rains while the other parts may be reeling under drought conditions due to scanty rainfall. The variability of rainfall in time and space plays havoc with agriculture which shatters the very foundation of economy in a predominantly agricultural country like India. It is often said that *Indian budget is a gamble in the monsoon.* In fact *monsoon is the pivot upon which the whole economic life of India swings.* Nowhere else in the world, so many people over so vast a land are so intimately wedded to the monsoon regime as they do in India. Another peculiar feature of the Indian rainfall is that it is concentrated in a few months of the year. Of the country's total rainfall, about 75 per cent is received in the monsoon months from June to September, 13 per cent comes in the post monsoon season, 10 per cent in the pre-monsoon season and the remaining 2 per cent in the winter season. At the same time, it is worth mentioning that one part or the other gets rainfall in each month of the year *i.e.* in no month

TABLE 5.3. Distribution of Rainfall

Percentage of the total land area	Amount of annual rainfall (cm)
11	above 200
21	125 to 200
37	75 to 125
24	35 to 75
7	Below 35

of the year the whole of India is completely dry. In January and February, north-west India gets rainfall from the western disturbances. In March thunderstorms start influencing Assam and West Bengal and give occasional pours till the arrival of the monsoons in June. Rainfall by south-west monsoons continues till the withdrawal of monsoons. Coromandel coast receives rainfall by the north-east monsoons in the winter season.

It has already been mentioned that the distribution of rainfall in India is very uneven. According to the calculations made by census of India in 1951 only 11 per cent area of India gets over 200 cms. of annual rainfall while about one third of the total land area of the country has to content with a mere 75 cm annually. Table 5.3 gives areal distribution of rainfall in India.

Indian rainfall is basically torrential in nature. Much of the rainfall is received in 3-4 months of the rainy season. Even in this season the actual rainy days are 40-45 only. The heaviest downpours occur in association with cyclones which originate in the Bay of Bengal and the Arabian Sea. A rainfall of 50-60 cm in a rainy day is not uncommon. The highest record, as already mentioned, is 103.6 cm in 24 hours at Cherrapunji. This place gets rainfall of 1,102 cm in 180 rainy days. Sri Ganganagar receives 12 cm of rain in 10-12 rainy days. Hence the statement, *it pours, it never rains in India*, is true whether it be Meghalaya or Rajasthan. The sudden heavy downpour results in devastating floods and excessive soil erosion.

Another very important aspect of Indian rainfall is that it is largely controlled by orography. The effects of the Himalayas and the Western Ghats on the amount and distribution of rainfall and the inability of the Aravalis to cause rainfall have already been discussed. The whole of India would have been a vast desert but for the size and lie of the Himalayas and the Western Ghats. Therefore, we can easily say that the *rainfall over the country is primarily orographic.*

CLIMATIC REGIONS OF INDIA

Although India has tropical monsoon climate as a whole, there are large regional variations in important climatic elements such as rainfall and temperature. This is quite natural for a vast country like India having subcontinental dimensions. Variations in rainfall are much more marked than those of temperature. Hence, most geographers have given more importance to rainfall than to temperature. The first attempt to divide India into climatic regions was made by Blanford towards the close of the 19th century. Among the subsequent attempts made to divide India into climatic regions, those made by W.G. Kendrew, L.D. Stamp, Koppen, Thornthwaite, G.T. Trewartha and Johnson are worth mentioning. Among the Indian geographers, attempts made by Subrahmanyam (1955), Bharucha and Shanbhag (1957) and R.L. Singh (1971) deserve appreciation.

Stamp's Classification of Climatic Regions

Dr. L. Dudley Stamp's classification of Indian climate is very much akin to that suggested by **W.G. Kendrew.** This classification is empirical, arbitrary and subjective, but uses quantitative limits to the regions in easily understood units like temperature and rainfall. Stamp's schemes has been presented here with slight modifications here and there. Stamp used 18°C isotherm of mean monthly temperature for January to divide the country into two broad climatic regions, *viz.*, temperate or continental zone in the north and tropical zone in the south. A look at **Fig. 5.27** will show that this line runs roughly across the root of the peninsula, more or less along or parallel to the Tropic of Cancer. The two major climatic regions are further divided into eleven regions depending upon the amount of rainfall and temperature.

A. The Temperate or Continental India has been divided into following five regions :

1. The Himalayan region (heavy rainfall)
2. The north-western region (moderate rainfall)
3. The arid low land
4. The region of moderate rainfall
5. The transitional zone

B. The tropical India has been divided into following six regions :

6. Region of very heavy rainfall
7. Region of heavy rainfall
8. Region of moderate rainfall
9. The Konkan Coast
10. The Malabar Coast
11. Tamil Nadu

A. Climatic regions of temperate or continental India

1. The Himalayan Region. This region embraces the entire Himalayan mountain area which includes from west to east, Jammu and Kashmir, Himachal Pradesh, large parts of Uttarakhand, the north hill region of West Bengal, Sikkim and Arunachal Pradesh. The winter and summer temperatures are 4°-7°C and 13°-18°C respectively. The higher reaches are perpetually under snow and ice. The average annual rainfall exceeds 200 cm in the east but it is much less in the west. Shimla in the west and Darjeeling in the east are its representative cities.

2. The North-western Region. It includes the northern parts of Punjab and southern parts of Jammu and Kashmir. The winter and summer temperatures are 16°C and 24°C respectively. Amritsar is its representative city.

3. The Arid Lowland. This is a vast dry area which includes the Thar desert of Rajasthan, south western part of Haryana and Kachchh of Gujarat. The average temperature in winter varies from 16° to 24°C which may shoot up to 48°C in summer. Jaipur is its representative city. The average annual rainfall does not exceed 40 cm.

4. The region of moderate rainfall. Parts of Punjab, Haryana, western Uttar Pradesh, Union Territory of Delhi, north-west Plateau area of Madhya Pradesh and eastern Rajasthan are areas of average rainfall with an annual rainfall of 40 to 80 cm. Temperatures in January and July are 15°-18°C and 33°-35°C respectively. Most of the rainfall occurs in summer. Delhi represents this region very well.

5. The Transitional Zone. Eastern Uttar Pradesh and Bihar comprise the transitional zone between areas of average rainfall on the west and areas of heavy rainfall in the east. The average annual rainfall in this zone is 100-150 cm. The temperatures in January and July vary between 15°-19°C and 30°-35°C. Patna is the representative city of this zone.

B. Climatic Regions of Tropical India

6. Region of very heavy rainfall. These areas receive more than 200 cm of annual rain and include large parts of Meghalaya, Assam, Tripura, Mizoram

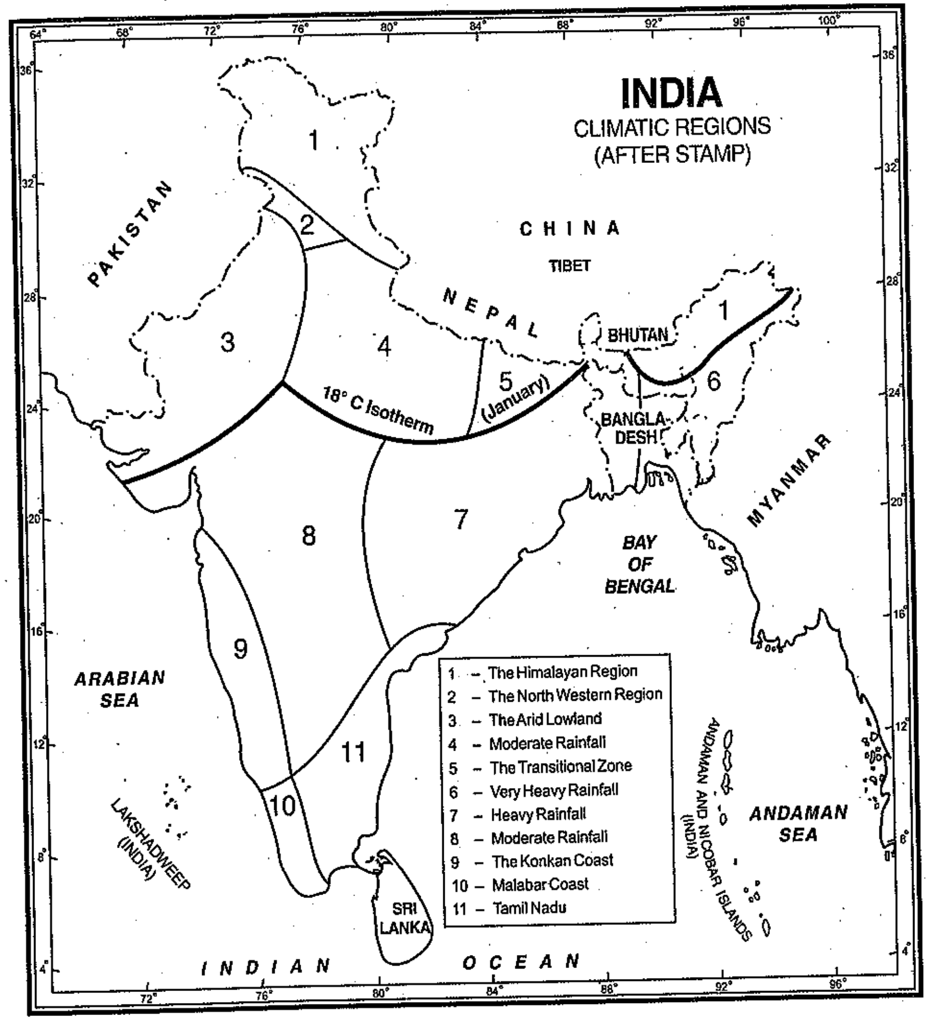

FIG. 5.27. Climatic Regions of India (After Stamp)

and Nagaland. Temperatures remain around 18°C in January and rise to 32°-35°C in July. Cherrapunji and Mawsynram in Meghalaya receive 1,102 cm and 1,221 cm of annual rainfall respectively.

7. Region of heavy rainfall. Chhattisgarh, Jharkhand, Gangetic West Bengal, Odisha and coastal Andhra Pradesh receive 100-200 cm annual rainfall and are termed as areas of heavy rainfall. The rainfall is primarily brought by the monsoon winds coming from the Bay of Bengal. The cyclones originating in the Bay of Bengal also bring some rainfall. The amount of rainfall decreases as we move from east to west and from north to south. The January and July temperatures range from 18°-24°C to 29°-35°C respectively. Kolkata is the representative city of this region.

8. Region of moderate rainfall. It includes mostly those areas between Western and Eastern Ghats which receive annual rainfall of 50-100 cm. Rainfall is comparatively low because this region lies in the rain shadow area of the Western Ghats. The average temperature in winter is 18°-24°C which rises to 32°C in summer. This region is represented by Hyderabad in Telangana.

9. The Konkan Coast. Extending from Mumbai in the north to Goa in the south, the Konkan Coast receives over 200 cm annual rainfall brought by the Arabian Sea branch of the south-west monsoons. The temperature remains fairly high and varies from 24°-27°C. Thus the annual range of temperature is very low; to the tune of 3°C only. Mumbai is the representative city of this region.

10. The Malabar Coast. It extends from Goa to Kanniyakumari and receives heavy annual rainfall of over 250 cm. The rainfall is mainly brought by the south-west monsoon winds coming from the Arabian Sea and continues for about nine months in a year. The temperature remains in the vicinity of 27°C and the annual range of temperature is only 3°C. This region is represented by Thiruvananthapuram.

11. Tamil Nadu. It includes Tamil Nadu and adjoining areas of Andhra Pradesh. The rainfall varies from 100 to 150 cm and is mainly caused by the retreating monsoons from north-east during November and December. The temperature remains somewhere around 24°C. There is not much change in summer and winter temperature and the annual range of temperature is only 3°C. Chennai is the representative city of this region.

Koppen's Classification of Climatic Regions

Dr. Wladimir Koppen of the University of Graz (Austria) first published his scheme of classification of world climates in 1901 and subsequently modified it a number of times, the major revisions being in 1918 and 1931. His latest work was published in 1936 in which he presented a new scheme of climatic classification.

This classification is based upon annual and monthly means of temperature and precipitation. It accepts the native vegetation as the best expression of the totality of a climate, so that many of the climatic boundaries are based upon vegetation. Koppen has expressed the view that the effectiveness of precipitation in vegetation growth depends not only upon the amount of precipitation, but also upon the intensity of evaporation and transpiration. Much of the water obtained from precipitation is lost from the soil and plants by evaporation and transpiration and is not available for vegetation growth. Thus a certain amount of rain falling in hot and dry climate may not be as useful to vegetation as the same amount of rain falling in a cool and humid climate.

Koppen has suggested five major types of climate which correspond with five principal vegetation groups. Each climatic type is represented by a capital letter explained as under :

A : Tropical rainy climate with no cool season. Temperature of the coolest month above 18°C.

B : Dry climate in which there is an excess of evaporation over precipitation.

C : Middle-latitude rainy climate with mild winters. Average temperature of coldest month below 18°C but above –3°C. Average temperature of warmest month over 10°C.

D : Middle-latitude rainy climate with severe winters. Average temperature of coldest month below –3°C and that of warmest month above 10°C.

E : Polar climate with no warm season. Average temperature of the warmest month below 10°C.

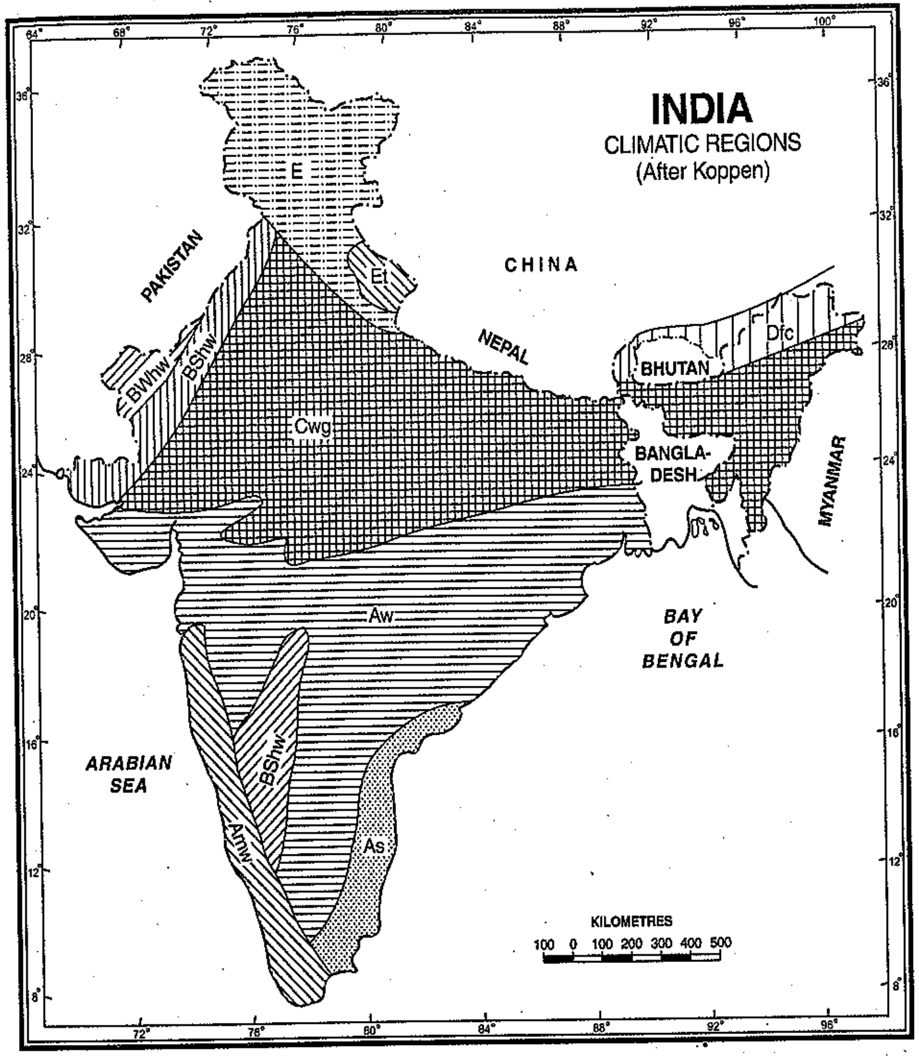

FIG. 5.27. Koppen's Climatic Regions of India

The above mentioned major climatic types are further subdivided depending upon the seasonal distribution of rainfall or degree of dryness or cold. They are designated by small letters *a, c, f, h, m, g, s* and *w* each having a specific meaning as per details given below :

a : hot summer, average temperature of the warmest month over 22°C

c : cool summer, average temperature of the warmest month under 22°C

f : no dry season

w : dry season in winter

s : dry season in summer

g : Ganges type of annual march of temperature; hottest month comes before the solstice and the summer rainy season.

h (heiss) : average annual temperature under 18°C

m (monsoon) : short dry season.

The capital letters *S* and *W* are employed to designate the two subdivisions of dry climate : semi arid or *Steppe (S)* and arid or *desert (W)*. Capital letters *T* and *F* are similarly used to designate the two subdivisions of polar climate : *tundra (T)* and *icecap (F)*.

Koppen divided India into nine climatic regions making use of the above scheme (**Fig. 5.28**).

1. Amw (Monsoon type with short dry winter season). This climate is found in the western coastal region, south of Mumbai. This area receives over 300 cm of annual rainfall in summer from the south-west monsoons.

2. As (Monsoon type with dry season in high sun period). This is the region in which rainfall occurs in winter and summer is dry. Coromandel coast experiences this type of climate. Coastal Tamil Nadu and adjoining areas of Andhra Pradesh are included in it. The amount of rainfall, mostly in winter is 75-100 cm and is received from the retreating monsoons.

3. Aw (Tropical Savanah type). This climate is found in most parts of the peninsular plateau barring Coromandel and Malabar coastal strips. The northern boundary of this climatic region roughly coincides with the Tropic of Cancer. The average annual rainfall is about 75 cm which is received in summer season from the south west monsoons. Winter season remains dry.

4. BShw (Semi-arid Steppe type). Some rainshadow areas of Western Ghats, large part of Rajasthan and contiguous areas of Haryana and Gujarat have this type of climate. Rainfall varies from 12 to 25 cm and most of it occurs in summer. Winter is completely dry. Some arid steppe vegetation is found here.

5. BWhw (Hot desert type). Most of western Rajasthan has hot desert type of climate where the amount of annual rainfall is less than 12 cm. Temperatures are very high in summer. Natural vegetation is almost absent.

6. Cwg (Monsoon type with dry winters). This type of climate is found in most parts of the Ganga Plain, eastern Rajasthan, Assam and in Malwa Plateau. The summer temperature rises to 40°C which falls to 27°C in winter. Most of rainfall occurs in summer and winter is dry.

7. Dfc (Cold, Humid winters type with shorter summer). Some of the north-eastern states such as Sikkim, Arunachal Pradesh and parts of Assam have this type of climate. Winters are cold, humid and of longer duration. The winter temperatures are about 10°C. Summers are short but humid.

8. Et (Tundra Type). This climate is found in the mountain areas of Uttarakhand. The average temperature varies from 0 to 10°C. There is fall in temperature with altitude.

9. E (Polar Type). The higher areas of Jammu & Kashmir and Himachal Pradesh experience polar climate in which the temperature of the warmest month varies from 0° to 10°C. These areas are covered with snow for most part of the year.

Thornthwaite's Classification of Climatic Regions

Following Koppen, Thornthwaite presented his classification of climates in 1931 and revised it in 1933 and 1948. Though his first two classifications are more or less similar, the classification put forward by him in 1948 was markedly different. While in the 1931 classification, the plant was viewed as a meteorological instrument for measuring climatic character, in the 1948 classification, vegetation is regarded as a physical mechanism by means of which water is transported from soil to the atmosphere; *it is the machinery of evaporation as the cloud is the machinery of precipitation*. The combined loss through evaporation from the soil surface and transpiration from plants is called ***evapotranspiration***. His classification is based on the principle that '*the plant is in the nature of a meteorological instrument which is capable of measuring all the integrated climatic elements*'. Under this system climatic types are identified and their boundaries determined empirically by noting vegetation, soil and drainage features.

It has been suggested by Thornthwaite that the plant growth depends not only upon precipitation but rather it is affected by precipitation effectiveness. *The precipitation effectiveness is determined by dividing total monthly precipitation by evaporation and is called the P/E ratio*. The sum of 12 monthly P/E ratios is called the P/E index. Based upon the P/E index, Thornthwaite recognised five humidly provinces each of which appears to be associated with a characteristic vegetation.

Humidity Province	Characteristic Vegetation	P/E Index
A, wet	Rainforest	128 and above
B, humid	Forest	64-127
C, subhumid	Grassland	32-63
D, semiarid	Steppe	16-31
E, arid	Desert	Under 16

The five principal humidity provinces are subdivided into four subtypes based upon seasonal concentration of precipitation.

r = rainfall adequate in all seasons

s = rainfall deficient in summer

w = rainfall deficient in winter

d = rainfall deficient in all seasons.

Thornthwaite also recognised six temperature provinces based upon thermal efficiency :

Temperature Province	T/E Index
A', tropical	128 and above
B', mesrothermal	64-127
C', microthermal	32-63
D', taiga	16-31
E', tundra	1-15
F', frost	0

A total of 120 combinations of three elements, precipitation effectiveness, seasonal concentration of rainfall, and thermal efficiency are possible but Thornthwaite recognised only 32 climatic types on the world map of climatic classifications prepared by him. Of these only 12 climatic types are found in India.

1. AA'r is tropical wet climate in which the P/E as well as T/E index is above 128. Rainfall occurs in all the seasons and dense rain forests grow. This climate is found along the west coast and in Tripura and Mizoram.

2. BA'w is tropical humid climate in which thick forests grow. T/E ratio is above 128 but P/E ratio is 64-127. Rainfall is deficient in winter. This climate is found on the eastern slopes of the Western Ghats and in West Bengal.

3. BB'w is temperate humid climate which is mainly found in parts of Assam, Meghalaya Mizoram and Nagaland. P/E index and T/E index vary from 64 to 127. The rainfall is deficient in winter. Such a climate is useful for the growth of vegetation.

4. CA'w covers large parts of the peninsular India. The T/E index is 128 and above but the P/E index falls to 32-63. Being a comparatively dry climate, it is suitable for grasslands only.

5. CA'w' is similar to *CA'w* with the only difference that the rainfall occurs in winter. Most of Tamil Nadu and the neighbouring parts of Andhra Pradesh enjoy this climate.

6. CB'w is temperate subhumid climate which covers most of the northern plain of India. The T/E index is 64 to 127 and the P/E index is still lower ranging between 32 and 63. This climate is suitable for grasslands.

7. DA'w is a tropical semi-arid climate which is mainly found in the northern Gujarat and southern Rajasthan. T/E index is 128 or above while P/E index is 16 to 31. This climate is suitable for steppe type of vegetation.

8. DB'd is temperate semi arid climate in which rainfall is deficient in all the seasons. T/E index is 64-127 while P/E index is 16-31. This climate is found in Jammu and Kashmir and is suitable for steppe vegetation.

9. DB'w is similar to DB'd climate with the only difference that the rainfall is deficient in winter. Parts of Punjab, Haryana and Rajasthan as well as some parts of rainshadow area in the peninsular India experience this climate.

10. D' is a taiga type climate in which T/E index is 16 to 31. It is found in Jammu and Kashmir, Himachal Pradesh, Punjab, and Uttarakhand in the west and Arunachal Pradesh, Sikkim and parts of upper Assam in the east.

11. E' is a cold tundra type of climate which is found in higher reaches of the Himalayas.

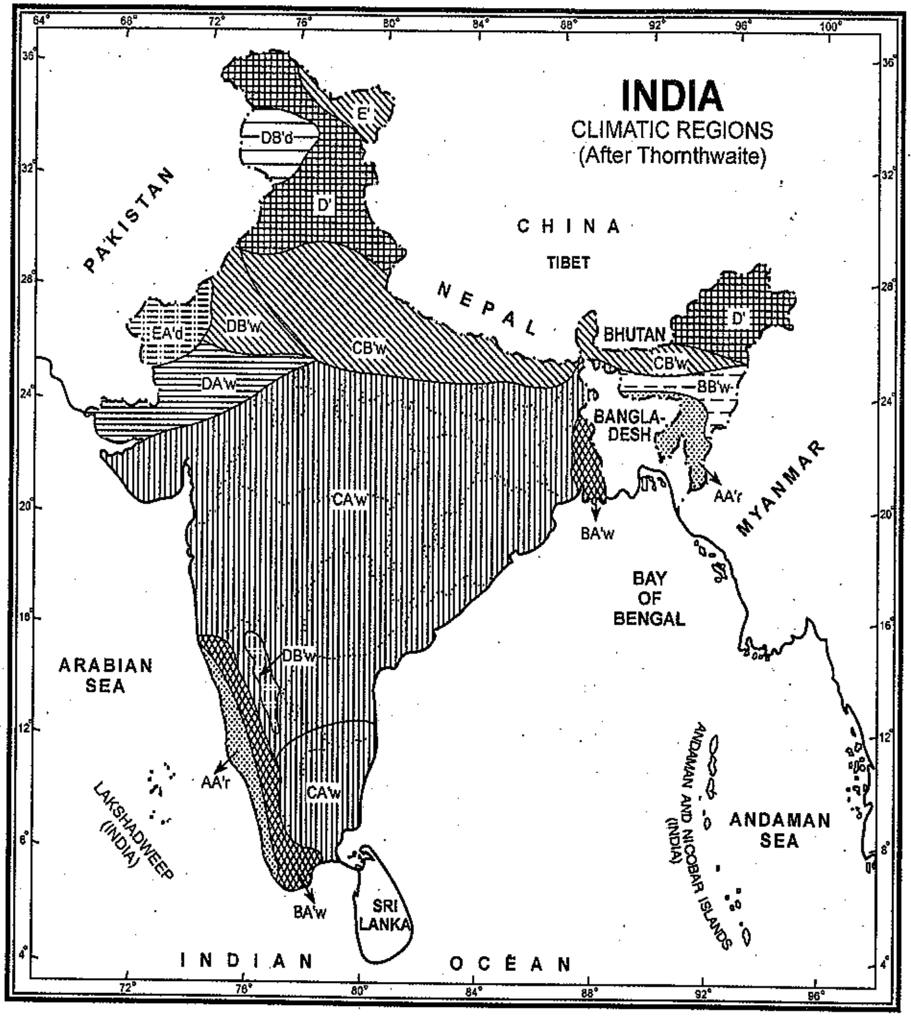

FIG. 5.29. India : Climatic Regions after Thornthwaite classification of climates

12. EA'd is extremely hot and dry climate in which T/E index is over 128 and P/E index remains below 16. Rainfall is deficient throughout the year. This type of climate is found in western part of Rajasthan.

Trewartha's Classification of Climatic Regions

Prof. Glenn T. Trewartha of the University of Wisconsin in the U.S.A., modified and simplified Koppen's classification and presented his own classification in his book entitled 'An Introduction to Climate'. He has recognised six major climates of the world. They are :

A. Tropical humid climates
B. Dry climates
C. Humid mesothermal climates
D. Humid microthermal climates
E. Boreal climates
F. Polar climates

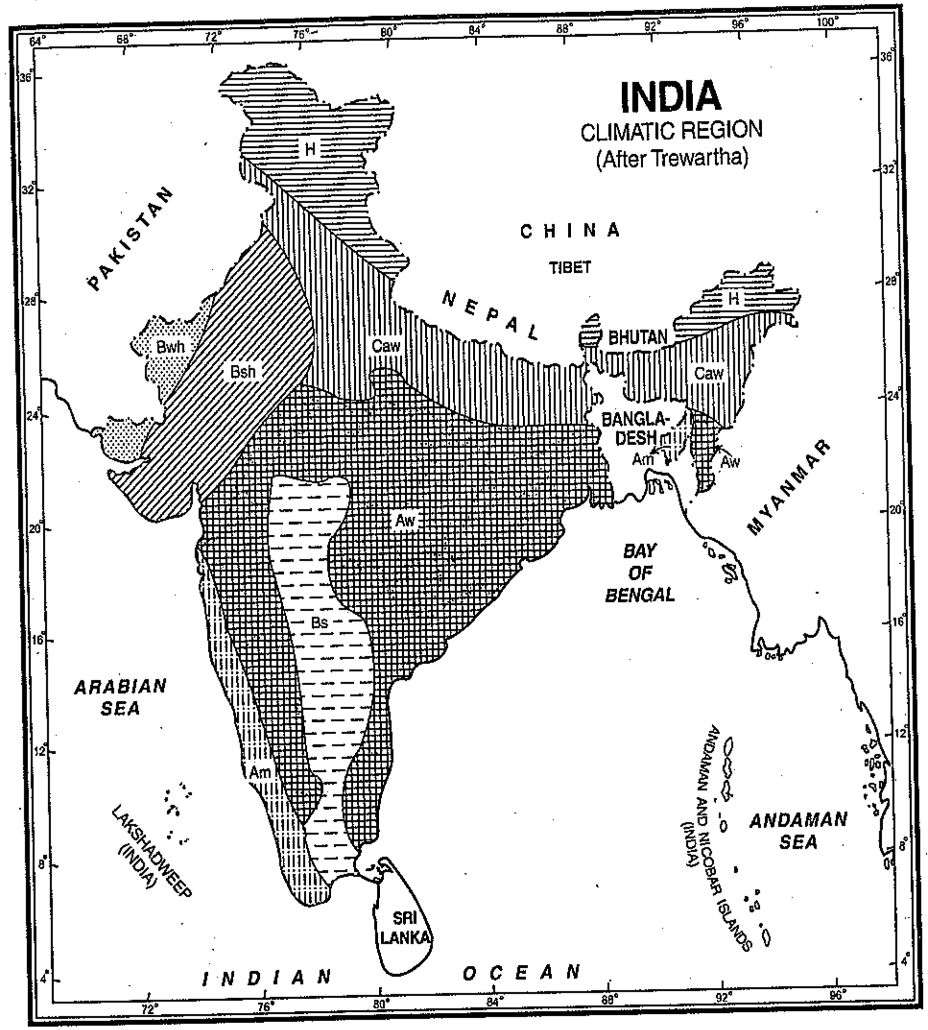

FIG. 5.30. Climatic Regions of India (after Trewartha)

In addition, he recognised H. undifferentiated climate of highlands.

Out of the above climatic types four types *viz. A, B, C* and *H* are found in India. These four types have further been divided into seven sub-types. A brief description of each climatic type is given below :

A is tropical humid climate in which temperature does not fall below 18°C. It has two subdivisions.

(*i*) *Am* is tropical monsoon type with average annual temperature of 27°C and annual rainfall of over 250 cm. Western Coastal plain and Tripura have this climate.

(*ii*) *Aw* is tropical wet and dry (savanna) type. The temperature here also remains at 27°C but the annual rainfall is much less, about 100 cm. The entire rainfall occurs in summer season. A major part of peninsular plateau and north-eastern state of Mizoram experience this climate.

B is a dry climate in which the annual rainfall is always less than 100 cm. This climate is divided into following three sub types.

(*i*) *Bs* is semi arid or steppe type which is found in the rain shadow of the Western Ghats. The average temperature is above 27°C but the rainfall is below 100 cm. Rainfall occurs mainly in summer and supports grasslands.

(*ii*) *Bsh* is tropical and subtropical desert climate in which the average annual temperature is above 27°C and the rainfall declines to 50-100 cm. Large parts of Gujarat, Rajasthan and south-west Haryana experience this type of climate.

(*iii*) *Bwh* is middle latitude desert climate which is found in west Rajasthan and Kachchh region of Gujarat. Here the temperatures are sufficiently high but the annual rainfall further declines to a low of 20 cm. This climate supports only thorny bushes.

C is mesothermal or subtropical climate in which winter is dry and cold.

Caw. Most parts of the northern plain of India have this type of climate where winter temperature falls below 18°C. Most of the rainfall occurs in summer and the amount of rainfall decreases from east to west. Western disturbances give light winter rainfall in the western part.

H climate indicates undifferentiated highlands where the temperatures are invariably low. Higher areas have snowfall in winter. Rainfall is caused by the monsoon winds in summer and by western disturbances in winter. Most of the Himalayan region including Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh have this climate.

R.L. Singh's Classification of Climatic Regions

Following Kendrew and Stamp, Dr. R.L. Singh presented his climatic divisions of India in 1971. He divided the country into 10 climatic divisions based on the temperature conditions of the hottest and the coldest months and average annual rainfall.

1. Per Humid North-East. As its name indicates, it covers most parts of the north-eastern states including Sikkim, Assam, Arunachal Pradesh, Nagaland, Tripura, Mizoram, and Meghalaya. The July temperature is 25°-33°C which falls to 11°-24°C in January. The average annual rainfall at most of places is 200 cm although there are places which record over 1,000 cm of rainfall.

2. Humid Sahyadri and West Coast. It includes Sahyadri (Western Ghats) and its western coastal belt extending from Narmada Valley in the north to Kanniyakumari in the south. Temperature in January is 19°-28°C which rises to 26°-32°C in July. The average annual rainfall is about 200 cm but at places it may be much higher especially on the western slopes of the Western Ghats.

3. Humid South-East. Odisha, West Bengal, Chhattisgarh and Jharkhand are included in it. January and July temperatures are 12°-27°C and 26°-34°C respectively. The average annual rainfall is 100-200 cm.

4. Subhumid Transition. It embraces the eastern part of Uttar Pradesh, Bihar and northern part of Jharkhand. January temperature is 9° to 24°C which rises to 24°-41°C in July. The average annual rainfall is 100-200 cm.

5. Subhumid Littorals. Eastern Tamil Nadu and coastal Andhra Pradesh have subhumid littoral climate. May is the hottest month when the temperature rises to 28°-38°C. In January the temperature falls to 20°-29°C. Summers are dry but winters are wet. The area as a whole receives 75-150 cm annual rainfall, most of which is caused by retreating monsoons in November-December.

6. Subhumid Continental. This climate is primarily found in the Ganga plain where January and July temperatures are 7°-23°C and 26°-41°C respectively. The average annual rainfall varies from 75 to 150 cm.

7. Semi arid and Subtropical. This climate prevails in the Satluj-Yamuna water divide which includes Punjab, Haryana, eastern Rajasthan and the Union Territories of Delhi and Chandigarh. The average rainfall is 25 to 100 cm, most of which falls in summer. Some rainfall is caused in winter by western disturbances. January temperatures are 6°-23°C which rise to 26°-41°C in May.

8. Semi arid Tropical. Large parts of Gujarat, Maharashtra, Madhya Pradesh, Chhattisgarh, Karnataka and Telangana have semi arid tropical

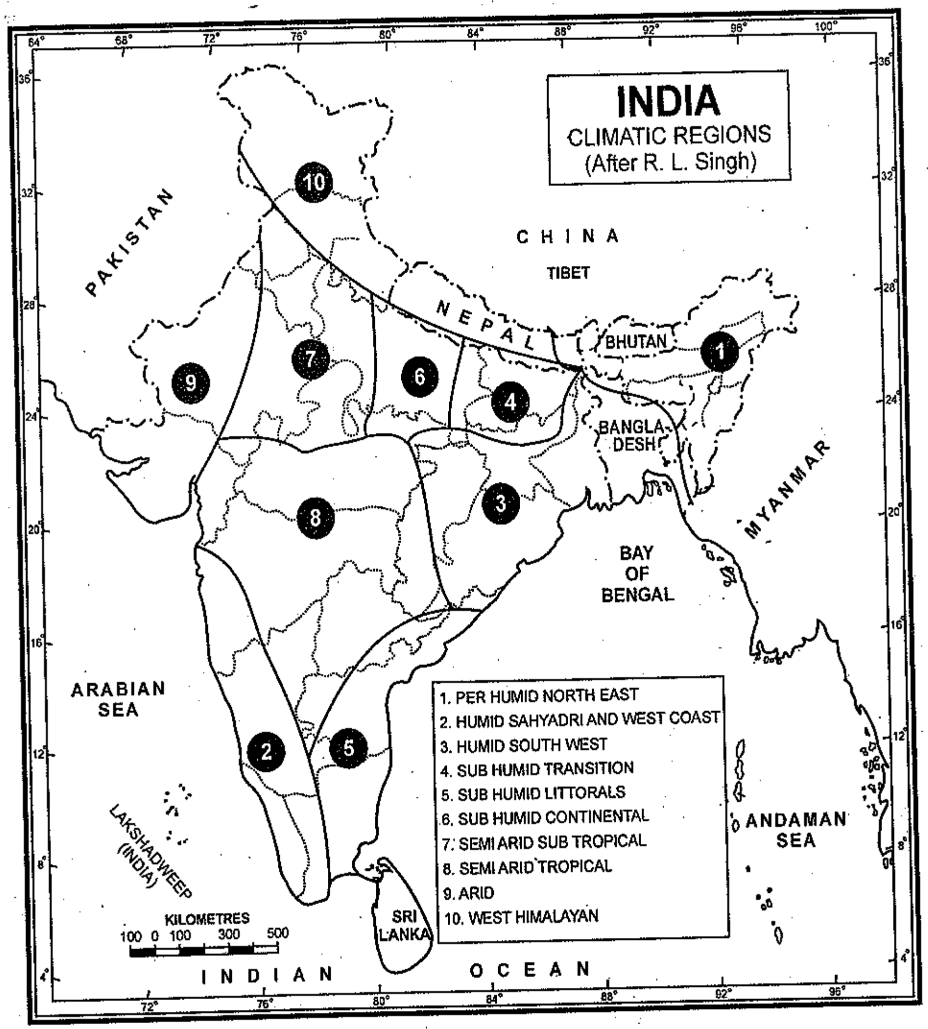

FIG. 5.31. India's Climatic Regions after R.L. Singh

climate. Temperature varies from 13°-29°C in January and from 26°-42°C in July. The average annual rainfall varies from 50 to 100 cm.

9. Arid. The areas of arid climate comprise the Thar desert and includes western Rajasthan, south-west Haryana and Kachchh region of Gujarat. This is extremely dry climate in which the annual rainfall is only 25 cm and at places it is as little as 10 cm. January temperatures are 5°-22°C which rise to 20°-40°C in June. The range of temperature, both diurnal and annual, is very large.

10. West Himalayan. This climate is found in west Himalayan region which includes Jammu and Kashmir, Himachal Pradesh and Uttarakhand. The July temperature is 5°-30°C which dips to 0°-4°C in January. The annual rainfall is 150 cm. The rainfall is caused by south-west monsoons in summer and by western disturbances in winter.

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Natural Vegetation and Wildlife

INTRODUCTION

Natural vegetation is the primeval plant cover unaffected by man either directly or indirectly. The word forest is derived from Latin 'fores' meaning outside, the reference being to a village boundary or fence and it must have included all uncultivated and uninhabited land. In general, a forest is defined as an area set aside for the production of timber and other forest produce or maintained under woody vegetation for certain benefits which it provides. Ecologically, a forest is a plant community, predominantly of trees and other woody vegetation, usually with a closed canopy.

FACTORS INFLUENCING VEGETATION

The geographical factors which influence natural vegetation include climate, soil and topography. The main climatic factors are rainfall and temperature. Generally speaking, rainfall is more important than temperature except in the Himalayas. The seasonal rainfall regime, the length of dry season and its relation to the march of temperature, are also important. The amount of annual rainfall has a great bearing on the type of vegetation. Areas receiving 200 cm or more rainfall per annum have stands of evergreen rain forests while monsoon deciduous forests dominate in areas with rainfall between 100 and 200 cm. In areas having 50 to 100 cm rainfall there are drier deciduous or tropical savana grading into open thorny scrub while those with less than 50 cm rainfall have only dry thorny scrub and low open bush merging into semi desert. In higher altitudes of the Himalayas and the hills of the Peninsula at elevation of more than 900 metre above sea level, temperature plays a more important role. As the temperature falls with altitude in the Himalayan region the vegetal cover changes from tropical to sub-tropical, temperate and finally alpine. Changes in soil conditions have given birth to different types of vegetation in different parts of the country. Mangrove forests, swamp forests, and beach and coastal

forests are some of the outstanding examples of influence of soil on natural vegetation. Topography in the narrow sense is responsible for certain minor types *e.g.* alpine flora, tidal forests, etc.

CLASSIFICATION OF NATURAL VEGETATION

A great variety of vegetation is found in different parts of India due to unequal distribution of rainfall and temperature as well as their seasonal variation, besides varied edaphic and biotic conditions. A generalised classification of Indian forests is, therefore, a difficult job. Various systematic classifications have been made by a number of botanists and ecologists. **H.G. Champion** (1936) distinguished 116 types of vegetation in India, some with further sub-divisions. Champion's classification has been much simplified by **G.S. Puri** (1960), **Legris** (1963), **Champion** and **S.K. Seth** (1968) and **S.S. Negi** (1990). Based on the suggestions of these scholars India's vegetation can be divided into 5 main types and 16 sub-types as per details given below :

A. Moist Tropical Forests

1. Tropical Wet Evergreen
2. Tropical Semi-Evergreen
3. Tropical Moist Deciduous
4. Littoral and Swamp

B. Dry Tropical Forest

5. Tropical Dry Evergreen
6. Tropical Dry Deciduous
7. Tropical Thorn

C. Montane Sub-tropical Forests

8. Sub-tropical broad leaved hill
9. Sub-tropical moist hill (pine)
10. Sub-tropical dry evergreen

D. Montane Temperate Forests

11. Montane Wet Temperate
12. Himalayan Moist Temperate
13. Himalayan Dry Temperate

E. Alpine Forests

14. Sub-Alpine
15. Moist Alpine scrub
16. Dry Alpine scrub

A. MOIST TROPICAL FORESTS

1. Tropical Wet Evergreen Forests. These are typical rain forests which grow in those areas where the annual rainfall exceeds 250 cm, the annual temperature is about 25°-27°C, the average annual humidity exceeds 77 per cent and the dry season is distinctly short. Due to high heat and high humidity, the trees of these forests do not shed their leaves annually, at least not together, and are termed as evergreen forests. These are lofty, very dense multilayered forests with mesosphytic evergreens. The trees often reach 45 metres in height, individual trees exceed 60 metres. The entire morphology looks like a green carpet when viewed from above. The sun light cannot reach the ground and owing to deep shade, the undergrowth is formed mainly of tangled mass of canes, bamboos, ferns, climbers, etc. A variety of orchids flourishes on the trees.

The true evergreen forests are found along the western side of the Western Ghats (between 500 to 1370 metres above sea level) south of Mumbai, in a strip running from north-east to south-west direction across Arunachal Pradesh, Upper Assam, Nagaland, Manipur, Mizoram and Tripura upto a height of 1070 metres and in the Andaman and Nicobar Islands.

The timber of these forests is fine-grained, hard and durable as a result of which it has high commercial value. The important species of these forests are mesua, white cedar, calophyllum, toon, dhup, palaquium, hopea, jamun, canes, etc. in the Western Ghats, and gurjan, chaplasha, jamun, mesua, agar, muli, bamboo etc. in the Himalayan region. Although these forests contain valuable commercial species, they have not been properly exploited due to dense undergrowth, absence of pure stands and lack of transport facilities.

2. Tropical Semi-Evergreen Forests. Bordering the areas of tropical wet evergreen forests, are comparatively drier areas of the tropical semi-evergreen forests. Here the annual rainfall is 200-250 cm, the mean annual temperature varies from 24°C to 27°C and the relative humidity is about 75 per cent. Obviously these forests are found on the Western coast, Assam, lower slopes of the Eastern Himalayas, Odisha and Andamans.

The semi-evergreen forests are less dense but more gregarious (especially in Assam) than the wet evergreen forests. At places, these forests represent a transition from wet evergreen to deciduous forests. Further, these forests are characterised by many species, frequently buttressed trunks, rougher and thicker bark, heavy climbers, less bamboos and abundant epiphytes. The important species of these forests are aini, semul, gutel, mundani, *hopea*, benteak, kadam, irul, laurel, rosewood, mesua, haldu, kanju, byasal, kusum, thorny bamboo, etc. on the Western Ghats, and bonsum, white cedar, Indian chestnut, *litsa*, hollock, champa, mango, etc. in the Himalayan region.

3. Tropical Moist Deciduous Forests. These forests are found in areas of moderate rainfall of 100 to 200 cm per annum, mean annual temperature of about 27°C and the average annual relative humidity of 60 to 75 per cent. Such areas include a belt running along the Western Ghats surrounding the belt of evergreen forests both on the western and the eastern slopes, a strip along the Shiwalik range including terai and bhabar from 77° E to 88° E, Manipur and Mizoram, hills of eastern Madhya Pradesh and Chhattisgarh, Chota Nagpur Plateau, most of Odisha, parts of West Bengal and in the Andaman and Nicobar islands.

The trees of these forests drop their leaves for about 6-8 weeks during the spring and early summer when sufficient moisture for the leaves is not available. The sub-soil water is not enough to enable the trees to retain their leaves throughout the year. The general appearance is burnt up and bare in April-May. These forests again become green when the leaves grow with the onset of the rainy season. Tropical moist deciduous forests present irregular top storey of different species, 25 to 60 metres high, heavily buttressed trees and fairly complete shrubby undergrowth with patches of bamboos, climbers and canes.

These are very useful forests because they yield valuable timber and several other forest products. The main species found in these forests are teak, sal, padauk, laurel, white chuglam, badam, dhup, chikrosi, kokko, haldu, rosewood, mahua, bijasal, lendi, semul, irul, dhaman, amla, kusum, tendu, paula, jamun, bamboo, etc. It is comparatively easy to exploit these forests due to their high degree of gregariousness.

These forests occupy a much larger area than the evergreen forests but large tracts under these forests have been cleared for cultivation.

4. Littoral and Swamp Forests. These forests occur in and around the deltas, estuaries and creeks prone to tidal influences and as such are also known as *delta* or *tidal* forests. While littoral forests occur at several places along the coast, swamp forests are confined to the deltas of the Ganga, the Mahanadi, the Godavari, the Krishna and the Cauvery. The most peculiar feature of these forests is that they can survive and grow both in fresh as well as brackish water. Dense mangroves occur all along the coastline in sheltered estuaries, tidal creeks, backwaters, salt marshes and mudflats covering a total area of 6,740 sq km which is about seven per cent of the world's total mangrove area. It provides useful fuel wood. The most pronounced and the densest is the *Sunderban* in the Ganga delta where the predominant specie *Sundri* (Heriteera) grows abundantly. It provides hard and durable timber which is used for construction and building purposes as well as for making boats.

The important species found in these forests are Sundri, burguiera, sonneratia, agar, bhendi, keora, nipa, amur, bhara, *rhizophora*, *screw pines*, canes and palms, etc.

B. DRY TROPICAL FORESTS

5. Tropical Dry Evergreen Forests. Along the coasts of Tamil Nadu are areas which receive annual rainfall of about 100 cm mostly from the north-east monsoon winds in October-December. Here, the mean annual temperature is about 28°C and the mean humidity is about 75 per cent. These areas are covered by the tropical dry evergreen forests. The growth of evergreen forests in areas of such low rainfall arouses great botanical interest, and the reason for such a phenomena is difficult to explain. It may be due to the seasonal distribution of rainfall. Most of rainfall occurs in winter. The chief characteristics of these forests are short statured trees, upto 12 m high, with complete canopy, mostly of coriaceous leaved trees of short boles, no canopy layer differentiation, bamboos are rare or absent and grasses not conspicuous. The important species are *khirni*, *jamun*, *kokko*, *ritha*, *tamarind*, *neem*,

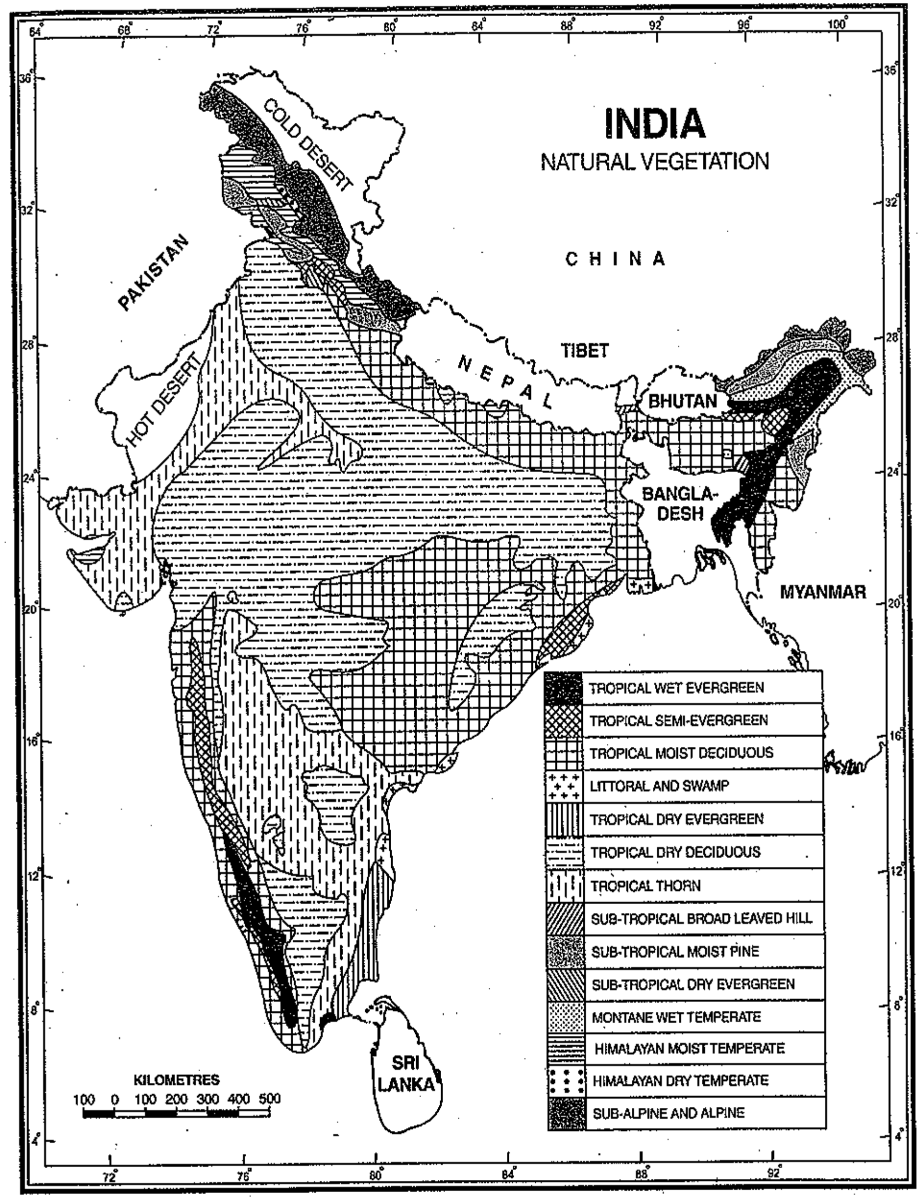

FIG. 6.1. India : Natural Vegetation

machkund, *toddypalm*, *gamari* canes, etc. Most of the land under these forests has been cleared for agriculture or casuarina plantations.

6. Tropical Dry Deciduous Forests. These are similar to moist deciduous forests and shed their leaves in dry season. The major difference is that the species of dry deciduous forests can grow in areas of comparatively less rainfall of 100-150 cm per annum. They represent a transitional type; on the wetter side, they give way to moist deciduous and on the drier side they degenerate into thorn forests. Such forests are characterised by closed and rather uneven canopy, composed of a mixture of a few species of deciduous trees, rising upto a height of 20 metres or so. Enough light reaches the ground to permit the growth of grass and climbers. Bamboos also grow but they are not luxuriant.

The tropical dry deciduous forests are widely distributed over a large area. They occur in an irregular wide strip running north-south from the foot of the Himalayas to Kanniyakumari except in Rajasthan, Western Ghats and West Bengal. The important species are teak, axlewood, tendu, bijasal, rosewood, amaltas, palas, haldu, kasi, bel, lendi, common bamboo, red sanders, anjair, harra, laurel, satinwood, papra, achar, sal, khair, ghont, etc.

Large tracts of this forest have been cleared for agricultural purposes and these forests have suffered from severe biotic factors such as over cutting, over grazing and fire, etc.

7. Tropical Thorn Forests. In areas of low rainfall (less than 75 cm), low humidity (less than 50 per cent) and high temperature (25°-30°C), there is not much scope for thick forests and only tropical thorn forests are found. The trees are low (6 to 10 metres maximum) and widely scattered. Acacias are very prominent, widely and pretty evenly spaced. Euphorbias are also conspicuous. The Indian wild date is common, especially in damper depressions. Some grasses also grow in the rainy season.

These forests are found in the north-western parts of the country including Rajasthan, south-western Panjab, western Haryana, Kachchh and neighbouring parts of Saurashtra. Here they degenerate into desert type in the Thar desert. Such forests also grow on the leeside of the Western Ghats covering large areas of Maharashtra, Karnataka, Telangana, Andhra Pradesh and Tamil Nadu. The important species are khair, reunjha, neem, babul, thor, cactii, khejra, kanju, palas, ak, nirmali, dhaman, etc.

C. MONTANE SUB-TROPICAL FORESTS

8. Sub-tropical Broad-leaved Hill Forests. These forests are found in the eastern Himalayas to the east of 88°E longitude at altitudes varying from 1000 to 2000 m where the mean annual rainfall is 75 cm to 125 cm, average annual temperature is 18°-21°C and the average humidity is 80 per cent. They form luxurious forests of evergreen species, are fairly high (20-30 metres) and dense. Evergreen oaks and chestnuts predominate with some ash and beech. Sals and pines may occur on lower and higher margins respectively. Climbers and epiphytes are common.

These forests are not so distinct in the southern parts of the country due to restricted area of southern hills. They occur in the Nilgiri and Palni hills at 1070-1525 metres above sea level. It is essentially a "stunted rain-forest" and is not so luxuriant as the true tropical evergreen. The higher parts of the Western Ghats such as Mahabaleshwar, the summits of the Satpura and the Maikal Range, highlands of Bastar and Mt. Abu in the Aravali Range also carry sub-types of these forests. But most of these forests have been destroyed, reduced and changed beyond recognition.

9. Sub-tropical Moist Pine Forests. These forests also occur at the same height as the wet hill forests *i.e.* at 1000 to 2000 metres above sea level but in the western Himalayas between 73°E and 88°E longitudes. Some parts of Arunachal Pradesh, Manipur, Naga Hills and Khasi Hills of Meghalaya are also covered by such forests at similar altitudes. Chir or Chil is the most dominant tree which forms pure stands. It provides valuable timber for furniture, boxes and buildings. It is also used for producing resin and turpentine. There is often a grassy floor with bulbous plants and little undergrowth, except for stunted evergreen oaks in wetter areas.

10. Sub-tropical Dry Evergreen Forests. Like the tropical moist evergreen, this occurs in a restructed area and is found in the *Bhabar*, the Shiwaliks and the western Himalayas upto about 1000 metres above sea level. Here the rainfall is 50-100 cm (15 to 25 cm in December-March). The summers are sufficiently hot and winters are cold enough for the occurrence of frequent frost. This is a low, practically scrub forest with small evergreen stunted trees and shrubs, including thorny species, herbs and grasses. Olive, acacia *modesta* and *pistacia* are the most predominant species. Considerable tracts are covered by dwarf creeping palm *Nonnorpops*.

D. MONTANE TEMPERATE FORESTS

11. Montane Wet Temperate Forests. This variety of forests grows at a height of 1800 to 3000 m above sea level in areas where the mean annual rainfall is 150 cm to 300 cm, the mean annual temperature is about 11°C to 14°C and the average relative humidity is over 80 per cent. This is mainly found in the higher hills of Tamil Nadu and Kerala, in the Eastern Himalayan region to the east of 88°E longitude including the hills of West Bengal, Assam, Arunachal Pradesh, Sikkim and Nagaland. These are closed evergreen forests in which the trees are mostly short-boled and branchy attaining a large girth. Leaves are dense and rounded. Branches are clothed with mosses, ferns and other epiphytes. Woody climbers are common. The trees rarely achieve a height of more than 6 metres.

Deodar, Chilauni, Indian chestnut, birch, plum, *machilus*, *cinnamomum*, *litsea*, *magnolia*, blue pine, oak, hemlock, etc. are important species.

12. Himalayan Moist Temperate Forests. Occurring in the temperate zone of the Himalayas between 1500 and 3300 metres where the annual rainfall varies from 150 cm to 250 cm, the Himalayan moist temperate forests cover the entire length of this mountain range in Kashmir, Himachal Pradesh, Uttarakhand, Darjeeling and Sikkim. Such forests are mainly composed of coniferous species, mostly pure, 30 to 50 m high. In the wetter east, the broad leaved evergreens are mixed with the dominant conifirs. Pines, cedars, silver firs, spruce, etc. are most important trees. They form high but fairly open forest with shrubby undergrowth including oaks, rhododendrons, laurels and some bamboos. In comparatively drier western parts where the rainfall varies from 115 to 180 cm especially to the west of 80°E longitude, deodar dominates the scene and forms pure stands. It provides fine wood which is of much use for construction, timber and railway sleepers.

13. Himalayan Dry Temperate Forests. These are predominantly coniferous forests with xerophytic shrubs in which deodar, chilgoza, oak, ash, maple, olive, celtis, parrotia, etc. are the main trees. Such forests are found in the inner dry ranges of the Himalayas where south-west monsoon is very feeble and the precipitation is below 100 cm, mostly snow. Such areas are in Ladakh, Lahul, Chamba, Kinnaur, Garhwal and Sikkim.

E. ALPINE FORESTS

The Alpine forests occur all along the Himalayas at altitudes ranging between 2,900 to 3,500 m or even upto 3800 m above sea level, depending upon the location and the variety of species. These forests can be divided into : (1) sub-alpine; (2) moist alpine scrub and (3) dry alpine scrub. The sub-alpine forests occur at the upper limit of tree forest adjoining alpine scrub and grasslands and comprise of dense growth of small crooked trees and large shrubs with coniferous overwood. It is a mixture of coniferous and broad-leaved trees in which the coniferous trees attain a height of about 30 m while the broad leaved trees reach only 10 m. Fir, kail, spruce, rhododendron, plum, yew, etc. are important species. *The moist alpine scrub* is a low evergreen dense growth of rhododendron, birch, berberis and honeysuckle which occurs from 3,000 metres and extends upto snowline. *The dry alpine scrub* is the uppermost limit of scrub xerophytic, dwarf shrubs, over 3,500 metres above sea level and found in dry zone. Juniper, honeysuckle, artemesia, potentilla, etc. are important species.

TABLE 6.1. India : Area under Forests

Sl. No.	Forest Group	Area in million hectares	Percentage of total area
1.	Tropical Wet Evergreen	5.120	8.0
2.	Tropical Semi-evergreen	2.624	4.1
3.	Tropical Moist Deciduous	23.680	37.0
4.	Littoral and Swamp	0.384	0.6
5.	Tropical Dry Evergreen	0.128	0.2
6.	Tropical Dry Deciduous	18.304	28.6
7.	Tropical Thorn	1.664	2.6
8.	Sub-tropical Broad-leaved	0.256	0.4
9.	Sub-tropical Moist Hill (pine)	4.224	6.6
10.	Sub-tropical Dry Evergreen	1.600	2.5
11.	Montane Wet Temperate	2.304	3.6
12.	Himalayan Moist Temperate	2.176	3.4
13.	Himalayan Dry Temperate	0.192	0.3
14.	Alpine (including sub-alpine, moist and dry alpine scrub)	1.344	2.1
	Total	**64.000**	**100.0**

Source : K.P. Sagreiya, Forests and Forestry (1994) p. 67.

As different forest groups grow under different geographical conditions, the area covered by each group differs greatly. The extent of forests of different groups for the country as a whole, is given in **table 6.1**:

Apart from the major classification of Indian forests described earlier, the Indian forests may also be classified on the basis of statutes, ownership, composition and exploitability.

1. Legal or Administrative Classification. This classification has been done to protect the forests against indiscriminate destruction. From legal or administration point of view, the Indian forests have been divided into : (*i*) Reserved, (*ii*) Protected and (*iii*) Unclassed. Reserved and protected forests are permanent forests which are maintained for regular supply of timber and other forest products as well as for ecological reasons. They cover about 54 per cent and 29 per cent of the total forest area respectively. The unclassed forests amounting to about 17 per cent of the total forest areas is largely degraded, unproductive and unprofitable forest.

2. Classification based on Ownership. Most of the forests are owned by the government through different departments such as forest department. Some of the forest land is owned by corporate bodies. A negligible proportion of less than 1 per cent is privately owned. Some forest land in Meghalaya, Odisha, Panjab, and Himachal Pradesh is privately owned.

3. Classification according to Composition. Mainly two types of forests are recognised according to composition. They are (*i*) Coniferous and (*ii*) Broad leaved. The ***Coniferous forests*** cover only 3.5 million hectares and are mainly confined to the Himalayan ranges. Some species of the coniferous forests are deodar, chir, fir, spruce, pine, etc. Though they contain valuable softwood timber, they are not properly exploited due to their inaccessibility, difficult terrain and lack of transport facilities. The ***broad leaved*** forests are widely spread and cover about 95 per cent of the total forest area of the country. Sal and teak are the most important species and provide valuable timber. They cover about 16.55 per cent and 13.82 per cent of the total area under broad leaved forests respectively. Bamboo covers about 7.48 per cent of the total area under broad leaved forests. The other species of the broad leaved forests are rosewood, Indian laurel, shistram, garyan and benteak.

4. Classification according to Exploitability. From the exploitability point of view, the forests can be classified into : (*i*) exploitable (*ii*) potentially exploitable and (*iii*) others. About half of our forests are exploitable. Most of them supply non-coniferous timber. About one fourth of the forests are potentially exploitable. Both the exploitable and potentially exploitable forests occur in Assam, Arunachal Pradesh, Tripura, Western Ghats, Satpura, Maikal, Chota Nagpur plateau, Andaman and Nicobar Islands, Odisha and adjoining areas of Andhra Pradesh and Chhattisgarh. Large proportion of our forests is inaccessible for effective exploitation and are also termed as *non-merchantable*. They lie in the high reaches of the Himalayas in Kashmir and Arunachal Pradesh where they cannot be exploited due to lack of transport facilities.

GEOGRAPHICAL DISTRIBUTION OF FOREST AREA

The total geographical area of the country is 32,87,263 sq km out of which an area of 6,77,816 sq km or 20.6 per cent was under forests in 2003 (**Table 6.2**). This is much below the average of 30.4 per cent for the world. The picture is very gloomy when we compare our percentage of forests area with 34.4 per cent of Canada, 36.0 per cent of Germany, 41.07 per cent of the U.S.A., 52.00 of Zaise, 56.10 per cent of Brazil, 57.8 per cent of Sweden and 67.6 per cent of Japan. India with about 17.5 per cent of the world's population has nearly 2 per cent of the total forests, and if the forest growing stock has been correctly estimated, it is one of the lowest per unit area *i.e.,* less than 1 per cent of that of the forests of the world. According to the National Forest Policy, the minimum desired area which is considered safe for a tropical country like India is about 33 per cent. As per broad policy recommendations, about 60 per cent of the area in the Himalayas and the Peninsular hills and 20 per cent in the Great Plains should be under forests. Furthermore, the per capita forest area in India is bare 0.06 hectares against the world average of 1.08 hectares. The per capita forest cover is 1.8 hectares in the U.S.A., 3.2 hectares in Sweden, 3.5 hectares in Russia, 5.1 hectares in Australia, 8.6 hectares in Brazil and 22.7 hectares in Canada. The production of Indian forests is also very low, being only 0.5 cubic metre per hectare a year as against the world average of 2.1 cubic metres per hectare per year. Thus the useful forest resources are extremely inadequate for a predominantly agricultural country like India.

The forest resources are very unevenly distributed in India. Madhya Pradesh has the largest area of over 76 thousand sq km under forests (**Table 6.3**). The other states with considerable area under forests are Arunachal Pradesh (68 thousand sq km), Chhattisgarh (56 thousand sq km), Odisha (48 thousand sq km), Maharashtra (47 thousand sq km) and Andhra Pradesh including Telangana (44 thousand sq km). Incidently, most of them are very large states and the total forest area is not a good index of forest prosperity.

Percentage of forest area to total area can serve as a better index of the forest cover. Unfortunately, the forests are conspicuous by their absence where they are needed the most. For example only 5 per cent of the total area in the thickly populated Ganga plain is under forests. In north-west India about 11 per cent of the area is under forests while the forests cover about 20 per cent of the area in Tarai. As per percentage of forest area to total area, Andaman Nicobar Islands. Arunachal Pradesh, Mizoram and Nagaland are very rich areas. These regions have over 80 per cent of their geographical area under forests. Lakshadweep, Manipur, Meghalaya, Tripura and Goa are also in a comfortable position as more than half of their geographical area is covered by forests. Forest cover is reasonably good in the states of Assam, Chhattisgarh, Himachal Pradesh, Jharkhand, Kerala, Madhya Pradesh, Odisha, Sikkim, Uttarakhand and the union territory of Dadra and Nagar Haveli where more than one-fourth of the geographical area is under forests. But there are other states where the percentage of forest area to total area is desperately low. For example, Punjab, Haryana and Rajasthan have very low of 3.09, 3.59 and 4.63 per cent of their land under forests. These happen to be the lowest percentages in any geographical region in the country. Other large and important states like Uttar Pradesh (5.86%), Bihar (5.92%), Gujarat (7.51%) and Jammu and Kashmir (9.57%) also have very low percentage of the area under forests. These states do not have even one-tenth of the area covered by forests. Rajasthan and Gujarat receive scanty rainfall and experience arid and semi-arid climate. Much vegetation cover is not expected under such conditions. In states like Punjab, Haryana, Uttar Pradesh and Bihar vast forest tracts have been cleared to make land available for cultivation. These are very rich areas from agriculture point of view. Among the union territories, Chandigarh, Daman and Diu, Delhi and Puducherry are poor states. In Jammu and Kashmir, the low percentage of the forest area is primarily due to low rainfall, steep barren slopes and snow covered peaks. The semi-arid lands of Maharashtra, Karnataka, Andhra Pradesh, Telangana,

TABLE 6.2. India : Forest Cover Estimates (sq km)

Cycle	Year	Satellite and Sensor	Data Period	Forest Cover
First	1987	Landsat-Mss	1981-83	640,819
Second	1989	Landsat-TM	1985-87	638,804
Third	1991	Lansat-TM	1987-89	639,364
Fourth	1993	Lansat-TM	1989-91	639,386
Fifth	1995	IRS-1B LISSII	1991-93	638,879
Sixth	1997	IRS-1B LISSII	1993-95	633,397
Seventh	1999	IRS-IC/ID LISSIII	1996-98	637,293
Eighth	2001	IRS-IC/ID LISSIII	2000	675,538
Ninth	2003	IRS-IDLISSIII	2002	677,816

Source : State of Forest Report 2005.

TABLE 6.3. India : Statewise Area under Forest (sq km) in 2005

State /Union Territory	Geographical Area	Total Forest	Dense Forest	Open Forest	Percentage of forest area to geographical area
STATES					
Andhra Pradesh (including Telangana)	2,75,069	44,372	24,329	20,043	16.13
Arunachal Pradesh	83,743	67,777	52,388	15,389	80.93
Assam	78,438	27,645	12,831	14,804	35.24
Bihar	94,163	5,579	3,114	2,465	5.92
Chhattisgarh	1,35,191	55,863	38,728	17,135	41.32
Goa	3,702	2,164	1,150	1,014	58.45
Gujarat	1,96,022	14,715	6,138	8,577	7.51
Haryana	44,212	1,587	526	1,061	3.59
Himachal Pradesh	55,673	14,369	8,928	5,441	25.81
Jammu & Kashmir	2,22,236	21,273	10,529	10,744	9.57
Jharkhand	79,714	22,591	11,622	10,969	28.34
Karnataka	1,91,791	35,251	22,090	13,153	18.38
Kerala	38,863	15,595	9,660	5,935	40.13
Madhya Pradesh	3,08,245	76,013	41,082	34,931	24.66
Maharashtra	3,07,713	47,476	28,384	19,092	15.43
Manipur	22,327	17,086	6,464	10,622	75.37
Meghalaya	22,429	16,988	7,176	9,842	75.74
Mizoram	21,081	18,684	6,306	12,378	88.63
Nagaland	16,579	13,719	5,838	7,881	82.75
Odisha	1,55,707	48,374	28,194	20,180	31.07
Punjab	50,362	1,558	723	855	3.09
Rajasthan	342,239	15,850	4,470	11,380	4.63
Sikkim	7,096	3,262	2,410	852	45.97
Tamil Nadu	1,30,058	23,044	12,440	10,604	17.72
Tripura	10,486	8,155	5,030	3,125	77.77
Uttarakhand	53,483	24,492	18,398	6,044	45.70
Uttar Pradesh	2,40,928	14,127	5,979	8,148	5.86
West Bengal	88,752	12,413	6,079	6,334	13.99
UNION TERRITORIES					
A. & N. Islands	8,249	6,629	6,005	624	80.36
Chandigarh	114	15	9	6	13.6
D.& N. Haveli	491	221	130	91	45.01
Daman & Diu	112	8	2	6	7.14
Delhi	1,483	176	54	122	11.87
Lakshadweep	32	25	15	10	78.12
Pondicherry	480	42	7	25	8.75
India	3287263	677088	387216	289872	20.60

Source : Data computed from Statistical Abstract, India, 2007, p. 150.

and Tamil Nadu in the rain-shadow of the Western Ghats receive much less rainfall and are devoid of thick forest growth. The coastal areas of Tamil Nadu and Andhra Pradesh receive sufficient rainfall in winter and support good forest cover but most of the forests in this region have been cleared for cultivation.

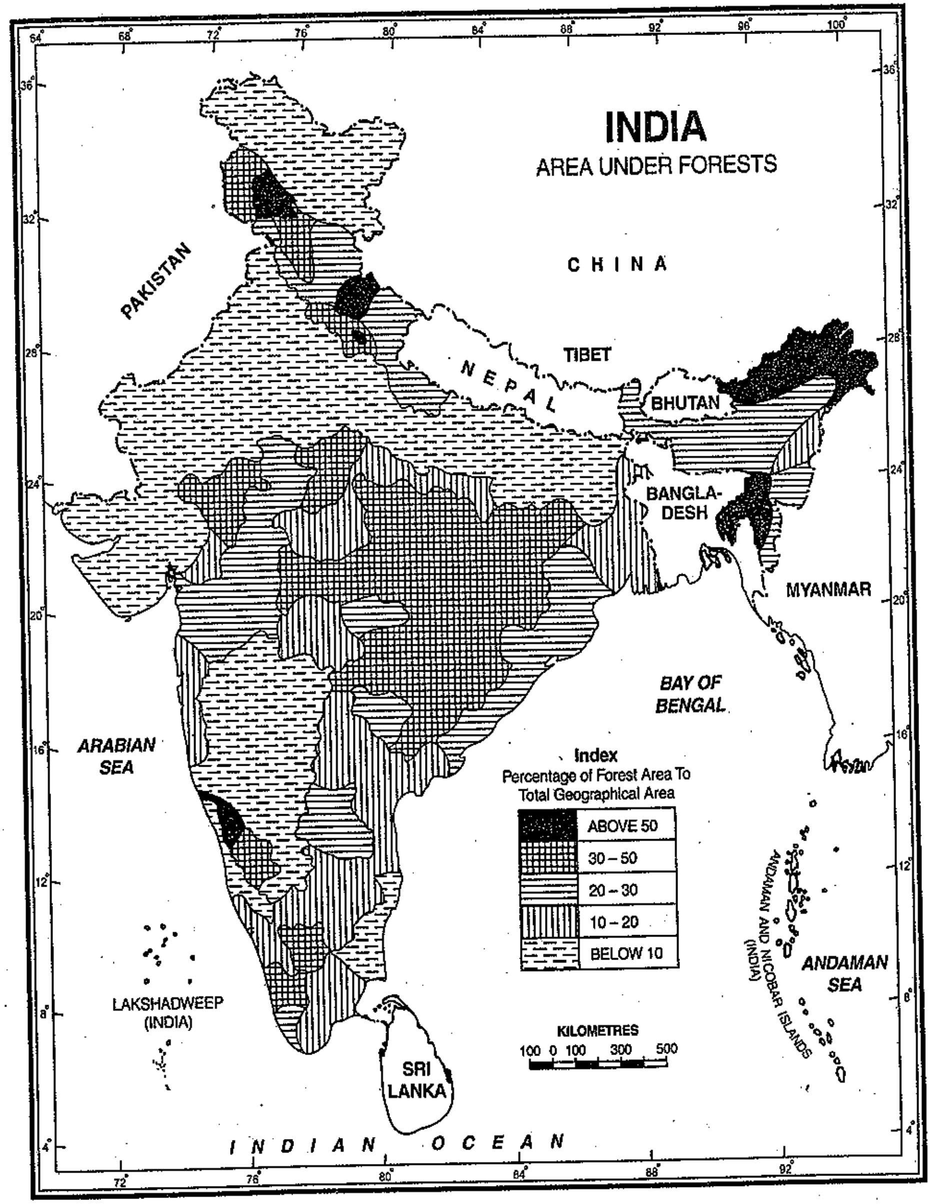

FIG. 6.2. India : Area under Forests

The forest areas do not follow political boundaries, and as such it would be better to study their growth and distribution according to the geographical conditions governing them. The areas more conductive for the forest growth are those receiving heavy rainfall, having sufficiently high temperature and soils as well as relief suitable for forest growth (see **figure 6.2**). **Table 6.4** would help in understanding the geographical distribution of forests in India.

TABLE 6.4. Geographical Distribution of Forests in India

Sl. No.	Geographical Region	Percentage of total forest of India
1.	Himalayan Region	18.00
2.	The Great Plain of India	5.00
3.	Peninsular plateaus and Hills	57.00
4.	Western Ghats and Western Coastal Plain	10.00
5.	Eastern Ghats and Eastern Coastal plain	10.00
	Total	100.00

FOREST PRODUCTS

Forests constitute one of the major natural resource of India. They produce a large variety of woods which are used as fuel, timber and industrial raw material. They also provide many more things out of which bamboos, canes, herbs, drugs, lac, grasses, leaves, oils, etc. are important. Accordingly the forest products of India are classified into two categories *viz.*, major products and minor products.

Major Forest Products

Major forest products consist of timber, smallwood and fuelwood including charcoal. Indian forests produce about 5,000 species of wood, of which about 450 are commercially valuable. Both hard and soft woods are obtained from Indian forests. *Hard woods* include important species such as teak, mahogany, logwood, iron-wood, ebony, sal, greenheart, kikar, semal, etc. These woods are used for furniture, wagons, tools, etc. *Soft woods* include deodar, poplar, pine, fir, cedar, balsam, etc. They are light, strong, fairly durable and easy to work and as such are very useful for constructional timbers. They also provide useful raw materials for making paper pulp. It is interesting to note that 70 per cent of hard wood is burnt as fuel and only 30 per cent is used in industries while 70 per cent of the soft wood is used in industries and only 30 per cent is burnt as fuel. Forests meet about 40 per cent of energy needs of the country including more than 80 per cent of the rural energy requirements. The current production of wood is about 52 million cubic metres out of which about 40 million cubic metres or nearly 77 per cent of total is used as fuel wood. The current production of wood is too short of our present demand which is increasing at an alarming rate. The increase in demand for industrial wood will be much more keeping in view the large scale industrialisation in the country.

Minor Forest Products

Minor forest products include all products obtainable from the forests other than wood and thus comprise products of vegetable and animal origin. Some of the imporant forest products of minor nature are described as under :

1. Grasses, bamboos and canes
2. Tans and Dyes
3. Oils
4. Gums and Resins
5. Fibres and Flosses
6. Leaves
7. Drugs, spices and poisons
8. Edible products
9. Animal products

1. Grasses, Bamboos and Canes. Different types of grasses grow in different parts of the country. Most of the grasses are used as fodder or for thatching, but some grasses are better used for cordage, matting and as an important raw material for manufacturing paper. Grasses like *sabai*, *bhabar* and elephant are used for papermaking. *Sabai* is the most important grass which provides the basic raw material for paper industry. It is a perennial grass which grows on the bare slopes of the sub-Himalayan tract and in Bihar, Odisha, West Bengal, Madhya Pradesh and western part of Himachal Pradesh. Annually over two million tonnes of sabai grass is collected and supplied

to paper mills. The roots of *khus* grass are used for making cooling screens. *Munj*, a tall grass is used for making chicks, stools, chairs, etc. and the leaves are twisted into strings.

Bamboo belongs to grass family but grows like a tree. It is woody, perennial and tall. It may attain a height of as much as 30 metres. More than 100 species of bamboo grow in the Indian forests covering an area of over one lakh sq km. Andhra Pradesh and Telangana (19.7 thousand sq km), Madhya Pradesh (14.9 thousand sq km), Odisha (10.5 thousand sq km), Assam (10.0 thousand sq km), Arunachal Pradesh (7.8 thousand sq km) and Karnataka (6.0 thousand sq km) are the main areas of its growth. The bulk of production comes from Andhra Pradesh, Telangana, Tripura, Rajasthan, Mizoram, Madhya Pradesh, Maharashtra, Gujarat, Karnataka, Kerala, Manipur, Punjab, Nagaland, and Andaman and Nicobar Islands. Bamboo is called the *poor man's timber* as it provides cheap material for roofing, walling, flooring, matting, basketry, cordage, carthoods and a host of other things. Young tender culms are eaten; the seed is collected and eaten as grain. However, the most significant commercial use of the bamboo is for making pulp for the production of paper and newsprint. Of the total bamboo consumed in India, 32 per cent is for construction, 30 per cent for rural use, 17 per cent for making paper pulp, 7 per cent for packaging and the remaining 14 per cent for other purposes.

Cane grows abundantly in moist forests of Andaman and Nicobar Islands, Karnataka, Madhya Pradesh, Kerala, Maharashtra, Nagaland, Manipur, Arunachal Pradesh and Mizoram. These are major producers of cane in India. Some parts of Assam, West Bengal, Kerala, Tamil Nadu, Jharkhand, Chhattisgarh and Odisha are also suitable for growth of cane. It is mainly used for making strings, ropes, mats, bags, baskets, furniture, walking sticks, umbrella handles, sports goods, etc.

2. Tans and Dyes. Tannins are secretion products of plant tissues. Tanning materials are used in leather industry. The most commonly used tanning materials are mangrove, amla, oak, hemlock, anwal, wattle, myrobalans, ratanjot, flowers of dhawri, babul, avaram, etc.

Some of the important dyes are obtained from red sander (bright red), khair (chocolate), flowers of Palas, fruits of *Mallotus phillipensis*, bark of wattle and roots of *Morinda tinctoria*. About two lakh tonnes of tans and dyes are produced every year in India.

3. Oils. A large number of plants and trees which grow in Indian forests contain several types of oils which are used to manufacture soaps, cosmetics, confectionary, pharmaceutical preparations and many more things. Commercially important oils are those obtained from sandalwood, lemon grass, khus and *euclyptus globulus*.

4. Gums and Resins. Gums are exuded from the stems or other parts of different trees, partly as a natural phenomenon and partly by injury to the bark or wood or blazing the tree. The most important gum is Karaya obtained from *Sterculia urens* or *S. villosa* trees of dry deciduous forests. It is mainly used in textiles, cosmetics, confectionery, medicines, inks, pastes, cigars, etc. Madhya Pradesh is the largest producer of gums in India. This state is closely followed by Maharashtra, Andhra Pradesh (including Telangana), Gujarat and Karnataka are other producers. A large proportion of Indian gums is exported to the USA, the UK and France.

Resin is obtained mainly from Chir pine which grows in the Himalayan region in Arunachal Pradesh, Uttarakhand, Himachal Pradesh, Jammu and Kashmir and some parts of Punjab. The main producers are Arunachal Pradesh, Punjab and Jammu and Kashmir. Some resin is produced in Manipur also. Crude resin consists of two principal constituents; a liquid known as oil of turpentine (25%) and a solid called resin (75%). They are separated after distillation. Turpentine is mainly used as a solvent for paints and varnish, synthetic camphor, pine oil, disinfectants, pharmaceutical preparations, wax, boot polish and industrial perfumes. Resin is an important raw material for several industries of which paper, paint, varnish, soap, rubber, water proofing, linoleum, oils, greases, adhesive tape, phenyl, plastic, etc. are important.

5. Fibres and Flosses. Fibres are obtained from the tissues of some trees. Most of such fibres are coarse and are used for rope making. However, the fibres of Ak (*Calotropis* spp.) is fine, strong and silky which is used for making fishing nets. Flosses are obtained from certain fruits and are used for stuffing pillows, mattresses, etc.

6. Leaves. Different types of leaves are obtained from the trees and are used for different purposes, the most important being the tendu leaves used as wrappers for *bidis*. The tendu tree grows in large numbers in Madhya Pradesh, Andhra Pradesh, Telangana, Bihar, Maharashtra, Gujarat, Rajasthan, Karnataka and Uttar Pradesh. About 6 lakh tonnes of tendu leaves are produced every year in India. With 246 thousand tonnes, Madhya Pradesh is the largest producer in India. Bihar with 53.5 thousand tonnes is the second largest producer. Andhra Pradesh and Telangana (51.2 thousand tonnes), Maharashtra (33 thousand tonnes) and Gujarat (12.9 thousand tonnes) are also important producers. Some quantity of leaves is also produced in Rajasthan, Karnataka and West Bengal. Tendu leaves and *bidis* are exported to Pakistan, Bangladesh, Sri Lanka and some other Asian and African countries.

Leaves of *Bauhinia vahlii* are converted into plates and leaf cups and are also used as wrappers by vendors of sweets.

7. Drugs, Spices and Poisons. Thousands of drugs are obtained from fruits, flowers, roots, stems and leaves of different types of trees, plants and herbs. Quinine is the most important drug obtained from the Indian forests.

Spices are used to add aroma or pungency to food to flavour certain dishes. The important spices are galangal, cinnamon or *Dalchini*, lesser cardamom (*Chhoti Ilayachi*), greater cardamom (*Badi Ilayachi*), etc.

Indian forests produce some poisonous substances which can act as good medicines when taken in small, regular doses. Some outstanding poisons are strychnine, aconite, datura, ganja etc.

8. Edible Products. Fruits, flowers, leaves or roots of various species provide edible products. Mango, *bel, ber, jamun, khirni, phalsa, sitaphal*, etc. are important fruits obtained from the forests. Among the kernels cashewnut, *akhrot* or walnut, *achar, chilgoza* and *kimal* are important. *Amla, anar, imli, karaunda, munga, kachnar, kaith, mushroom, zimikand, guchchi*, etc. are important products used as pickles or vegetables. Palmyrah, palm, mahua, corolla are used to obtain liquor and their seeds are eaten. *Tejpata*, used for flavouring curries are leaves of a small evergreen tree.

9. Animal Products. Lac is the most important animal product obtained from the forests. It is secreted by a minute insect (*Laccifer lacca*) which feeds on the saps of a large variety of trees like palash, peepul, kusum, sissoo, sisir, kul, gular, ber, banyan, jujuba and ghont. These trees grow extensively in the Chota Nagpur plateau of Jharkhand, eastern districts of Madhya Pradesh, Chhattisgarh, western border areas of West Bengal, eastern part of Maharashtra, northern districts of Odisha and to a lesser extent in Assam, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, Karnataka and Punjab. India practically holds a monopoly in the production of lac. The current annual production of lac in India is about 18.5 thousand tonnes which is about 85 per cent of the world production. The main producing states are Jharkhand (40%), Chhattisgarh (30%), W. Bengal (15%), Maharashtra (5%), Gujarat, U.P., Odisha and Assam. About 95% of the total production is exported. Our main customers are the USA, Russia, Germany and U.K. At present it is widely used in medicines, plastics, electrical insulation material, dyeing silk, making bangles, paints, sealing wax, leather and wood finishing, ornamental articles, etc.

The other animal products are honey, wax, silk moths, horns and hides of dead animals, ivory, antlers of deer, etc.

The above mentioned major and minor forest products are used for various purposes and form an important sector of Indian economy. About 3.5 million persons are engaged in different forest activities. About two per cent of the government revenue comes from the forests. There has been a steady increase in government revenue from the forests. In some states like Maharashtra, Uttarakhand, Karnataka, Kerala, Odisha and Andhra Pradesh, gross revenue from forests is far greater than the expenditure on forest activities. Some foreign exchange is also earned by exporting forest products.

INDIRECT USES OF FORESTS

Apart from their direct uses described above, the forests are of immense use to man indirectly also. They prevent soil erosion, regulate the flow of rivers and reduce the frequency and intensity of floods, check the spread of deserts, add to soil fertility and ameliorate the extremes of climate.

1. Prevention and control of soil erosion. Forests play a significant role in the prevention and control of soil erosion by water and wind. The destruction of forest cover leads to increased runoff of rain water and its diminished seepage and storage in soil. The structure of the soil suffers, runoff increases and loosens the soil which is carried away to other regions. The fertility of the soil is thus lost, and it becomes barren and unproductive. The reckless destruction of forests in the Shiwalik hills, Western Ghats, Chota Nagpur plateau and in the Deccan table-land has resulted in serious problem of soil erosion. The most effective way to check soil erosion is to stop reckless cutting of forests and to plant more trees.

2. Flood Control. Roots of the trees absorb much of the rain water and use it slowly during the dry season. Thus they regulate the flow of water and help in controlling the floods. The forest cover acts as a **rain-holder** and a **rain banker**. Trees also act like millions of tiny dams and check the flow of water like a barrage. With the increased rate of deforestation, the frequency and the intensity of floods has increased in different parts of the country. In the absence of forests, the increased runoff along with sand and silt, especially after heavy downpour, comes in as a sudden rush and often gets blocked in the silted streams and causes devastating floods.

3. Checks on spread of deserts. Sand particles are blown away by strong winds in the deserts and are carried over long distances, thus resulting in the spread of deserts. The roots of trees and plants bind the sand particles and do not permit their easy transportation by wind. Therefore, the forests are a great instrument to put a check on the spread of deserts. In the long run, the forests add humidity to the atmosphere and further help in checking the spread of deserts. A great success has been achieved in checking the march of the Thar desert by planting a 650 km long and 8 km wide strip of trees on its periphery.

4. Increase of soil fertility. The fallen leaves of trees add humus to soil after their decomposition. Thus forests help in increasing the fertility of soil.

5. Effect on Climate. Forests have a far reaching effect on climate. They ameliorate the extremes of climate by reducing the heat in summer and cold in winter. They also influence the amount of rainfall by lowering the temperature of moisture laden winds and increase the relative humidity of the air through the process of transpiration. They reduce the surface velocity of winds and retard the process of evaporation.

PROBLEMS OF INDIAN FORESTRY

Indian forests face a number of problems which are both natural and manmade. Some of the major problems are briefly discussed as follows :

1. Inadequate and Dwindling Forest Cover. The biggest problem of the Indian forests is the inadequate and fast dwindling forest cover. It has already been mentioned that forests cover only 20.6 per cent of the area against the required coverage of 33 per cent. Even this small percentage of forest cover is seriously threatened by the increasing demand for major and minor forest products. These products are badly needed for fuel, building and to feed a large number of forest based industries. Vast forest tracts have been cleared for agriculture. Shifting agriculture in different parts of the country has played havoc with forests. Overgrazing is a big factor which is responsible for serious damage to forests. India possesses a livestock population of about 529.70 million of which nearly 304.42 million are bovine animals, about one-tenth of which graze in the forests. Whenever forests are easily accessible, the livestock entirely depends on grazing in them.

A large part of our achievements made by virtue of afforestation are neutralised by diversion of forest land for non-forest use.

2. Low Productivity. Productivity of Indian forests is very low as compared to some other countries. For example, annual productivity of Indian forest is only 0.5 cubic metre per hectare while it is 1.25 cubic metre per hectare in the USA, 1.8 cubic metre per hectare in Japan and 3.9 cubic metre per hectare in France.

3. Nature of Forests and their Uneconomical Utilisation. The forests are thick, inaccessible, slow growing and lack in gregarious stands in many parts of the country. Some of them are very thin and comprise only of thorny bushes. These factors make their utilization uneconomical because there is a good deal of wastage and this makes it very expensive in spite of the cheap labour available in India.

4. Lack of Transport Facilities. One of the biggest problems faced by the Indian forests is the lack of proper transport facilities. About 16 per cent of the forest land in India is inaccessible and does not have proper transport facilities. It must be remembered that the major product of the forests is timber which is a cheap and bulky commodity. As such it cannot afford high freights charged by the railways and roadways. Therefore, Indian forests cannot be economically exploited without the availability of cheap and efficient transport facilities. Unfortunately, in India, the railways serve thickly populated areas only and are not of much use to forests. All weather roads in the forest areas are badly lacking. Water transport has only limited scope. Considering these facts, we can easily say that transport with reference to forests is inadequate in India.

5. Forest Fires. Large tracts of vegetal cover are destroyed every year by forest fires. Forest fires in India are most destructive in dry season. Insufficiency of properly trained personnel to prevent and fight fires is a big handicap.

6. Plant Diseases, Insects and Pests. Large tracts of forest cover suffer from plant diseases, insects and pests which leads to considerable loss of forest wealth. For example, thousands of hectares of sal forests in Madhya Pradesh and Chhattisgarh are being threatened by sal borer for which no remedial measures have been adopted so far. Forest officials are only using the primitive methods of hiring the tribals to catch and kill the insects.

7. Obsolete Methods of Lumbering and Sawing. In most of the Indian forests, obsolete methods of lumbering, sawing etc. are practised. This system leads to a lot of wastage and low forest productivity. Large quantities of inferior wood which could be put to better use through seasoning and preservation treatment remain unutilised or go waste. Saw mills use old obsolete machinery and do not get proper power supply.

8. Lack of Commercial Forests. In India most of the forests are meant for protective purposes and commercial forests are badly lacking. Growing awareness about environmental degradation has forced us to look at forest wealth as a protective agent for environment rather than treating it as a commercial commodity.

9. Lack of Scientific Techniques. Scientific techniques of growing forests are also lacking in India. Only natural growth of forests takes place in India whereas in many developed countries new scientific techniques are being used through which tree growth is quickened. A large number of trees are malformed or consist of species which are slow growing and poor yielders.

10. Undue Concessions to Tribals and Local People. In vast forest tracts, tribals and local people have been granted customary rights and concessions for free-grazing as well as removing timber fuel and minor forest products. They are also allowed to continue with age-old shifting cultivation. These practices have led to the reduction in forest yield. In addition, there has been encroachment on these forests by the village people inhabiting the peripheral areas.

Remedies

At present there is an urgent need of undertaking silvicultural operations on a large scale. This can be done through the following measures :

1. Intensive development schemes for afforestation should be adopted. High yielding varieties should be planted in suitable areas.
2. Improved techniques of logging and extraction should be used.
3. Proper transport facilities should be provided to remote and inaccessible forest areas.
4. Saw mills should get uninterrupted power supply.
5. Latest techniques of seasoning and preservation are necessary to avoid wastage.
6. Proper arrangements to save forests from fires and plant diseases can go a long way to solve several problems.
7. A thorough inventory of forest resources is necessary to make an accurate assessment of our forest resources and make plans for their proper use.
8. Shifting cultivation should be discouraged and tribals depending on this type of cultivation should be provided with alternate sources of livelihood.

9. People associated with forest protection should be properly trained.

SOCIAL FORESTRY

Social forestry means the management and protection of the forests as well as afforestation of barren lands aimed at helping in environmental, social, and rural development as against the traditional objective of securing revenue. It is aptly described as *forestry of the people, by the people and for the people*. The main thrust of social forestry is to reduce pressure on the traditional forest areas by developing plantations of fuelwood, fodder and grasses. The term social forestry was used for the first time by the National Commission on Agriculture in 1976, to denote tree raising programmes to supply firewood, small timber and minor forest produce to rural population. This commission divided social forestry into; (*i*) agro forestry, (*ii*) expansion forestry, (*iii*) rehabilitation of degraded and low grade forests and (*iv*) recreation forestry. The programme was formally launched in 1978 and it became an integral part of the Sixth Plan in 1980. In the second Forestry Conference (1980) it was decided that social forestry scheme should be given priority over barren and waste land, community land and lands along the roads, railways and canals.

Agro forestry, community forestry, commercial farm forestry, non-commercial farm forestry and urban forestry are the main components of social forestry. **Agro forestry** involves the raising of trees and agricultural crops either on the same land or in close association in such a way that all land including the waste patches is put to good use. This enables the farmer to get food, fodder, fuel, fruit and timber from his land. The land gives maximum production and provides employment to rural masses. **Community forestry** involves the raising of trees on public or community lands aimed at providing benefit to the community as a whole. Although the plants and seedlings are provided by the forest department, the protection of plantations is primarily the responsibility of the community as a whole. India is second only to China in community forestry. Remarkable success has been achieved in community forestry in some major states like Gujarat, Tamil Nadu, Rajasthan, Kerala, Karnataka, Uttar Pradesh, Haryana, Odisha and Himachal Pradesh. **Commercial farm forestry** involves growing of trees in the fields in place of food and other agricultural crops. In this way, the farmers grow trees for direct commercial gain. This type of forestry has become very popular in Haryana, Punjab, Gujarat, Uttar Pradesh, Rajasthan and in some parts of south India. Farmers in these areas grow eucalyptus, poplars, and casuarina in their land and sell them to paper, pulp, rayon and match industries and also use them for making packing cases and fuel. The state governments are encouraging this forestry in a big way. **Non-commercial farm forestry** involves tree planting by farmers on their own land for their own use and not for sale. The land mainly used for this purpose includes margins of agricultural fields, wastelands and marginal lands which are not usually cultivated, grasslands and pastures and land around homes and cowsheds. This type of forestry is practised in Gujarat, Haryana, Kerala and Karnataka for obtaining fuel, fodder and fruit. **Urban forestry** pertains to raising and management of trees on public and privately owned lands in and around urban centres. It includes green belts, roadside avenues, recreational parks, wildlife parks, etc. Its main objectives are reduction of environmental pollution, recreation and improving aesthetic values.

FOREST CONSERVATION

Forests comprise a unique gift of nature to man and constitute one of the prized assets of a nation. They play a significant role in the national economy of a primarily agricultural and developing country like India. The agricultural and industrial progress of the country is not only stabilized but accelerated by a proper conservation and utilization of forest resource. As mentioned earlier, the uses of forests, both direct and indirect, are so large that they are aptly termed as *an index of prosperity of a nation*. Keeping in view the benefits which we derive from the forests, it is of utmost importance that strong steps should be taken to conserve forests.

Our increased demand for forests products has led to increasing destruction and degradation of our forests which is causing heavy erosion of top soil, erratic rainfall and frequent devastating floods. In short, depletion of forests has a chain reaction in eco-system. Though it is a renewable resource, it takes its own time to regenerate. We have been destroying our forest resources so ruthlessly and so quickly that large forest tracts of yesteryears are now devoid of any forest cover. India's woods, once dark and deep, are now a living example of man's ravage and destruction. The saying that *man finds forests but leaves deserts could not be more true to India.* Over the past four decades, about 25 million hectares of land that originally had tree cover has been laid bare for agriculture and other purposes. The latest reports of the National Remote Sensing Agency (NRSA) indicates that the country is losing about 1.3 million hectares of forest cover every year. This will be detrimental to our national interest. *Nature never forgives the abuse of her gifts.* Hence, the urgent need for conservation of forests.

Forest conservation does not mean the denial of use, but rather the proper use without causing any adverse effect on our economy or environment. But any scheme of conservation of forests on a piecemeal basis will not solve the problem. Conservation of forests is a national problem and should be tackled as such. There should be perfect coordination between the forest department and other departments for an effective conservation of forests. People's participation in any forest conservation is of vital importance. ***Van Mahotsava*** was launched in 1950 to make people aware of the importance of planting trees. ***Chipko movement*** is a living example of general public awareness about forests.

The year 2011 has been declared as the International Year of Forests.

Forests have to be developed and worked for obtaining various raw materials and for providing an effective means of flood control, checking soil erosion, for regulating the flow of water in streams and for conserving moisture in the soil. Therefore, a carefully coordinated scientific policy for conservation of forests should be the first step in any scheme of national planning of the country.

While contribution of forests to the nation's economy, apart from their vital role in environment, can never be underestimated, the investment in forestry sector has been rather low. For example, from the first to the sixth Five Year Plans, the investment in forestry was between 0.39 per cent and 0.71 per cent of the total plan outlay. In the seventh Five Year Plan, the allocation was raised to 1.03 per cent of the total plan outlay. But again, the investment in the forestry sector during the eighth Five Year Plan had fallen to 0.94 per cent of the total plan outlay. At present the total investment in forestry is about ₹ 800 crore against the required investment of about ₹ 3,000 crore. This is too small an investment and unless it is increased, it will not be possible to ensure sustainable supply of goods and services for the huge sector of population dependent on forests.

The Forest (Conservation) Act, 1980 enacted to check indiscriminate deforestation/ diversion of forest lands was amended in 1988 to make it more stringent by prescribing punishment for violations. Guidelines have been prepared for working plans. Some salient features are : (*i*) working plans should be up-to-date and stress conservation; (*ii*) preliminary working plan should have multi-disciplinary approach; (*iii*) tribal rights and concessions should be highlighted along with control mechanism; (*iv*) grazing should be studied in detail and specific prescriptions should cover fodder propagation; (*v*) shifting cultivation and encroachments need to be controlled; (*vi*) clear-felling with artificial regeneration should be avoided as far as possible and clear-felling blocks should not exceed 10 hectares in hills and 25 hectares area in plains and (*vii*) banning all felling above 1000 metre altitude for a few years should be considered to allow these areas to recover. Critical areas in hills and catchment areas prone to landslides, erosion, etc. should be totally protected and quickly afforested.

The Indian Council of Forestry Research and Education (ICFRE) was created in 1987 under the Central Ministry of Environment and Forests. Later on it was constituted into an autonomous body on the pattern of the Indian Council of Agricultural Research with its headquarters at Dehra Dun. Following forestry research institutions are working under this organisation :

(*i*) Forest Research Institute, Dehra Dun
(*ii*) Institute of Arid Zone Forestry Research, Jodhpur
(*iii*) Institute of Rain and Moist Deciduous Forests, Jorhat
(*iv*) Institute of Wood Science and Technology, Bengaluru.
(*v*) Tropical Forestry Research Institute, Jabalpur
(*vi*) Institute of Forest Genetics and Tree Breeding, Coimbatore
(*vii*) Temperate Forest Research Centre, Shimla

(*viii*) Centre for Forest Productivity, Ranchi and
(*ix*) Centre for Social Forestry and Environment, Allahabad.

The future welfare and prosperity of India would very much depend upon our ability, effort and success in conserving, developing and proper utilisation of our forest resources. It is, therefore, high time that the nation as a whole awakens to this burning problem for the sake of a better future.

Forest Policy and Law

(*i*) Forest Policy of 1894. Forest policy was first declared by the British Government of India on 19 October, 1894 at the recommendation of **Dr. Voelcker**, a German expert who studied the role of forests vis-a-vis agriculture.

(*ii*) Forest Policy of 1952. With the passage of time and with India becoming an Independent country, major changes of economic and political nature took place. The population, both of human beings and livestock, had increased very substaintially, resulting in a heavier pressure on the forests for securing more land for agriculture and pasturage. The reconstruction schemes also leaned heavily on the forest products. The Government of free India thought it desirable to come out with a new National Forest Policy in 1952. While retaining the major clauses of the earlier forest policy, this policy laid greater emphasis on some other points also. It proposed the classification of forests on a functional basis into *protection forests, national forests and village forests*. The policy recommended the establishment of tree-lands wherever possible. It also stressed upon increasing pastures and timber and made a strong plea against the indiscriminate extension of agriculture by excision of forests. The policy also stressed that the *productive, protective* and *bioaesthetic* roles of forest entitle them to an adequate share of land. It also emphasised the need to protect wildlife. The policy laid stress on, (*i*) weaning the primitive people by persuation, from the baneful practice of shifting cultivation, (*ii*) increasing the efficiency of forest administration by having adequate forest laws, (*iii*) giving requisite training to the staff of all ranks, (*iv*) providing adequate facilities for management of forests and for conducting research in forestry and forest products utilization, (*v*) controlling grazing in the forestry and (*vi*) promoting welfare of the people.

(*iii*) Forest Policy of 1988. The country made rapid strides after Independence under planned development and changes of far reaching consequences occurred in the economic, political, environmental and social set up of the country since the forest policy of 1952 was declared. Therefore, the Government of India came out with a new forest policy in December, 1988. The main plank of the revised forest policy of 1988 is protection, conservation and development of forests. Its aims are : (*i*) maintenance of environmental stability through preservation and restoration of ecological balance (*ii*) conservation of natural heritage ; (*iii*) check on soil erosion and denudation in catchment area of rivers, lakes and reservoirs ; (*iv*) check on extension of sand dunes in desert areas of Rajasthan and along coastal tracts ; (*v*) substantial increase in forest/tree cover through massive afforestation and social forestry programmes ; (*vi*) steps to meet requirements of fuel wood, fodder, minor forest produce and soil timber of rural and tribal populations; (*vii*) increase in productivity of forest to meet the national needs; (*viii*) encouragement of efficient utilisation of forest produce and optimum substitution of wood and (*ix*) steps to create massive people's movement with involvement of women to achieve the objectives and minimise pressure on existing forests.

WILDLIFE

Wildlife comprises animals, birds, and insects living in forests. With large regional variations in physiography, climate and edaphic types, Indian forests offer a wide range of habitat types which are responsible for a large variety of wild life in India. India boasts of more than 90,000 species of animals which is about 6.5% of the word's total species. Indian fauna includes about 6,500 invertebrates, 5,000 mollusc, 2,546 species of fishes, 2,000 species of birds, 458 species of reptiles, 4 species of panthers and over 60,000 species of insects.

Elephant is the largest Indian mammal which only a few centuries ago, was found in large numbers in vast forest tracts of India. There are about 6,000 elephants in the forests of Assam and West Bengal, about 2,000 in Central India and nearly 6,000 in three southern states of Karnataka, Kerala and Tamil Nadu. The one-horned ***rhinoceros***, India's second largest mammal was once found throughout the Indo-Gangetic Plain as far west as Rajasthan. The number of this mammal has drastically decreased and now there are less than 1,500 rhinoceroses in India, confined to the restricted locations in Assam and West Bengal. They survive under strict protection in the *Kaziranga* and *Manas* sanctuaries of Assam and the *Jaldapara* sanctuary of West Bengal. The ***arna*** or wild buffalo is found in Assam and in Bastar district of Chhattisgarh. The ***gaur*** or the Indian bison is one of the largest existing bovine and is found in the forests of Central India. There are about 1,700 ***tigers*** in India mainly found in the forests of eastern Himalayan foothills and in parts of the peninsular India. The number of ***Cheetahs*** had fallen to less than two hundred until successful breeding programme in the *Gir sanctuary* in Gujarat resulted in some recovery. The arboreal clouded *leopard* is found in northern Assam while the *black* ***Panther*** is a widely distributed predator. *Desert* and *jungle* cats live in north western parts of the country. ***Lynx*** live upto 3,010 m in Ladakh. *Brown*, *Black* and *Sloth Bear* are found at high altitudes in the north-western and central Himalayas.

Yak, the ox of snow, is largely found in Ladakh and is tamed to be used as a draught animal. Several species of wild sheep and wild goats are also found in India. The *shapu* or *urial*, *bhoral* the blue sheep, and *nayan*, a huge sheep with curved horns are the main types of wild sheep. *Serow* and *goral* are the goat antelopes of the Himalayas. The Kashmir *markhar*, the *ibex* and the Himalayan *thar* are some of the Himalayan wild goats.

Deer also used to roam widely across the Indian forests, although their number has been drastically reduced. Stag or ***barasingha*** is found in Assam, Chhattisgarh and Madhya Pradesh. The ***Munjac*** or barking deer are found extensively in the lower wooded slopes of the Himalayas and in the forests of southern India. The ***kastura*** or the musk deer, much sought after for its musk pod, live in the birch woods in the higher forests of the Himalayas. *Thamin* is a pretty deer found in Manipur containing *Kasturi*.

Several species of ***monkeys*** are found in almost all the forest areas of India, the two commonest being the Rhesus Macaque and the Common ***Langur***. There are wide regional variations in the body structure and behaviour of monkeys in India.

The ***Chinkara*** or the Indian gazelle, the black buck or the Indian antelope, the ***nilgai*** or the blue bull, the mouse deer or the Indian chevrotain, the ***chawsinga*** or the four horned antelope, wild dog, the fox, the jackal, the hyena, the mongoose, shrews, hedgehogs, mole, bats, rodents and squirrels are the other mammals found in the Indian forests.

India also abounds in large variety of reptiles, although many of them are now endangered species. There are more than 200 species or subspecies of snakes, the best known being the ***Cobra***, ***Krait*** and ***Russel's Viper***. These are poisonous snakes while *Dhaman* is a non-poisonous large snake. The length of the King Cobra may be well over five metres which makes him the longest poisonous snake. However, the Rock Python and the Reticulated Python may be seven metres long, weighing over 115 kg. Several snakes living in water are also poisonous, although many of them are non-poisonous. The Blunt Nosed or Marsh Crocodile (the *Magar* or *Mugger*) and the long nosed *Gharial* are important large sized reptiles, although their number has drastically reduced. They are hunted for their skins which fetch handsome price. The big Estuarine Crocodile is still found from the Ganga to the Mahanadi. The lizards include well known Chameleon and the monitor lizard or varanus. They are found both in deserts and forests but are endangered species. India has some important breeding beaches for a number of species of turtle. In Odisha about 3,00,000 Olive Ridley Turtles breed while Hawksbill Turtles breed in southern Tamil Nadu.

India is extremely rich in bird life. There are about 2,000 species of birds in India which is about three times the number of species found in Europe. Although most of the birds have their origin in India, a number of them have their source in other areas. Some birds such as ducks, cranes, swallows, and fly-catchers migrate from central Asia to the wetlands of Bharatpur every winter. Recently, some migratory birds have been seen near Mathura.

Indian bird-life has all the varieties of birds including aquatic, gallinaceous and arboreal. Aquatic birds include a large variety of storks, herons, ducks, flamingoes, egrets and cormorants. Among the waders and shore birds are the snipes, iluses, gulls, cranes and the lapwings. The Great Indian Bustard, pea fowl, jungle fowl, quail and partridge are the main ground birds. Babblers, barbits, bulbuls, mynas, pigeons, parakeets, doves, cuckoos, rollers, beaters, fly-catchers, orioles, warblers, wagtails, finchlarks, finches, drongos, hoops, etc. are other important birds. India is the home of a large number of birds of prey, the important being owl, eagle, kite, falcon, kestrel, etc. *Peacock* is the ***national bird of India***. Its magnificant plumage symbolizes the colour and wealth of India's bird life.

PRESERVATION OF WILDLIFE

The fast dwindling forest cover in India has adversely affected wildlife in the country. The number of several species has been drastically reduced, some are endangered species, the others are on the verge of extinction while some of them have already disappeared. This is a very serious trend and will disturb the ecological balance. Therefore, it must be checked and reversed at all costs. This calls for urgent measures for preserving wildlife.

Indian Board for Wildlife was constituted in 1952. The main purpose of the board was to advise the Government on the means of conservation and protection of wildlife, construction of national parks, sanctuaries and zoological gardens as well as promoting public awareness regarding conservation of wildlife. The wildlife (Protection) Act, 1972 is a comprehensive law which has been adopted by all states except Jammu and Kashmir (which has its own Act). It governs wildlife conservation and protection of endangered species. The Act prohibits trade in rare and endangered species. An Inter-State Committee has been set up to review the Wildlife (Protection) Act, 1972 and other laws. The wildlife (Protection Amendment Bill 2002 proposes to enhance penalties for violation of the provision of the Act. Under this, export or import of endangered species and their products are governed by the conditions and stipulations laid down therein.

Project Tiger, one of the premier conservation efforts in the country was launched on 1 April 1973. It is a centrally financed scheme under which 27 Tiger Reserves have been set up in 17 states. The tiger population had slid to a near extinction level before the implementation of Project Tiger. There were only 711 tigers in all the 27 tiger reserves in 1979. This figure rose to 1,141 in 1984, 1,327 in 1989, 1,396 in 1993 and 1,575 in 1971. The number tigers further increased to 3642 in 2001 after which there was a sharp decline and their number stood at 1411 only in 2006. Again the number of tigers started increasing and according to 2010 census, India had 1706 tigers, including 70 tigers in the border region of the Sundarbans which was excluded in the 2006 assessment. The 2010 survey was conducted in a more exhaustive manner in 17 states using hidden cameras and DNA tests. Distribution of tigers are the time of 2006 and 2010 census is shown in **table 6.5**.

TABLE 6.5. India : Number of tigers in 2006 and 2010

Area	Number of tigers in 2006	Number of tigers in 2010
1. Shiwalik Gangetic Plains	297	353
2. Central India and Eastern Ghats	602	601
3. Western Ghats	412	534
4. Northeast hills and Brahmaputra flood basins	100	148
5. Sunderbans	—	70
Total	1,411	1,706

However, the sad part of the census report is that the habitat of tigers has shrunk from 93,600 sq km in 2006 to 72,800 sq km in 2010—a loss of 20,800 sq km of tiger territory across the country.

The primary object of the project tiger is "to ensure maintenance of the viable population of tigers in India for scientific, economic, aesthetic, cultural and ecological values, and to preserve for all times, areas of biological importance as a national heritage for the benefit, education and employment of the people". Following are the salient features of project tiger :

- Amendment of the Wild Life (Protection) Act 1972 for providing provisions for constitution of the National Tiger Conservation Authority and the Tiger and other Endangered Species Crime Control Bureau.

- 100 per cent Central Assistance to 38 Tiger Reserves for deployment of Tiger Protection Force, comprising ex-army personnel and local workforce.
- Constitution of the National Tiger Conservation Authority with effect from September 4, 2006.
- Constitution of a multi-disciplinary Tiger and Other Endangered Species Crime Control Bureau

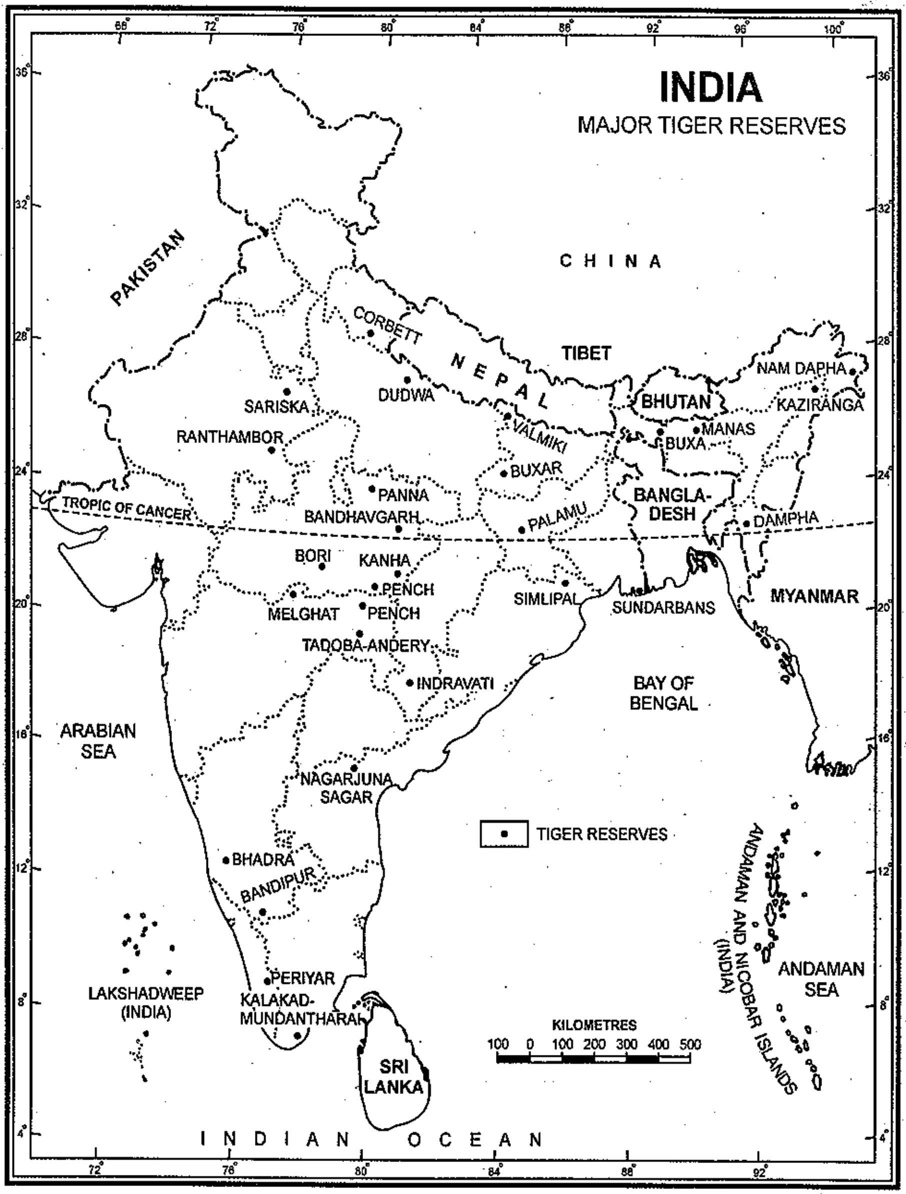

FIG. 6.3. India : Major Tiger Reserves

(Wildlife Crime Control Bureau) with effect from June 6, 2007.

- Approval accorded for declaring eight new Tiger Reserves. Notification for Sahyadri Tiger Reserve in Maharashtra has been issue in January, 2011.
- The revised Project Tiger guidelines have been issued to states for strengthening tiger conservation.
  - A scientific methodology for estimating tiger (including co-predators, prey animals and assessment of habitat status) has been involved and mainstreamed. According to the refined technology, an estimated land of 93,697 sq km has been observed as tiger habitat. An area of 29,284.76 sq km has been notified by 15 Tiger States as core or critical tiger habitat.
  - India has a Memorandum of Understanding (MoU) with Nepal on controlling transboundary illegal trade in wildlife and conservation, apart from a protocol on tiger conservation with China.
  - A Global Tiger Forum of Tiger Range Countries has been created for addressing international issues related to tiger conservation.

Out of 17 tiger states in India 16 states have notified the core or critical tiger habitat under section 38V of the Wildlife Protection Act, 1972 as amended in 2006 covering a total area of 31,407.11 sq km. These states are Andhra Pradesh, Arunachal Pradesh, Assam, chhattisgarh, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Mizoram, Odisha, Rajasthan, Tamil Nadu, Uttarakhand, Uttar Pradesh and West Bengal. Bihar has decided to notify the core or critical tiger habitat (840 sq km).

Approval has been accorded for creation of five more tiger reserves in five different states (**Table 6.6**).

TABLE 6.6. Proposed new tiger reserves

Name of the Tiger Reserve	Name of the state
1. Rataponi	Madhya Pradesh
2. Sunabeda	Odisha
3. Pilibhit	Uttar Pradesh
4. Biligiri Ranganitha Temple	Karnatata
5. Mukundara Hills	Rajasthan

Source : India 2013, A Reference Annual, p. 301.

Further, following areas have been suggested by the National Tiger Conservation Authority to States for creation as tiger reserves.

Major tiger reserves are shown in **Figure 6.3**.

Name	*State*
1. Satyamangalam	Tamil Nadu
2. Nazzira-Navegaon	Maharashtra
3. Bor	Maharashtra
4. Suhelwa	Uttar Pradesh

Source : India 2013, A Reference Annual, p. 302.

A tiger crisis cell has also been formed in the Ministry of Environment and Forests. Tiger has been declared as our **national animal.** Honourable Supreme Court has banned tourist entry into core tiger areas with effect from 25th July 2012. The core tiger areas where tourist entry is banned are Corbett, Ranthambar, Panna, Kanha, Melghat, Bandipur, Kaziranga, Bandhavgarh, Nagarajunsagar and Periyar.

Project Elephant was launched as a centrally sponsored scheme in February 1992. Under this project, states having free-ranging population of wild elephants are being given financial as well as technical and scientific assistance to ensure long-term survival of identified viable populations of elephants in their natural habitats. The project is being implemented in 15 states *viz.* Andhra Pradesh, Arunachal Pradesh, Assam, Chhattisgarh, Jharkhand, Karnataka, Kerala, Maharashtra, Meghalaya, Nagaland, Odisha, Tamil Nadu, Tripura, Uttarakhand, and West Bengal. These states are being given financial as well technical assistance in achieving the objectives of this project. Other states with small population of elephants are given assistance for the purpose of census, training of field staff and mitigation of human-elephant conflict.

Crocodile Breeding Project. This project was initiated on April 1, 1974 and the project began on April 1, 1975 in Odisha. Gherial eggs were hatched for the first time in the world at Tikerpada, Distt. Dhankanal, Odisha in June, 1975. A small betal was also hatched at Kurkrail, near Lucknow same year. Crocodile husbandry work was undertaken with a view to sanctuary development. A total of 16 crocodile rearing centres were developed in the country by 1978 in eight states. Out of these 16 sanctuaries, eleven have been declared under the project. Two largest sanctuaries are the Krishna Sanctuary in Andhra Pradesh (3,600 sq km) and the Chambal Sanctuary, a tri-state statuary in Uttar Pradesh, Rajasthan and Madhya Pradesh. Andhra Pradesh has the largest number of five sanctuaries.

Gharial rehabilitation began in 1977 with the release of 26 animals in the Mahanadi River (Odisha). By 1980, 107 animals had been released in the river where their number was reduced to a critical level of just five.

A central Zoo Authority has been set-up for the proper management of zoological parks in the country. It coordinates the activities of over 200 zoos and also supervises the exchange of animals. A national policy on zoos prepared by the authority provides appropriate directions to the government and other zoo operations.

The National Wildlife Action Plan (NWAP) provides the framework of strategy as well as programmes for conservation of wildlife. The first National Wildlife Action Plan of 1983 has been revised and new Wildlife Action Plan (2002-2016) has been adopted. The Indian Board of Wildlife is the apex advisory body overseeing and guiding the implementation of various schemes for wildlife conservation.

National Park. A national parks is relatively large land or water area which contains representative samples and sites of major natural regions, features, scenery, and/or plant and animal species of national or international significance and are of special scientific, educational and recreational interest. Usually the national parks contain one or several entire ecosystems that are not materially altered by human exploitation or occupation. National parks are protected and managed by the government in a natural or near natural state. Visitors enter under special conditions for inspirational, educational, cultural and recreational purposes.

Wile Life Sanctuary. It is more or less similar to a national park which is dedicated to protect the wildlife and concerned species. A wild life sanctuary is an area constituted by competent authority in which killing and capturing of any form of wild life is prohibited, except with permission and boundaries and character of which are sacrosanct. Entry to the sanctuary is restricted, and allowed only under permission of the chief wild life warden, for research photography, tourism or other lawful business with those residing within the sanctuary. The people who are permitted to live in the sanctuary are authorised officers or persons with right over the immovable property within the limits of the sanctuary. Grazing or movement of livestock is regulated and the livestock permitted to enter the sanctuary have to be immunised against communicable diseases. The chief warden is authorised to allow or disallow entry into the sanctuary or construction of roads, building, fences, etc. Hunting is also restricted and strictly regulated. Approval of the government is necessary before the chief warden gives his permission for hunting.

Biosphere Reserves. A biosphere reserve is a unique and representative ecosystem of terrestrial and coastal areas which are internationally recognised within the framework of UNESCO's Man and Biosphere (MAB) programme. It consists of more or less concentric zones with core at the centre which is followed by buffer zone, transitional zone and finally zone of human encroachment **(Fig. 6.4)**.

The objectives of Man and Biosphere Programme (MAB) are as follows :

1. Conserve representative samples of all ecosystems and habitat type.
2. Provide long term *in-situ* conservation of genetic diversity.
3. Promote and facilitate basic and applied research and monitoring of wild life.
4. Promote mass education, awareness and capacity building.
5. Promote appropriate sustainable management of natural resources.
6. Dissemination of experience so as to promote sustainable development elsewhere.
7. Biosphere management mandates people's participation for conservation of natural resource and shopping of national landscape.

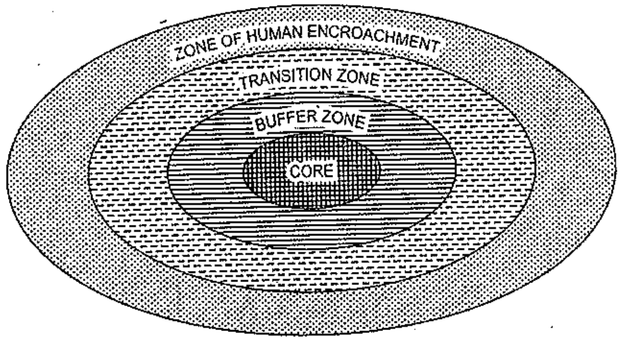

FIG. 6.4. The concept of biosphere reserve

Distinction between National Park, Sanctuary and Biosphere Reserve

National Park	Sanctuary	Biosphere Reserve
1. Hitched to the habitat for particular wild animal species such as tiger, lion, hangul, rhino, etc.	Generally species-oriented such as citrus, pitcher plant, Great Indian Bustard, etc.	Hitched to the whole ecosystem *i.e.* totality of all form of life *i.e.* ecosystem-oriented.
2. In India, the size of a national park may range from 0.04 to 3162 sq km. The most common average size is 100 to 500 sq km (in about 40% case) and 500 to 1,000 sq km (about 15%)	Size range is 0.61 to 7818 sq km. Most common (in about 40%) is 100 to 500 sq km. In 25% cases the size is 500 to 1,000 sq km.	Size range over 5,670 sq km.
3. Boundaries are fixed by legislation	Boundaries are not sacrosant	Boundaries are fix by legislation
4. Except the buffer zone, no biotic interference	Limited biotic interference	Except the buffer zone, no biotic interference
5. Tourism permissible	Tourism permissible	Tourism normally not permissible.
6. Research and scientific management lacking	Lacking	Managed
7. So far no attention to genepods and conservation	So far not such attention	Attention given

Distribution of National Parks, Wildlife Sanctuaries and Biosphere Reserves

At present there are 100 national parks, 515 wildlife sanctuaries and 17 biosphere reserves.

National Parks. India is one of the mega diversity countries of the world and houses a large number of wild species found nowhere else in the world. This is the reason that India currently as many as 100 national parks spread through the length and breadth of the country. Major national parks are shown in **Fig. 6.5**.

Wildlife Sanctuaries. As mentioned earlier, India currently has 515 wildlife sanctuaries. Like National Parks they provide shelter to a large variety of animal species and can be traced in almost all parts of the country. **(Fig. 6.6)**

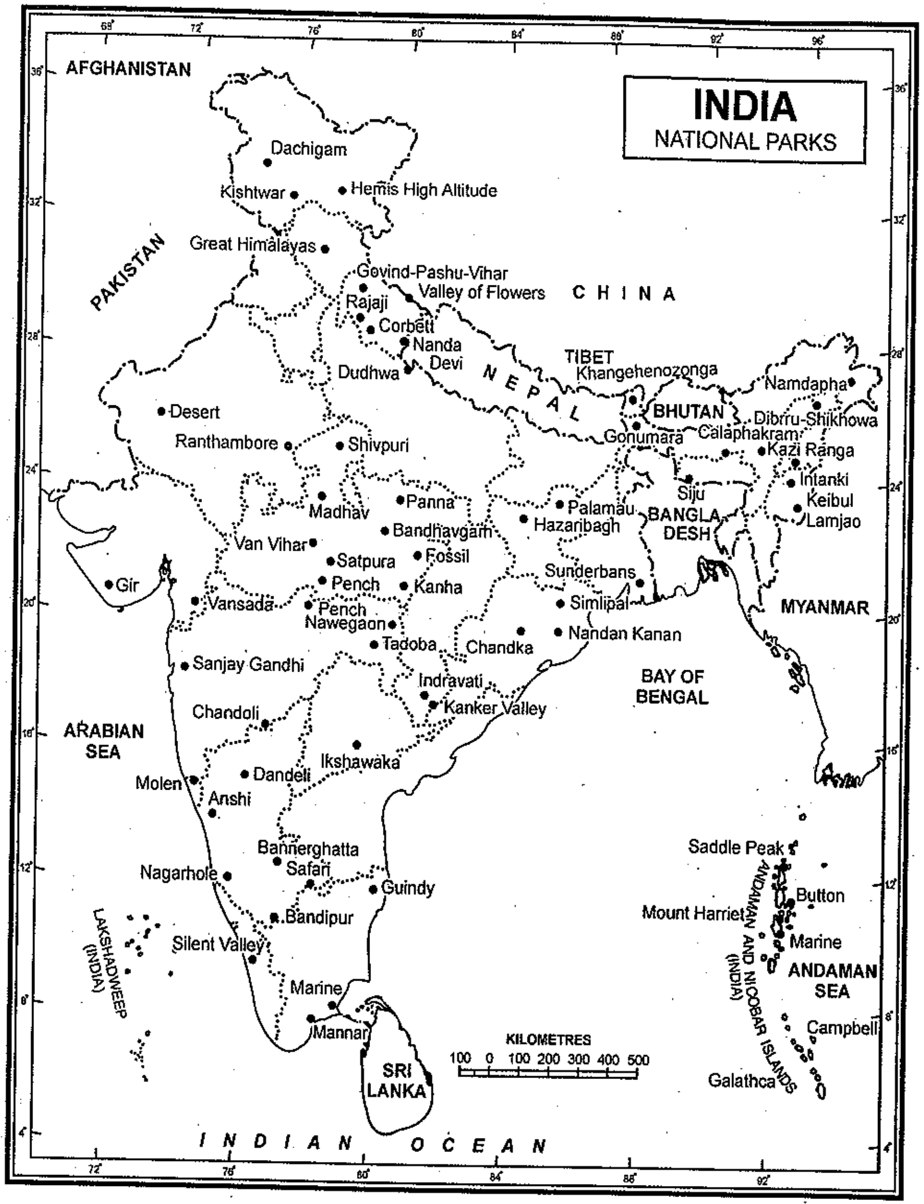

FIG. 6.5. Location of important national parks in India.

Biosphere Reserves

The biosphere reserves are required to meet a minimal set of criteria and adhere to a minimal set of conditions before they are admitted to the World Network of Biosphere Reserves designated by UNESCO. These Reserves are very rich in biological

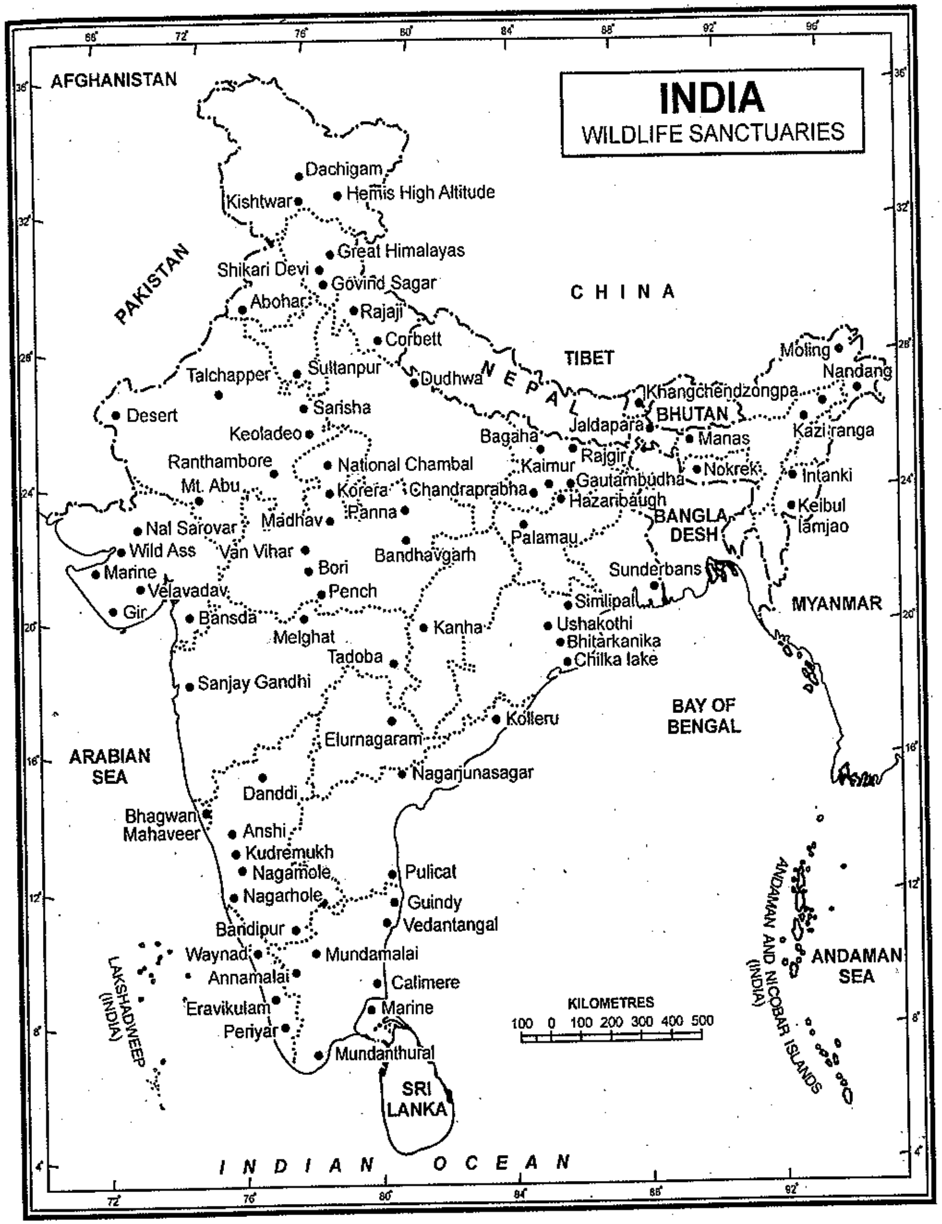

FIG. 6.6. Location of some important wildlife sanctuaries in India.

and cultural diversity and encompass unique features of exceptionally pristine nature. India has been divided into 10 Biogeographic zones and these zones together consist of 25 biogeographic provinces. The

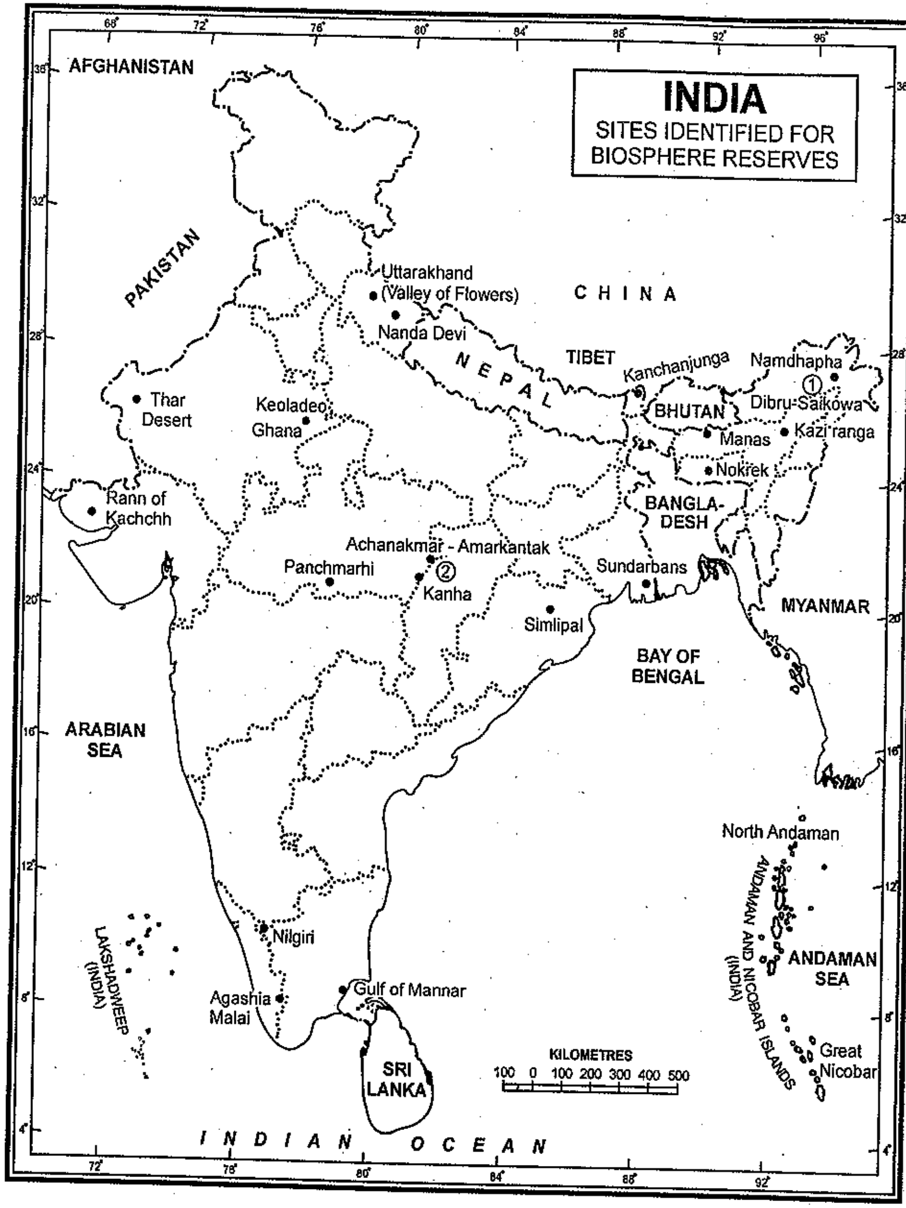

FIG. 6.7. Biosphere Reserves

aim is to designate one representative site as Biosphere Reserve in each bio-geographic province for long term conservation.

The programme was initiated in 1986 and till date 17 sites have been designated as Biosphere Reserves in different parts of the country. Out of

these 17 Biosphere Reserves, 7 Biosphere Reserves have been included in the World Network of Biosphere Reserves till now. They are (*i*) Sundarbans (West Bengal), Gulf of Mammal (Tamil Nadu), (*iii*) Nilgiri (Tamil Nadu, Kerala and Karnataka), (*iv*) Nanda Devi (Uttarakhand), (*v*) Panchmarhi (Madhya Pradesh), (*vi*) Simplipal (Odisha), and (*vii*) Nakrek (Meghalaya). The proposals in respect of Kanchanjunga (Sikkim) and Manas (Assam) are in active consideration of the UNESCO for their recognition on the world network. Strenuous efforts are being made for getting remaining Biosphere Reserves included in the World Network of Biosphere Reserves.

Measures of Conserving Wildlife

The following measures can prove effective tools for conserving wildlife:

(*a*) Ban on hunting should be strictly implemented.

(*b*) Poachers and herdsmen should not be allowed to enter the forests.

(*c*) More national parks and wildlife sanctuaries should be established.

(*d*) Existing national parks and sanctuaries should be further developed and more amenities should be provided in them.

(*e*) Captive breeding of wildlife should be encouraged.

(*f*) Seminars, workshops, exhibitions should be arranged in national parks and sanctuaries to improve the wildlife and general awareness among the public.

(*g*) Adequate medical facilities should be provided in national parks and sanctuaries for the wildlife so that their health is improved.

(*h*) Proper conditions should be created for living and breeding of wild fauna in the national parks and sanctuaries.

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CHAPTER 7

Soils

INTRODUCTION

Soil is the thin surface-layer on the earth, comprising mineral particles formed by the break-down of rocks, decayed organic materials, living organisms, water and air. Soil is formed under specific natural conditions and each of the elements of the natural environment contributes to this complex process, described by the soil scientists as the process of *pedogenesis*.

Soil is a very important natural resource of India because agricultural production is basically dependent on the fertility of soil. The rich, deep fertile soils of the Ganga Plain, especially its delta, and coastal plain of Kerala support high density of population through agricultural prosperity. On the other hand, the shallow and coarse grained soils of Telangana and Rajasthan support only a small population because these soils do not provide a base for prosperous agriculture.

SOIL FORMATION IN INDIAN CONDITIONS

Indian soils, as in other parts of the world, reflect a combination of factors which have contributed to their formation. In Indian conditions, there is wide diversity with respect to geographical conditions such as, physiography, climate and vegetation. Consequently soils display a wide variety of physical and chemical characteristics. In India, soil formation is mainly related to the parent rock material, surface relief, climate and natural vegetation. Animals, insects and man also play an important role in soil formation. Some of the important factors of soil formation are mentioned below :

1. Parent Material. The material for soil formation is mainly derived from the rocks and is termed as the parent material by soil scientists. The parent material determines the colouration of the soil, its mineral composition and texture. India possesses a great variety of parent material which is generally categorised into following six classes :

(*i*) Ancient crystalline and metamorphic rocks
(*ii*) Cuddapah and Vindhyan rocks
(*iii*) Gondwana rocks
(*iv*) Deccan basalts
(*v*) Tertiary and Mesozoic sedimentary rocks of extra peninsular India
(*vi*) Recent and sub-recent rocks.

The surface rocks are exposed to the process of weathering and suffer decay and decomposition. In this process, the rocks are converted into fine grains and provide a base for the soil formation. The *ancient crystalline and metamorphic rocks* constitute greater part of the peninsular region. These rocks are basically granites, gniesses and schists which are rich in ferromagnesian materials. Such rocks give rise to red soils on weathering. The red colour of these soils is largely due to the presence of iron oxide. The *Cuddapah and Vindhyan rocks* have weathered to give calcareous and argillaceous soils. These soils are native. The *Gondwana rocks* give rise to comparatively less mature soils of more or less uniform character but of low fertility. *The Deccan traps* are composed of basalt. Basalts are quite rich in titanium, magnetite, aluminium and magnesium. Consequently the weathering of these rocks has given rise to soils of darker colour. The soil derived from the Deccan trap is fertile with high moisture holding capacity and is popularly known as ***'regur'*** or ***black cotton soil***. The *Tertiary and Mesozoic* sedimentary rocks of extra peninsular India have given rise to soils with high porosity. These soils are generally immature *recent and sub recent* rocks, result in alluvial soils on weathering.

The soils of the Northern Plain of India have been largely derived from the depositional work of the Himalayan rivers. This depositional work has been continuing for thousands of years. These are alluvial fertile soils consisting of fine silts and clay. These soils have little relation with the original rocks. On the other hand, the soils of peninsular plateau are generally coarse-grained and are closely related to the parent rocks. The peninsular soils are generally less fertile.

2. Relief. Relief influences the process of soil formation in many ways, the most important being the slope of land. Steep slope encourages the swift flow of water and hinders the process of soil formation. There may even be soil erosion in areas of steep slope. Chambal ravines offer an important example of soil erosion. The areas of low relief or gentle slope generally experience deposition and have deep soils. Because of this reason, there are thick layers of fertile alluvial soils in the northern plain of India whereas the soils are generally shallow in the plateau area. The exceptions in the plateau are river basins where the soil layers are sufficiently deep. The degree of slope also largely determines the fertility of soil.

3. Climate. Climate is the single most important factor in soil formation. Most important climatic factors affecting soil formation are the amount and seasonal distribution of temperature and rainfall. Climate controls the type and effectiveness of weathering of the parent material, the quantity of water seeping through the soil and the type of micro-organisms present therein. In areas of heavy rainfall and high temperature, the soils are red or lateritic. Torrential rainfall during the rainy season washes the upper soil and leaches the materials into deeper horizon. During the dry summer season the evaporation exceeds precipitation and through capillary action iron and aluminium sesquioxides are transported to the surface making the soil red. In areas of alternate wet and dry climate, the leached material which goes deep down in the horizon is brought up and the blazing sun bakes the top soil so hard that it resembles a brick. Therefore, this soil is called **lateritic which literally means brick.** In arid and semi-arid regions, evaporation always exceeds precipitation. Under such circumstances, two main factors determine the nature and properties of soils. Firstly there is very little vegetation and the soils badly lack humus content. Hence the soils are invariably of light colour. Secondly, the excess of evaporation makes soils lime accumulating. Thus they are bound to be pedocal in nature. Such soils are widely spread in the extreme western part of the country. In cold climates of the Himalayan region, the process of vegetation decay is very slow and the soils formed under such circumstances are acidic in nature. When the climatic control acts for a sufficiently long period, it reduces the differences in the parent materials. Two different parent materials may develop the same soil in the same type of climate. Similarly, the same parent material may produce two different types of soils in two different types of climates. The crystalline granites produce laterite soil *in relatively moist* parts of the monsoonal region and non-laterite soil in drier areas. Hot summer and low rainfall develops black soil as is found in some parts of Tamil Nadu irrespective of the parent rock. In Rajasthan, both granite and sandstone give birth to sandy soil under arid climate. This soil is poor in organic matter.

4. Natural Vegetation. Natural vegetation reflects the combined effects of relief and climate. The formation and development of soil is very much influenced by the growth of vegetation. The decayed leaf material adds much needed **humus** to soil thereby increasing its fertility. The densely forested areas contain some of the best soils in India. There is a close relationship between the vegetation types and soil types in India.

MAJOR SOIL GROUPS OF INDIA

India is a country of vast dimensions with varied conditions of geology, relief, climate and vegetation. Therefore, India has a large variety of soil groups, distinctly different from one another. Different criteria have been applied to classify Indian soils, the outstanding being geology, relief, fertility, chemical composition and physical structure, etc. Any classification based on any one of the aforesaid criteria has its own inherent drawback. Even the most competent pedologist would find it difficult to present an accurate, complete, comprehensive and generalised account of the Indian soils.

During the British rule in India, a vast body of fascinating accounts had emerged in district gazetteers and official reports. These accounts were generally directed towards the assessment of differential soil fertility and land revenue collection, but did not attempt classification of soil types in the country. The earlier studies of Indian soils were made by foreign scholars like *Volckar* (1893), *Leather* (1898), *Schokalskaya* (1932), *Champion* (1936), etc. Indian scholars including *Wadia* (1935), *Basu* (1937), *Vishwanath and Ukil* (1944), *Chatterjee, Krishnan, and Roychaudhary* (1954) made strenuous efforts to classify soils of India. In 1957, The *National Atlas Organisation* (Kolkata) published a soil map of India in which Indian soils were classified into 6 major groups and 11 broad types. The *Irrigation Atlas of India* (1972) and Spate's *India, Pakistan* and *Ceylon* (1976) utilised the 7th approximation soil classification developed by the U.S. Department of Agriculture (USDA). The 7th approximation defines soil classes strictly in terms of their morphology and composition as produced by a set of natural and human forces. The classification is determined by quantifiable criteria.

Geologically, Indian soils can broadly be divided into two main types : (*a*) Soils of peninsular India and (*b*) Soils of extra-peninsular India.

The soils of Peninsular India are those which have been formed by the deomposition of rocks *in situ*, *i.e.* directly from the underlying rocks. They are transported and redeposited to a limited extent and are known as sedentary soils. On the other hand, the soils of the Extra-Peninsula are formed due to the depositional work of rivers and wind. They are mainly found in the river valleys and deltas. They are very deep and constitute some of the most fertile tracts of the country. They are often referred to as *transported or azonal soils.*

The Indian Council of Agricultaral Research (ICAR) set up an All India Soil Survey Committee in 1953 which divided the Indian soils into eight major groups. They are (1) Alluvial soils, (2) Black soils, (3) Red soils, (4) Laterite and Lateritic soils, (5) Forest and Mountain soils, (6) Arid and Desert soils, (7) Saline and Alkaline soils and (8) Peaty and Marshy soils (See **Fig. 7.1**). This is a very logical classification of Indian soils and has gained wide acceptance. A brief account of these eight soils is given as under :

1. Alluvial Soils. Alluvial soils are by far the largest and the most important soil group of India. Covering about 15 lakh sq km or about 45.6 per cent of the total land area of the country, these soils contribute the largest share of our agricultural wealth and support the bulk of India's population. Most of the alluvial soils are derived from the sediments deposited by rivers as in the Indo-Gangetic plain although some alluvial soils in the coastal areas have been formed by the sea waves. Thus the parent material of these soils is all of transported origin. The streams bring with them the products of weathering of rocks from the mountains and deposit them in the low-lying areas. The alluvial soils are yet immature and have weak profiles. They differ in consistency from *drift sand to rich loams* and from *silts* to *stiff clays*. A few occasional *kankar* beds are also present. However, pebbly, stony or gravelly soils are rare in this group. The chemical composition of the alluvial soils make this group of soils as one of the most fertile in the world. The proportion of nitrogen is generally low, but potash, phosphoric acid and alkalies are adequate, while iron oxide and lime vary within a wide range. The porosity and texture provide good drainage and other conditions favourable for bumper crops. These soils are easily replenished by the recurrent river floods and support uninterruped crop growth.

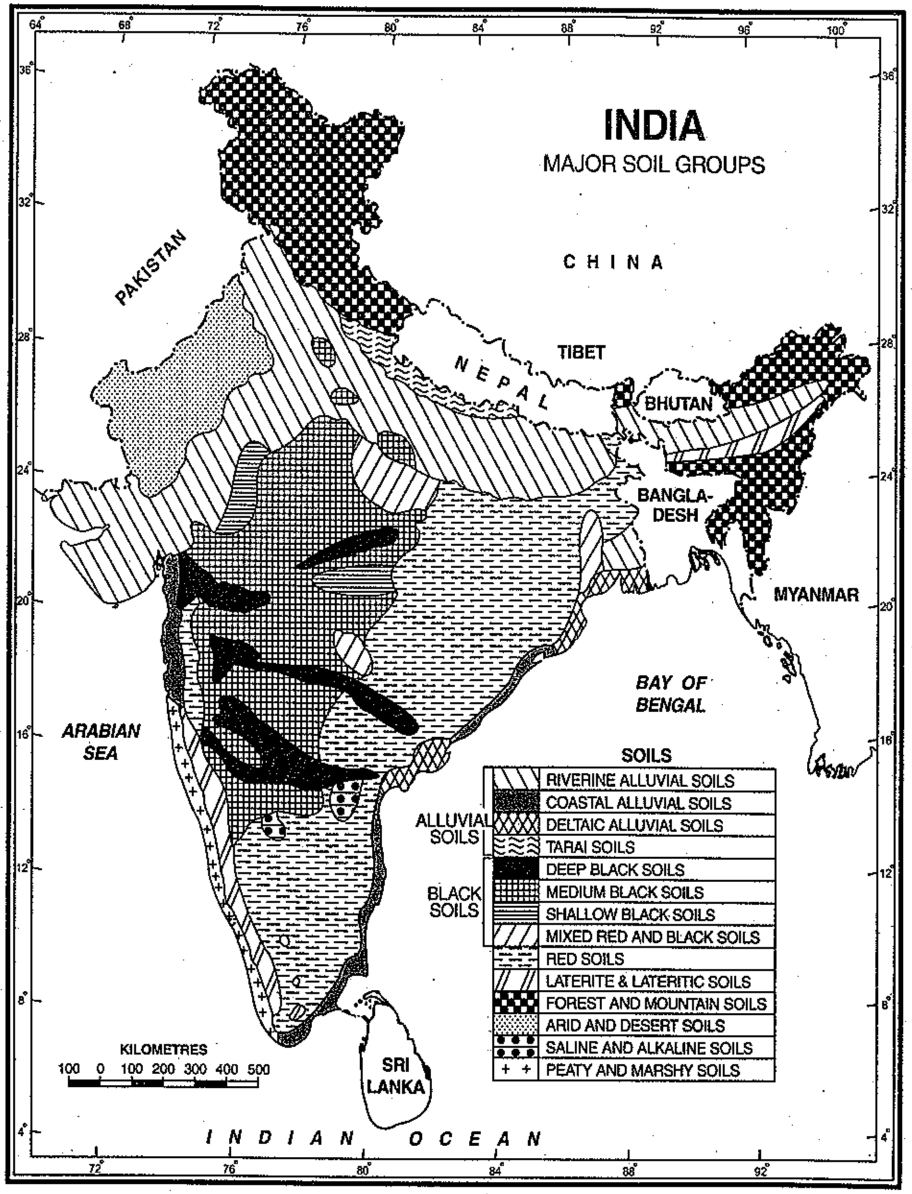

FIG. 7.1. India : Major Soil Groups

The widest occurrence of the alluvial soils is in the Great Indo-Gangetic Plain starting from Punjab in the west to West Bengal and Assam in the east. They also occur in deltas of the Mahanadi, the Godavari, the Krishna and the Cauvery, where they are called ***deltaic alluvium***. Along the coast they are known as ***coastal alluvium***. Some alluvial soils are found in the Narmada and Tapi valleys. Northern parts of Gujarat also have some cover of alluvial soils.

Geologically, the alluvium of the Great plain of India is divided into newer or younger *khadar* and older *bhangar* soils. The ***khadar*** soils are found in the low areas of valley bottom which are flooded almost every year. They are pale brown, sandy clays and loams, more dry and leached, less calcareous and carbonaceous *i.e.* they are less *kankary*. ***Bhangar***, on the other hand, is found on the higher reaches about 30 metres above the flood level. It is of a more clayey composition and is generally dark coloured. A few metres below the surface of the bhangar are beds of lime nodules known as ***kankar***. Along the Shiwalik foothills, there are alluvial fans having coarse, often pebbly soils. This zone is called ***bhabar***. To the south of the *bhabar* is a long narrow strip of swampy lowland with silty soils. It covers an area of 56,600 sq km and is called ***tarai***. The tarai soils are rich in nitrogen and organic matter but are deficient in phosphate. These soils are generally covered by tall grasses and forests but are suitable for a number of crops such as wheat, rice, sugarcane, jute and soyabean under reclaimed conditions.

Due to their softness of the strata and fertility the alluvial soils are best suited to irrigation and respond well to canal and well/tube-well irrigation. When properly irrigated, the alluvial soils yield splendid crops of rice, wheat, sugarcane, tobacco, cotton, jute, maize, oilseeds, vegetables and fruits. Increasing trend of rice cultivation in Punjab and Haryana with the help of intense irrigation is a living example.

2. Black Soils. The black soils are also called ***regur*** (from the Telugu word Reguda) and ***black cotton soils*** because cotton is the most important crop grown on these soils. Several theories have been put forward regarding the origin of this group of soils but most pedologists believe that these soils have been formed due to the solidifaction of lava spread over large areas during volcanic activity in the Deccan Plateau, thousands of years ago. Most of the black soils are derived from two types of rocks, the Deccan and the Rajmahal trap, and ferruginous gneisses and schists occurring in Tamil Nadu. The former are sufficiently deep while the later are generally shallow.

Krebs holds that the regur is essentially a mature soil which has been produced by relief and climate, rather than by a particular type of rock. According to him, this soil occurs where the annual rainfall is between 50 to 80 cm and the number of rainy days range from 30 to 50. The occurrence of this soil in the west deccan where the rainfall is about 100 cm and the number of rainy days more than 50, is considered by him to be an exception.

In some parts of Gujarat and Tamil Nadu, the origin of black cotton soils is ascribed to old lagoons in which the rivers deposited the materials brought down from the interior of Peninsula covered with lava.

Geographically, black soils are spread over 5.46 lakh sq km (*i.e.* 16.6 per cent of the total geographical area of the country) encompassed between 15°N to 25°N latitudes and 72°E to 82°E longitudes. This is the region of high temperature and low rainfall. It is, therefore, a soil group of the dry and hot regions of the Peninsula. These soils are mainly found in Maharashtra, Madhya Pradesh, parts of Karnataka, Telangana, Andhra Pradesh, Gujarat and Tamil Nadu.

The black colour of these soils has been attributed by some scientists to the presence of a small proportion of titaniferous magnetite or even to iron and black constituents of the parent rock. The black colour of this soil may even be derived from crystalline schists and basic gneisses such as in Tamil Nadu and parts of Andhra Pradesh. Various tints of the black colour such as deep black, medium black, shallow black or even a mixture of red and black may be found in this group of soils.

The black soil is highly retentive of moisture. It swells greatly and becomes sticky when wet in rainy season. Under such conditions, it is almost impossible to work on such soil because the plough gets stuck in the mud. However, in the hot dry season, the moisture evaporates, the soil shrinks and is seamed with broad and deep cracks, often 10 to 15 cm wide and upto a metre deep. This permits oxygenation of the soil to sufficient depths and the soil has extraordinary fertility. Remarkably "*self-ploughed*" by loosened particles fallen from the ground into the cracks, the soil "*swallows*" itself and retains soil moisture. This soil has been used for growing a variety of crops for centuries without adding fertilizers and manures, or even fallowing with little or no evidence of exhaustion.

A typical black soil is highly argillaceous with a large clay factor, 62 per cent or more, without gravel or coarse sand. It also contains 10 per cent of alumina, 9-10 per cent of iron oxide and 6-8 per cent of lime and magnesium carbonates. Potash is variable (less than 0.5 per cent) and phosphates, nitrogen and humus are low. The structure is cloddish but occasionally friable. In all *regur* soils in general, and in those derived from ferromagnesian schists in particular, there is a layer rich in *kankar* nodules formed by segregation of calcium carbonate at lower depths. As a general rule, black soils of uplands are of low fertility but they are darker, deeper and richer in the valleys.

Because of their high fertility and retentivity of moisture, the black soils are widely used for producing several important crops. Some of the major crops grown on the black soils are cotton, wheat, jowar, linseed, virginia tobacco, castor, sunflower and millets. Rice and sugarcane are equally important where irrigation facilities are available. Large varieties of vegetables and fruits are also successfully grown on the black soils.

3. Red Soils. This comprehensive term designates the largest soil group of India, comprising several minor types. Most of the red soils have come into existence due to weathering of ancient crystalline and metamorphic rocks. The main parent rocks are acid granites and gneisses, quartzitic and felspathic. The colour of these soils is generally red, often grading into brown, chocolate, yellow, grey or even black. The red colour is due more to the wide diffusion rather than to high percentage of iron content.

The red soils occupy a vast area of about 3.5 lakh sq km which is about 10.6 per cent of the total geographical area of the country. These soils are spread on almost the whole of Tamil Nadu, parts of Karnataka, south-east of Maharashtra, Telangana, Andhra Pradesh, Madhya Pradesh, Chhattisgarh, Odisha and Chota Nagpur in Jharkhand. In the north the red soil area extends in large parts of south Bihar; Birbhum and Bankura districts of West Bengal; Mirzapur, Jhansi, Banda and Hamirpur districts of Uttar Pradesh; Aravallis and the eastern half of Rajasthan, parts of Assam, Nagaland, Manipur, Mizoram, Tripura and Meghalaya.

By and large, the red soils are poor in lime, magnesia, phosphates, nitrogen and humus, but are fairly rich in potash. In their chemical composition they are mainly siliceous and aluminous, with free quartz as sand, the alkali content is fair, some parts being quite rich in potassium. The texture of these soils varies from sand to clay, the majority being loams. On the uplands, the red soils are thin, poor and gravelly, sandy or stony and porous, but in the lower areas they are rich, deep dark and fertile.

The red soils respond well to the proper use of fertilizers and irrigation and give excellent yields of cotton, wheat, rice, pulses, millets, tobacco, oil seeds, potatoes and fruits.

4. Laterite and Lateritic Soils. The word 'laterite' (from Latin word meaning brick) was first applied by Buchanan in 1810 to a clayey rock, hardening on exposure, observed in Malabar. But many authors agree with Fermor's restriction of this term to soils formed as to 90-100 per cent of iron, aluminium, titanium and manganese oxides. According to majority opinion, the laterite soil is formed under conditions of high temperature and heavy rainfall with alternate wet and dry periods. According to Polynov, laterite soils may be "the end products of weathering given sufficiently long time". In the opinion of George Kuriyan, "It is probably the end product of decomposition found in regions of heavy rainfall, more than 200 cm. Such climatic conditions promote leaching of soil whereby lime and silica are leached away and a soil rich in oxides of iron and aluminium compounds is left behind. We have numerous varieties of laterite which have bauxite at one end and an indefinite mixture of ferric oxides at the other. Almost all laterite soils are very poor in lime and magnesia and deficient in nitrogen. Sometimes, the phosphate content may be high, probably present in the form of iron phosphate but potash is deficient. At some places, there may be higher content of *humus*.

Laterite and lateritic soils are widely spread in India and cover an area of 2.48 lakh sq km. They are mainly found on the summits of Western Ghats at 1000 to 1500 m above mean sea level, Eastern Ghats, the Rajamahal Hills, Vindhyas, Satpuras and Malwa Plateau. They also occur at lower levels and in valleys in several other parts of the country. They are well developed in south Maharashtra, parts of Karnataka, Telangana, Andhra Pradesh, Odisha, West Bengal, Kerala, Jharkhand, Assam and Meghalaya.

Due to intensive leaching and low base exchange capacity, typical laterite soils generally lack fertility and are of little use for crop production. But when manured and irrigated, some laterites and lateritics are suitable for growing plantation crops like tea, coffee, rubber, cinchona, coconut, arecanut, etc. In low lying areas paddy is also grown. Some of the laterite soils in Kerala, Karnataka, Chota Nagpur region of Jharkhand, Odisha and Assam respond well to the application of fertilizers like nitrogen, phosphorus and potassium. In some areas, these soils support grazing grounds and scrub forests.

Laterite and lateritic soils have a unique distinction of providing valuable building material. These soils can be easily cut with a spade but hardens like iron when exposed to air. Because it is the end-product of weathering, it cannot be weatherd much further and is indefinitely durable.

5. Forest and Mountain Soils. Such soils are mainly found on the hill slopes covered by forests. These soils occupy about 2.85 lakh sq km which is about 8.67 per cent of the total land area of India. The formation of these soils is mainly governed by the characteristic deposition of organic matter derived from forest growth. These soils are heterogeneous in nature and their character changes with parent rocks, ground-configuration and climate. Consequently, they differ greatly even if they occur in close proximity to one another. In the Himalayan region, such soils are mainly found in valley basins, depressions, and less steeply inclined slopes. Generally, it is the north facing slopes which support soil cover; the southern slopes being too precipitous and exposed to denudation to be covered with soil. Apart from the Himalayan region, the forest soils occur on Western and Eastern Ghats as well as in some parts of the Peninsular plateau.

The forest soils are very rich in *humus* but are deficient in potash, phosphorus and lime. Therefore, they require good deal of fertilizers for high yields. They are especially suitable for plantations of tea, coffee, spices and tropical fruits in Karnataka, Tamil Nadu and Kerala and wheat, maize, barley and temperate fruits in Jammu and Kashmir, Himachal Pradesh and Uttarakhand.

6. Arid and Desert Soils. A large part of the arid and semi-arid region in Rajasthan and adjoining areas of Punjab and Haryana lying between the Indus and the Aravalis, covering an area of 1.42 lakh sq km (or 4.32% of total area) and receiving less than 50 cm of annual rainfall, is affected by desert conditions. The Rann of Kachchh in Gujarat is an extension of this desert. This area is covered by a mantle of sand which inhibits soil growth. This sand has originated from the mechanical disintegration of the ground rocks or is blown from the Indus basin and the coast by the prevailing south-west monsoon winds. Barren sandy soils without clay factor are also common in coastal regions of Odisha, Tamil Nadu and Kerala. The desert soils consist of aeolian sand (90 to 95 per cent) and clay (5 to 10 per cent). Some of these soils contain high percentages of soluble salts, are alkaline with varying degree of calcium carbonate and are poor in organic matter. Over large parts, the calcium content increases downwards and in certain areas the subsoil has ten times calcium as compared to that of the top soil. The phosphate content of these soils is as high as in normal alluvial soils. Nitrogen is originally low but its deficiency is made up to some extent by the availability of nitrogen in the form of nitrates. Thus, the presence of phosphates and nitrates make them fertile soils wherever moisture is available. There is, therefore, great possibility of reclaiming these soils if proper irrigation facilities are available. The changes in the cropping pattern in the Indira Gandhi Canal Command Area is a living example of the utility of the desert soils. However, in large areas of desert soils, only the drought resistant and salt tolerant crops such as barley, rape, cotton, wheat, millets, maize and pulses are grown. Consequently, these soils support a low density of population.

7. Saline and Alkaline Soils. These soils are found in Andhra Pradesh, Telangana and Karnataka. In the drier parts of Bihar, Uttar Pradesh, Haryana, Punjab, Rajasthan and Maharashtra, there are salt-impregnated or alkaline soils occupying 68,000 sq km of area. These soils are liable to saline and alkaline efflorescences and are known by different names such as ***reh, kallar, usar, thur, rakar, karl*** and ***chopan.*** There are many undecomposed rock and mineral fragments which on weathering liberate sodium, magnesium and calcium salts and sulphurous acid. Some of the salts are transported in solution by the rivers, which percolate in the sub-soils of the plains. In canal irrigated areas and in areas of high sub-soil water table, the injurious salts are transferred from below to the top soil by the capillary action as a result of evaporation in dry season. The accumulation of these salts makes the soil infertile and renders it unfit for agriculture. It has been estimated that about 1.25 million hectares of land in Uttar Pradesh and 1.21 million hectares in Punjab has been affected by *usar.* In Gujarat, the area around the Gulf of Khambhat is affected by the sea tides carrying salt-laden deposits. Vast areas comprising the estuaries of the Narmada, the Tapi, the Mahi and the Sabarmati have thus become infertile.

8. Peaty and Marshy Soils. Peaty soils originate in humid regions as a result of accumulation of large amounts of organic matter in the soils. These soils contain considerable amount of soluble salts and 10-40 per cent of organic matter. Soils belonging to this group are found in Kottayam and Alappuzha districts of Kerala where it is called ***kari.*** Marshy soils with a high proportion of vegetable matter also occur in the coastal areas of Odisha and Tamil Nadu, Sunderbans of West Bengal, in Bihar and Almora district of Uttarakhand. The peaty soils are black, heavy and highly acidic. They are deficient in potash and phosphate. Most of the peaty soils are under water during the rainy season but as soon as the rains cease, they are put under paddy cultivation.

Characteristics of Indian Soils. Following are the chief characteristics of Indian soils :

1. The Indian soils have been formed under varied geographical conditions and differ widely in their physical properties, chemical composition and fertility level.
2. Most soils are old and mature. Soils of the peninsular plateau are much older than the soils of the great northern plain.
3. Indian soils are largely deficient in nitrogen, mineral salts, humus and other organic materials.
4. Plains and valleys have thick layers of soils while hilly and plateau areas depict thin soil cover.
5. Some soils like alluvial and black soils are fertile while some other soils such as laterite, desert and alkaline soils lack in fertility and do not yield good harvest.
6. Indian soils have been used for cultivation for hundreds of years and have lost much of their fertility. As such there is urgent need of giving scientific treatment to our soils.
7. Indian climate is characterised by seasonal rainfall and our soils need irrigation during the dry period.
8. Indian soils suffer from soil erosion and other allied problems.

PROBLEMS OF INDIAN SOILS

Indian soils suffer from a number of problems, some of them taking a serious turn. Some of the important problems faced by Indian soils are (*i*) soil erosion, (*ii*) deficiency in fertility, (*iii*) desertification, (*iv*) waterlogging (*v*) salinity and alkalinity (*vi*) wasteland, (*vii*) over exploitation of soils due to increase in population and rise in living standards and (*viii*) encroachment of agricultural land due to urban and transport development.

SOIL EROSION

Soil erosion is the removal of soil by the forces of nature, particularly wind and water, more rapidly than the various soil forming processes can replace it. Soil erosion is a serious menace which is adversely affecting our agricultural productivity and the economy of the country as a whole. Although the process of soil erosion is imperceptibly slow and it can scarcely be detected, the loss over periods of time is indeed very great.

TYPES OF SOIL EROSION

Two natural agents i.e., water and wind, are constantly at work causing soil erosion. Therefore, we can talk of two types of soil erosion *viz.,* water erosion and wind erosion.

Water Erosion. During heavy rains, water removes a lot of soil. Rain drops fall with an

approximate speed of 10 metres per second and wash away the top soil. The soils most readily detached by raindrop splash erosion are sands and silt. Coarser particles are not shifted about as much because of their greater volume and weight. Run off water is responsible for much soil erosion, moving the soil

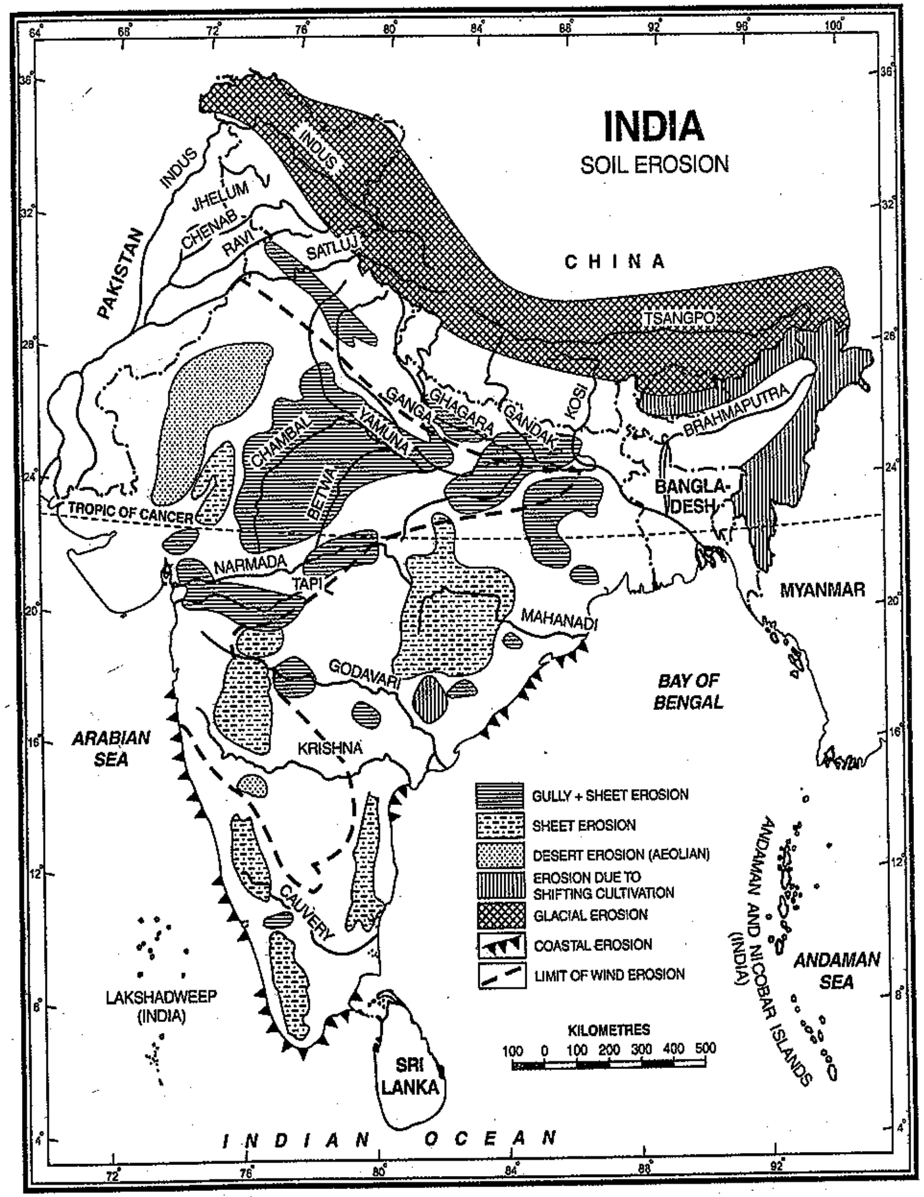

FIG. 7.2. India : Soil Erosion

particles by *surface creep*, *saltation* and *suspension*. Water erosion consisting of *rilling*, *gullying*, *sheet-wash and rain peeling process* is mainly confined to the mountains, hills and upper slopes of the piedmont zone. If erosion continues unchecked for a sufficient time, numerous finger-shaped grooves may develop all over the area due to silt laden run off. The whole pattern resembles that of the twigs, branches and trunk of a tree. This is called ***rill erosion***. With further erosion of the soil, the rills may deepen and become enlarged and are ultimately turned into **gullies**. The cutting of soil goes to immense size and volume and the entire area may be turned into **badland topography**. When a gully bed cuts into the soil with an immediate drop of 3 to 4 metres and gradually flattens out, a **ravine** is formed. The depth of a ravine may extend to 30 metres or even more. When the entire top sheet of soil is carried away by water or by wind, leaving behind barren rock, it is called ***sheet erosion***. Sheet erosion is no less harmful than gully erosion. This type of erosion is more prominent on relatively steeper slopes, receiving heavy rainfall. Sheet erosion is particularly harmful because it attacks the top soil relatively early and renders the land almost unfit for cultivation. If one cubic metre of soil be lost from one hectare of land each week for a period of 30 years, the loss would amount to 15 cm from the entire surface.

It is not the total annual rainfall that is important, but rather how and when it comes. A single heavy downpour continuing for a few hours may result in severe soil erosion, while the same amount of rainfall fairly distributed over a longer period may cause little erosion or even may be useful for protecting soil. The slope of the land is a potent factor in determining the velocity of water and the consequent soil erosion. Other things being equal, the steeper the slope the more rapidly does water run down resulting in more soil erosion. Theoretically, *if the rate of flow is doubled, the scouring capacity is increased four times, the carrying capacity thirty two times and the size of the particles carried sixty four times*.

In the coastal areas, tidal waves dash along the coast and cause heavy damage to soil. This is called ***sea erosion***. In the higher reaches of the Himalayan region, soil erosion on a large scale is caused by glaciers. This is called ***glacial erosion*** (**Fig. 7.2**).

Wind Erosion. In arid and semi arid lands with little rainfall, the wind acts as a powerful agent of soil erosion causing heavy loss to agricultural land. Winds blowing at considerable speed, remove the fertile, arable, loose soils leaving behind a depression devoid of top soil. Wind erosion is accentuated when the soil is dry, weakly aggregated, devoid of vegetation cover along with over grazing and the winds are strong. Even modest wind velocities can keep individual particles of humus, clay and silt in suspension. Very fine, fine and medium sands are moved by wind in a succession of bounds and leaps, known as ***saltation***. Coarse sand is not usually airborne but rather is rolled along the soil surface. This type of erosion is called ***surface creep***. Very coarse sand (1.0-2.0 mm in diameter), gravels, peds and clods are too large to be rolled by wind, so wind-eroded soils have surfaces covered with coarse fragments larger than 1.00 mm in diameter. This kind of arid soil surface is known as ***desert pavement***.

HUMAN FACTORS OF SOIL EROSION

Soil erosion is the result of a number of factors, working in isolation or in association with one another. Apart from the natural factors such as torrential rainfall, resulting in swift flow of water, strong winds in dry areas, nature of soil and the physiography, man is an important factor responsible for soil erosion. Man's ill judged activities such as deforestation, overgrazing and faulty methods of agriculture have made soil erosion a serious national problem. Besides diversion of natural drainage courses, wrong orientation of roads and railways, embankments and bridges have also led to soil erosion. Thus it is rightly said that soil erosion is essentially a problem created by man and also faced by man himself.

1. Deforestation. With the increase in population, the pressure on forest resources is increasing with each passing day. This has resulted in reckless cutting of forests which has led to the problem of soil erosion. Roots of trees and plants bind the soil particles and regulate the flow of water, thus saving soil from erosion. Therefore, deforestation invariably results in floods and soil erosion. The large scale damage to soil in Shiwalik range, the *Chos* of Punjab, parts of Haryana and the *ravines* of Madhya Pradesh, Uttar Pradesh and Rajasthan is largely due to deforestation.

2. Overgrazing. Forests and grasslands provide much needed fodder for animals. During the rainy season, there is plenty of growth and animals get enough fodder. But during the long dry period, there is shortage of fodder and the grass is grazed to the ground and torn out by the roots by animals. This leads to loose structure of the soil and the soil is easily washed away by rains. Moreover, soil is pulverised by the hoofs and teeth of animals, especially by sheep and goats and thus proves detrimental to top soil when heavy showers fall on it. Soil erosion due to overgrazing is a common site in the hilly areas of Himachal Pradesh, Uttarakhand, Jammu and Kashmir and in the dry areas of Rajasthan, Madhya Pradesh, Maharashtra, Karnataka and Andhra Pradesh.

3. Faulty Methods of Agriculture. Much of the soil erosion in India is caused by faulty methods of agriculture. The most outstanding are wrong ploughing, lack of crop rotation and practice of shifting cultivation. If the fields are ploughed along the slope, there is no obstruction to the flow of water and the water washes away the top soil easily. In some parts of the country, the same crop is grown year after year which spoils the chemical balance of the soil. This soil is exhausted and is easily eroded by wind or water.

Another outstanding example of faulty method of agriculture is the *shifting cultivation* practised in some areas in the north-eastern states of Arunachal Pradesh, Assam, Meghalaya, Manipur, Tripura, Mizoram as well as in Odisha. It is sporadically practised in Telangana, Andhra Pradesh, Madhya Pradesh, Chhattisgarh, Maharashtra, Kerala, Karnataka and Tamil Nadu. In this method, a piece of forest land is cleared by felling and burning of trees and crops are grown. The removal of the forest cover leads to the exposure of the soil to rains and sun which results in heavy loss of top soil, especially on the hill slopes. Thus the soil becomes unfit for cultivation and the tribes move to another piece of land after 2-3 years, returning to the earlier one after a gap of 10-15 years. In this way, the whole of the forest area is adversely affected by shifting cultivation resulting in intensive soil erosion in vast areas.

EXTENT OF SOIL EROSION IN INDIA

It has been estimated that an area of over 80 million hectares or about one-fourth of our total area is exposed to wind and water erosion out of which 40 million hectares of land has undergone serious erosion. Ironically the extent of soil erosion is increasing inspite of our efforts to check soil erosion. Experts have estimated that about 40,000 hectares of our land is permanently lost to cultivation and much larger area is rendered less productive every year due to wind and water erosion. About 21 million hectares are subject to severe wind erosion in Rajasthan and adjoining areas of Punjab, Haryana, and Gujarat (**Fig. 7.2**).

Wind erosion is a serious problem in arid and semi-arid parts of north west India. About 45 million hectares of land is subject to severe wind erosion in Rajasthan and adjoining areas of Punjab, Haryana, Gujarat and Western Uttar Pradesh (**Fig. 7.2**). It is estimated that 34 lakh tonnes of fertile soils is removed by wind every year in the districts of Jodhpur, Bikaner, Kota, Jaipur, Bharatpur, Kishangarh etc. in Rajasthan. These areas receive scanty rainfall. They are devoid of vegetation cover and have sandy soil. As such these areas are exposed to wind erosion. Faulty farming practices, failure to conserve moisture, lack of managing and over grazing make the problem of wind erosion more complicated. According to the latest estimates about 8 million tonnes of soil has been removed from every square kilometre area in desert during the last hundred years.

TABLE 7.1. Area Under Ravines in India (lakh hectares)

State	Area
Uttar Pradesh	12.30
Madhya Pradesh	6.83
Rajasthan	4.52
Gujarat	4.00
Punjab	1.20
West Bengal	1.04
Bihar	0.60
Tamil Nadu	0.60
Maharashtra	0.20

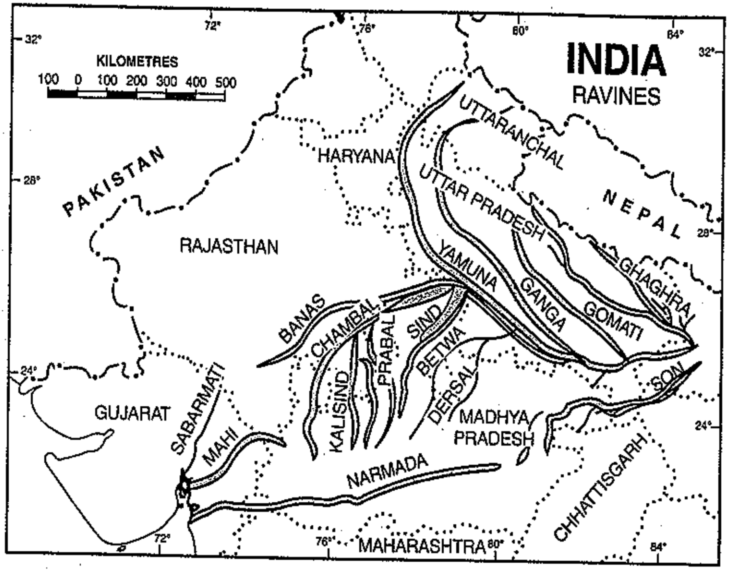

FIG. 7.3. India : Ravines

Water erosion is more active in wet areas receiving more rainfall. Steep slope, swift flow of rivers and scarce vegetation cover lead to water erosion. According to estimates by the Indian Council of Agricultural Research (ICAR), the loss due to water erosion is 53.34 million hectares annually. A working group set up by the Ministry of Home Affairs in 1971 estimated that there are 39.75 lakh hectare ravines spread in 18 states, out of which 27.65 lakh hectares (or 69.55 per cent) are in the states of Uttar Pradesh, Madhya Pradesh, Rajasthan and Gujarat (**Table 7.1**). The aerial survey carried out for Chambal Development Scheme has shown that the area covered by ravines upto 4.5-6.0 metre depth is about 50,600 hectares. In Madhya Pradesh about 4 to 8 lakh hectares are affected by deep gullies and ravines along the banks of rivers Chambal and Kali Sindh. Out of this about 2.4 lakh hectares are in the districts of Gwalior, Morena and Bhind. In Uttar Pradesh the ravines are mostly along the banks of the Chambal, the Yamuna, the Gomati, Son and their tributaries (**Fig. 7.3**). Agra, Etawah and Jalaun are the worst affected districts. According to another estimate the Chambal-Yamuna badlands covering a total area of about 32 lakh hectares are the result of 1000 years of soil erosion wherein 0.25 tonnes of soil is being removed every day.

In Timil Nadu, ravines are common in South Arcot, North Arcot, Kanniyakumari, Tiruchchirapalli, Chingleput, Salem and Coimbatore districts. In West Bengal numerous gullies and ravines exist in the upper catchment areas of the Kangsabati river in Purulia district. In Bihar, river courses of the Ganga, the Gandak, the Kosi and the Son are affected by ravines.

The flood plains of the Ganga and its tributaries in Uttar Pradesh and Bihar also suffer from the problem of soil erosion caused by water. These rivers are carving deep furrows and removing fertile top soil. According to one estimate the Ganga river is transporting about 30 million tonnes of eroded material per year from the Ganga plain to the Bay of Bengal. Similarly the Brahmaputra is transporting about 10 million tonnes annually from the Brahmaputra valley to the Bay of Bengal.

The Shiwalik range has also been badly affected by gully erosion. Rivers descending from the Shiwalik hills and flowing into Punjab are locally

called ***Chos***. Erosion by ***chos*** is most marked in Hoshiarpur district of Punjab. In the 130 km of the Shiwalik, nearly a hundred streams debouch onto the plains.

The loss of soil due to *shifting agriculture* is no less pronounced. It has been estimated that more than 15 lakh hectares of forest land is cleared for shifting agriculture every year. The total area affected by shifting cultivation is estimated to be 45 lakh hectares. Some portion of this land is permanently lost to agriculture. Shifting agriculture has caused maximum soil erosion in tribal areas of Assam, Meghalaya, Tripura, Nagaland, Mizoram, Kerala, Andhra Pradesh, Odisha, Madhya Pradesh, Chhattisgarh etc. It is reported that about 207,287 hectares in Assam, 41,963 hectares in Tripura and 21,862 hectares in Manipur are under shifting cultivation. In Odisha about 33,08,502 hectares of land are subjected to shifting cultivation.

In Tamil Nadu the bad effects of misuse of land are illustrated in the Nilgiri Hills where potato is one of the main crops. Here potato cultivation is done on steep slopes, sometimes exceeding 60 per cent. This has led to intense erosion of soil and the yields of potato have gone down by about 50 per cent in spite of heavy application of fertilisers. Land steeper than 1 in 4 should not be open for cultivation but put under grasses and trees.

Coastal erosion is another form of erosion caused by constant pounding of tidal waves and currents on the sea coast. Waves and currents strike the coast with great force and break the hanging cliff rocks. The broken material is carried away by the retreating waves. Coastal erosion is quite pronounced in the season of monsoon winds and during storms and cyclones. Several coastal areas in Gujarat, Maharasthra, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh and Odisha have suffered heavily at the hands of sea erosion. Of the 560 km long coast of Kerala, about 32 km stretch consisting of sandy beaches is subject to severe sea erosion. Erosion of beaches along the Kerala coast is evidenced by uprooting of coconut trees.

Effects of Soil Erosion. The adverse effects of soil erosion are reflected in the following points :

1. Top soil is eroded which leads to loss of soil fertility and fall in agricultural productivity.
2. Flooding and leaching result in loss of mineral nutrients.
3. Ground water level is lowered and there is decrease in soil moisture.
4. Natural vegetation cover dries up and arid lands expand.
5. Frequency and intensity of floods and drought increases.
6. Rivers, canals and tanks are silted and their water holding capacity decreases.
7. The incidence and damaging power of landslides increases.
8. Economy as whole suffers a great setback.

Soil Salinity and Soil Alkalinity. Soil salinity and soil alkalinity are the results of over irrigation in canal irrigated areas. In canal irrigated areas plenty of the water is available and the farmers indulge in over irrigation of their fields. Under such conditions, the ground water level rises and saline and alkaline efflorescences consisting of salts of sodium, calcium and magnesium appear on the surface as a layer of white salt through capillary action. *Salinity* means the predominance of chlorides and sulphates of sodium, calcium and magnesium in the soils in sufficient quantity to be able to seriously interfere with the growth of most plants. *Alkalinity* implies the dominance of sodium salts, specially sodium carbonate. Although salts of alkali are somewhat different in their chemical properties from the salts of saline soils both soils occur in the same areas. Increasing salinity and alkalinity always indicate extension of waterlogging salt encrustation (saline efflorescence) or ***thur*** tendencies. Sandy soils are more prone to alkalinity and the loamy soils to salinity-alkalinity. Salinity and alkalinity have adverse effect on soil and reduce soil fertility. It is estimated that about 80 lakh hectares of land (2.43% of the country's total area) is affected by the problem of salinity and alkalinity. Vast tracts of canal irrigated areas in Uttar Pradesh, Punjab and Haryana; arid regions of Rajasthan, semi-arid areas of Maharashtra, Gujarat, Andhra Pradesh, Telangana and Karnataka and coastal areas of Odisha, Gujarat and West Bengal are facing this problem (**Table 7.2**). The western part of Uttar Pradesh is one of the worst sufferers at the hands of salinity and alkalinity. In some parts of Uttar

TABLE 7.2. Salinity Affected Areas in India

States/Union territories	Area (lakh hectares)
1. Uttar Pradesh	12.95
2. Punjab	12.25
3. Gujarat	12.14
4. West Bengal	8.50
5. Rajasthan	7.28
6. Maharashtra	5.34
7. Haryana	5.26
8. Karnataka	4.04
9. Odisha	4.04
10. Madhya Pradesh	2.24
11. Andra Pradesh and Telangana	0.42
12. Delhi	0.11
13. Bihar	0.04
14. Tamil Nadu	0.04

Pradesh the internal drainage is greatly restricted and the soils are charaterised by alkalinity. Some of the most fertile soils in Punjab and Haryana have been rendered useless by salinity and alkalinity. In Punjab about 6,000 to 8,000 hectares of good land is becoming barren every year due to salinisation. Although Indira Gandhi canal in Rajasthan has turned the sandy desert into a granary, it has given birth to serious problems of salinity and alkalinity. Alkali soils are met with almost all over the state of Maharashtra. In Gujarat, the area around the Gulf of Khambhat is affected by sea tides carrying silt-laden deposits. Nearly 173,530 sq km comprising estuaries of the Narmada, the Tapi, the Mahi and the Sabarmati have been damaged in this way. Portions of Dharwar districts and of Bijapur taluk are affected by what is locally known a ***karl*** soils which are saline, alkali and fairly deep and clayey. Salt lands of the Nira valley have developed due to excessive irrigation on deep black soils of the locality.

Effects of salinity and alkalinity

Soil salinity and alkalinity has many adverse effects, some important effects are as under :

(*a*) Soil fertility is reduced which results in crop failure. Cultivation is not possible on saline soils unless they are flushed out with large quantities of irrigation water to leach out the salts.

(*b*) Choice of crops is limited because some crops are sensitive to salinity and alkalinity. Only high salt tolerant crops such as cotton, rape, barley etc. and medium salt tolerant crops like wheat, rice, linseed, pulses, millets etc. can be grown.

(*c*) Quality of fodder becomes poor.

(*d*) Salinity and alkalinity create difficulties in building and road construction.

(*e*) These cause floods due to reduced infiltration, leading to crop damage in the adjoining areas.

Steps to treat salinity and alkalinity

Following steps are necessary to treat salinity and alkalinity and restore the fertility of soil.

1. Providing outlets for water to drain out excess water and lower water table. Efforts should also be made to seal all points and strips of the leakage from canals, tanks and ponds by lining them.
2. Minimising the use of water. Making judicious use of irrigation facilities.

TABLE 7.3. Area under Arid and Semi-arid conditions in India (as per cent to the total geographical area)

States	Arid	Semi-arid
Rajasthan	57.42	36.67
Gujarat	33.72	47.50
Haryana	29.32	59.77
Punjab	24.60	75.40
Maharashtra	0.42	61.17
Andhra Pradesh and Telangana	7.18	44.66
Karnataka	4.27	72.60
Jammu & Kashmir	31.13	6.22
Uttar Pradesh	—	21.73
Madhya Pradesh	—	13.38
Tamil Nadu	—	15.54
Total average	12.13	29.13

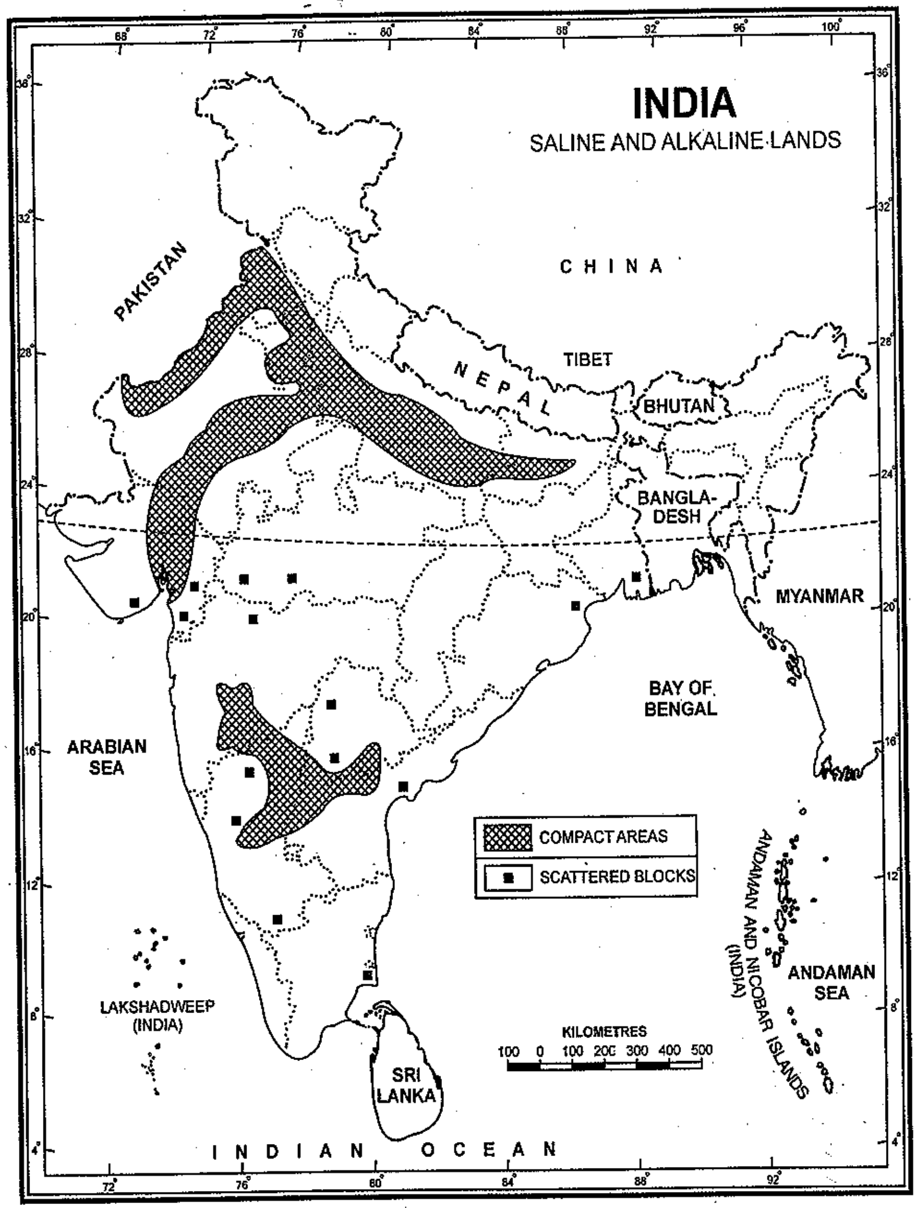

FIG. 7.4. India : Saline and Alkaline Lands

3. Planting salt tolerant vegetation and crops such as cotton, rape, barley, date palm, linseed etc. and certain grasses as fodder crops can be helpful.
4. It has been found that crop rotation involving ***dhaincha*** (green fodder)—cotton in the Deccan plateau, ***dhaincha***—rice in the Uttar Pradesh and ***dhaincha***—rice-barseem

in Punjab and Haryana have been very helpful.

5. Liberal application of gypsum in upper 15 cm thick soil to convert the alkalies into soluble compounds. Alkali can be removed by adding sulphuric acid or acid forming substances like sulphur and pyrite. Also organic residues such as rice husks and rice straw can be added to promote formation of mild acid as a result of their decomposition.
6. Flushing the salt by flooding the fields with excess water. However, this practice can lead to accumulation of saline water in the downstream area.

Desertification. Desertification can be defined as spread of desert like conditions in arid or semi-arid areas due to man's influence or climatic change. A large part of the arid and semi-arid region belonging to Rajasthan and south Punjab and Haryana and lying between the Indus and the Aravali range is affected by desert conditions. This area is characterised by scanty rainfall, sparse vegetation cover and acute scarcity of water. The Rajasthan desert is partly natural but largely man made and the fear is often expressed, quite rightly too, that the desert is spreading and that conditions within the desert are deteriorating. Desert soils suffer maximum erosion by wind. The sand carried by wind is deposited on the adjoining fertile lands whose fertility dwindles and sometimes the fertile land merges with the advancing desert. It has been estimated that the Thar Desert is advancing at an alarming rate of about 0.5 km per year. Currently about 12.13 per cent of India's total area is classed as arid and about 30 per cent area is termed as semi-arid. The highest concentration of arid land is found in Rajasthan where more than half of the total area is arid. Gujarat has about one-third of its total area as arid land. Jammu and Kashmir has cold deserts in Leh and Ladakh where the annual rainfall hardly exceeds 20 cm. Punjab and Haryana have about one-fourth of the total land characterised by arid conditions. Semi arid conditions prevail in large parts of Rajasthan, Gujarat, Punjab, Haryana, Maharashtra, Telangana, Andhra Pradesh, Karnataka, Jammu and Kashmir, Uttar Pradesh, Tamil Nadu and Madhya Pradesh (**Table 7.3**). Semi-arid conditions in north-western parts of India and in the states of Rajasthan, Punjab, Haryana etc. are created by their long distances from the sea while such conditions in the southern states like Karnataka, Telangana Andhra Pradesh, Tamil Nadu, Maharashtra etc. are caused by the presence of the Western Ghats. These states are located in the rain shadow area of the Western Ghats.

The process of desertification is attributed to various causes of which more important are uncontrolled grazing, reckless felling of trees and growing population. Climate change have also contributed to the spread of deserts.

Desertification has several ecological implications. Some important implications are listed below.

(*i*) Drifting of sand and its accumulation on fertile agricultural land.
(*ii*) Excessive soil erosion by wind and to some extent by water.
(*iii*) Deposition of sand in rivers, lakes and other water bodies thereby decreasing their water containing capacity.
(*iv*) Lowering of water table leading to acute water shortage.
(*v*) Increase in area under wastelands.
(*vi*) Decrease in agricultural production.
(*vii*) Increase in frequency and intensity of droughts.

Measures of Controlling Desertification

(*i*) Intensive tree plantation programme should be initiated.
(*ii*) Shifting sand dunes in Bikaner, Barmer, Churu, Jaisalmer and Jhunjhunun districts of Rajasthan cover an approximate area of 74 thousand sq km. Central Arid Zone Research Institute, Jodhpur has suggested mulching them with different plant species. Mulches are put in small squares and serve as an effective physical barrier to the moving sand.
(*iii*) Grazing should be controlled and new pastures should be developed.
(*iv*) Indiscriminate felling of trees should be banned.
(*v*) Alternative sources of fuel can reduce the demand for fuelwood and save the trees from destruction hence checking the onward march of the desert.

(*vi*) Sandy and wastelands should be put to proper use by judicious planning.

Waterlogging. The flat or nearly level surfaces and saucer-like depressions make the movement of surface water sluggish leading to accumulation of rain water which in turn results in waterlogging and flooding of the soil. Waterlogged soils are soaked or saturated with water. Moreover seepage from unlined channels or canal systems also leads to waterlogging in the contiguous arable lands. It has been estimated that extent of waterlogged soils is about 12 million hectares in India; half of which lies along its coast and the other half in the inland area under existing or newly created irrigation command areas (**Fig. 7.5**).

Waterlogging is believed to be one of the chief causes of salinity. The problem of land reclamation under waterlogging conditions is a complex one and must therefore, be tackled with great care as the scheme involves huge expenditure. Proper layout of drainage schemes is the only way to overcome the menace of waterlogging. The basic methods of removing excess water from waterlogged soils are (*a*) surface drainage and (*b*) vertical drainage.

(a) Surface Drainage. Surface drainage involves the disposal of excess water over ground surface through an open drainage system with an adequate outlet. Surface drainage is helpful where (*i*) soils are deep with low infiltration rates, where (*ii*) intensity of rainfall is high, where (*iii*) terrain is level to nearly level and where (*iv*) the water table is high.

(b) Vertical Drainage. Any bore or well from which the underlying water is extracted is defined as vertical drainage. The success of vertical drainage depends upon the presence of favourable aquifer and water table for lifting the ground water on sustainable basis and the favourable quantity of water that could be re-utilised for irrigation purposes. Such conditions prevail in the Indo-Gangetic plain. In the Punjab-Haryana plain the water-table has been successfully lowered through tubewell pumping. As a consequence waterlogged saline lands could be reclaimed.

SOIL CONSERVATION

Soil conservation includes all those measures which help in protecting the soil from erosion and exhaustion. Soil erosion has been continuing over such a large part of India for such a long time that it has assumed alarming proportions. According to Prof. **S.P. Chatterjee**, "*Soil erosion is the greatest single evil to Indian agriculture and animal husbandry*". Soil is our most precious asset and no other gift of nature is so essential to human life as soil. Productive soil alone ensures prosperous agriculture, industrial development, economic betterment and a higher standard of living. A healthy agriculture is bound up with healthy soil. While emphasising the significance of conservation, **G.T. Renner** has said that conservation is defined as "the greatest good to the largest number for the longest time." According to **S.I. Kayastha**, "*With soil conservation people rise and with its destruction they fall.*" It has been estimated that about two thirds of our arable land needs conservation measures. There is, therefore, an urgent need to conserve soil for the sake of prosperity of our masses. Unfortunately, it has not attracted the attention that it deserves. Our peasantry is not fully aware of many benefits of soil conservation and *neglect of soil is like killing the hen that lays the golden eggs*. Following methods are normally adopted for conserving soil :

1. Afforestation. The best way to conserve soil is to increase area under forests. Indiscriminate felling of trees should be stopped and efforts should be made to plant trees in new areas. A minimum area of forest land for the whole country that is considered healthy for soil and water conservation is between 20 to 25 per cent but it was raised to 33 per cent in the second five year plan; the proportion being 20 per cent for the plains and 60 per cent for hilly and mountainous regions.

2. Checking Overgrazing. Overgrazing of forests and grass lands by animals, especially by goats and sheep, should be properly checked. Separate grazing grounds should be earmarked and fodder crops should be grown in larger quantities. Animals freely move about in the fields for grazing and spoil the soil by their hoofs which leads to soil erosion. This should be avoided.

3. Constructing Dams. Much of the soil erosion by river floods can be avoided by constructing dams across the rivers. This checks the speed of water and saves soil from erosion.

4. Changing Agricultural Practices. We can save lot of our valuable soil by bringing about certain

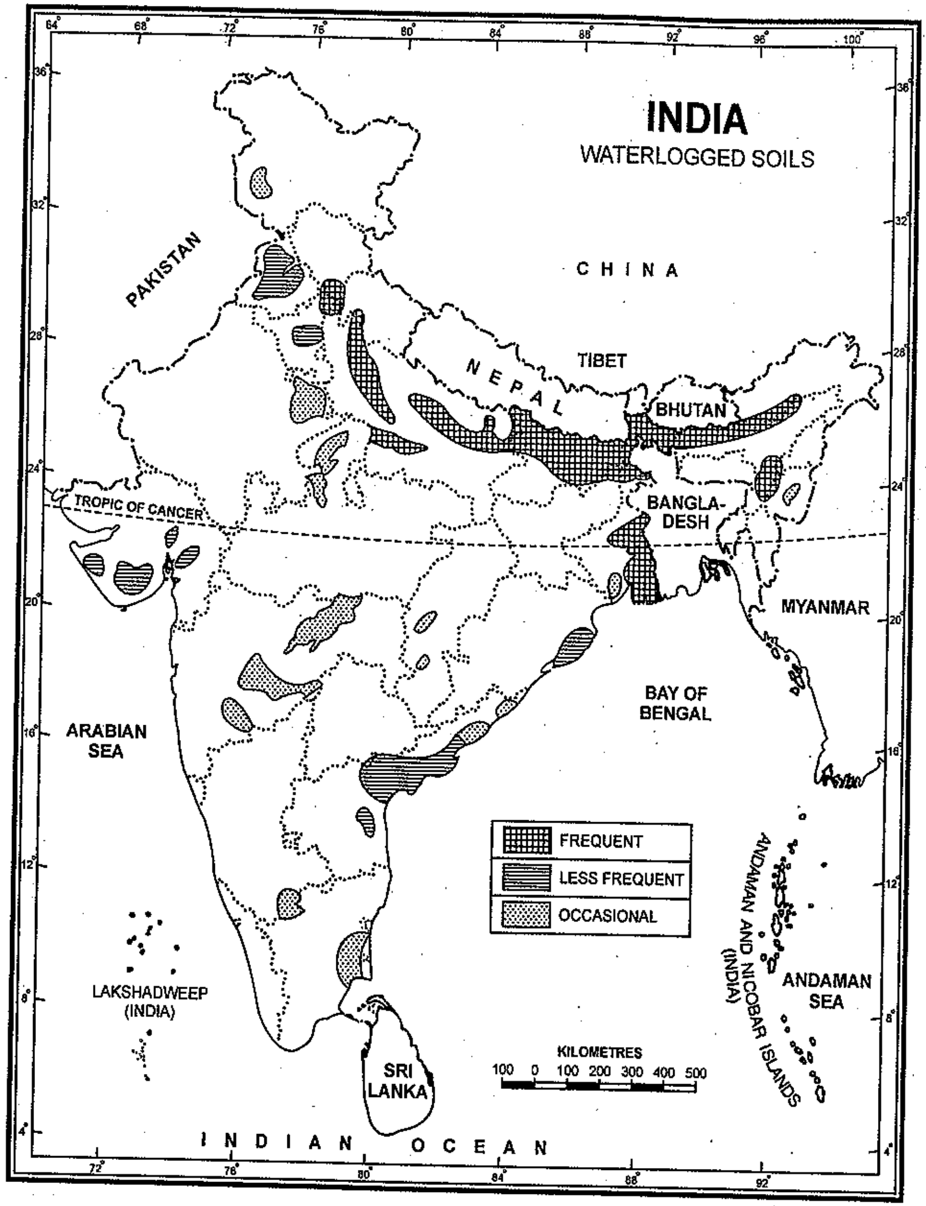

FIG. 7.5. India : Waterlogged Soils

changes in our agricultural practices. Some of the outstanding changes suggested in this context are as under :

*(i) **Crop Rotation.*** In many parts of India, a particular crop is sown in the same field year after year. This practice takes away certain elements from the soil, making it infertile and exhausted rendering it unsuitable for that crop. *Rotation of crops is the system in which a different crop is cultivated on a piece of land each year.* This helps to conserve soil fertility as different crops make different demands on the soil. For example, potatoes require much potash but wheat requires nitrate. Thus it is best to alternate crops in the field. Legumes such as peas, beans, clover, vetch and many other plants, add nitrates to the soil by converting free nitrogen in the air into nitrogenous nodules on their roots. Thus if they are included in the crop rotation nitrogenous fertilisers can be dispensed with. By rotating different types of crops in successive years, soil fertility can be naturally maintained. For example, wheat may be cultivated in the first year, barley in the second and legumes in the third. The cycle may then be repeated. Further, there are some crops such as maize, cotton, tobacco and potato which can be classed as erosion inducing, whilst some other crops such as grass, forage crops and many legumes are erosion resisting. Small grain crops like wheat, barley, oats and rice are between these two extremes.

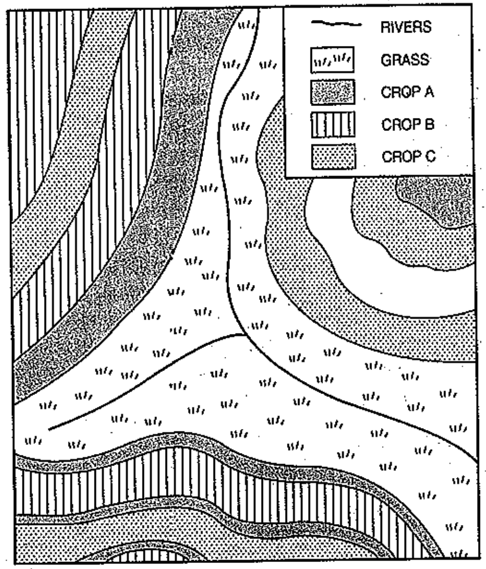

FIG. 7.6. Strip farming following the contour pattern

*(ii) **Strip Cropping.*** Crops may be cultivated in alternate strips, parallel to one another. Some strips may be allowed to lie fallow while in others different crops may be sown *e.g.*, grains, legumes, small tree crops, grass etc. Various crops ripen at different times of the year and are harvested at intervals. This ensures that at no time of the year the entire area is left bare or exposed. The tall growing crops act as wind breaks and the strips which are often parallel to the contours help in increasing water absorption by the soil by slowing down run off (**Fig. 7.6**).

*(iii) **Use of Early Maturing Varieties.*** Early maturing varieties of crops take less time to mature and thus put lesser pressure on the soil. In this way it can help in reducing the soil erosion.

*(iv) **Contour Ploughing.*** If ploughing is done at right angles to the hill slope, following the natural contours of the hill, the ridges and furrows break the flow of water down the hill. This prevents excessive soil loss as gullies are less likely to develop and also reduce run-off so that plants receive more water. Thus by growing crops in contour pattern, plants can absorb much of the rain water and erosion is minimised. When viewed from above, the field looks like a contour map (**Fig. 7.7**).

FIG. 7.7. Contour Ploughing

*(v) **Terracing and Contour Bunding.*** Terracing and contour bunding across the hill slopes is a very effective and one of the oldest methods of soil conservation. Hill slope is cut into a number of terraces having horizontal top and steep slopes on the back and front. Contour bunding involves the construction of banks along the contours. Terracing and contour bunding which divide the hill slope into numerous small slopes, check the flow of water,

promote absorption of water by soil and save soil from erosion. Retaining walls of terraces control the flow of water and help in reducing soil erosion. Sometimes tree crops such as rubber are also planted to combat soil erosion (**Fig. 7.8**). But there is a limit to which bunding is an effective measure of soil conservation. When the slope is steeper than 8 per cent or 1 in 12, bunding becomes expensive and less effective. Nothing over 20 per cent or 1 in 5 should be terraced. Fields of a slope steeper than 15 per cent or 1 in 6 should be withdrawn from ploughing as they are not usually worth the labour of making benches very close together.

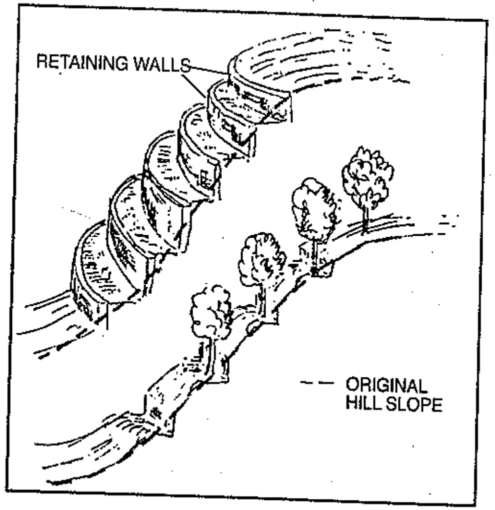

FIG. 7.8. Two ways of terracing steep hill slopes to prevent soil erosion and to produce flat-land conditions artificially.

(*vi*) Checking Shifting Cultivation. Checking and reducing shifting cultivation by persuading the tribal people to switch over to settled agriculture is a very effective method of soil conservation. This can be done by making arrangements for their resettlement which involves the provision of residential accommodation, agricultural implements, seeds, manures, cattle and reclaimed land.

(*vii*) Ploughing the Land in Right Direction. Ploughing the land in a direction pependicular to wind direction also reduces wind velocity and protects the top soil from erosion.

ACHIEVEMENTS IN SOIL CONSERVATION

Soil and water conservation measures have been adopted as one of the essential inputs for increasing agricultural output in the country right from the beginning of the First Five Year Plan. Appreciating the value of soil and the seriousness of the problem of soil erosion, the Central Government as well State Governments have taken a number of steps to conserve soil. The soil and water conservation division set up by Central Government in the Department of Agriculture and Cooperation aims at providing an overall perspective of problems like water and wind erosion, degradation through waterlogging, salinity, ravines, torrents, shifting cultivation and coastal sands.

Another scheme was sponsored by the Central Government in the Third Plan which aimed at preventing premature siltation of multi-purpose reservoirs. Scheme of Flood-Prone Rivers (FPR) was started in the Sixth Five Year Plan. Both the schemes were clubbed together during the Ninth Five Year Plan. Under the programme for the catchment management of River Valley Projects and Flood Prone Rivers, 53 catchments are covered, spread over 27 states. The total catchment area is 96.14 million hectares with Priority Area needing urgent treatment in 26 million hectares. Out of this 5.86 million hectares have been treated till 2003-04.

The *trio* of salinity-alkalinity-acidity leads to deficiency in chemical-biological nutrients and their problem has been acquiring increasing importance. Reclamation of saline and alkaline soils is a difficult task. Removal of the top soil, providing proper drainage to the waterlogged areas, avoiding seepage of water from canals, installing tube-wells in canal irrigated areas, and afforestation are some of the measures which can check the growth of unwanted salts in these soils. Application of farmyard manures, green manures, and addition of gypsum, lime, and sulphur can add to the fertility of these soils. Cultivation of salt-resistant crops like rice, barseem, barley, jowar and sugarcane has been suggested in such soils. A centrally sponsored scheme for reclamation of alkaline (usar) soils initiated in the seventh Five Year Plan is continuing in Haryana, Punjab and Uttar Pradesh. The scheme was extended

to Gujarat, Madhya Pradesh and Rajasthan during the Eighth Five Year Plan. During Ninth Plan extension of the scheme to all other states was approved where alkali soil problems exist as per scientific parameters. The scheme aims at improving physical conditions and productivity status of alkali soils for restoring optimum crop production. An area of 0.62 million hectares out of 3.5 million hectares of alkali land has been reclaimed till the end of 2003-04.

Land reclamation in the ravines spreading over 27.65 lakh hectares in Madhya Pradesh, Rajasthan, Uttar Pradesh and Gujarat is a challenging job. A ravine reclamation programme was launched in 1987-88 which was transferred to state sector in 1991-92 as per decision of the National Development Council. Major components of the ravine reclamation programme are peripheral bunding to halt any ingress of ravines, table land treatment in vicinity of upstream of the peripheral bund, afforestation, irrigation of shallow ravines and rehabilitation. About 1.266 lakh hectares of land has been treated so far.

Contour bunding and levelling have been very effective in checking soil erosion and in increasing crop yields. In Maharashtra, Karnataka, Telangana, Andhra Pradesh, Gujarat and Punjab, an increase of 25 per cent in the crop yields has been recorded as a result of contour bunding. This has also increased the water recharging capacity of wells in the adjoining areas. According to the reports of National Commission on Agriculture, the 'Kharif' and 'Rabi' crops raised in semi-arid alluvial plains of Uttar Pradesh have recorded yield increases of 35 per cent due to bunding and 60 per cent due to levelling. By bench terracing in the Kunda catchement in Nilgiris (Tamil Nadu) potato yields have gone up by 15-65 per cent.

A scheme for controlling shifting agriculture was implemented in Arunachal Pradesh and Mizoram in 1986-87. A larger scheme was launched in 1987-88 to cover nine states of Arunachal Pradesh, Assam, Meghalaya, Manipur, Tripura, Nagaland, Mizoram, Odisha and Andhra Pradesh. Till 1990-91, 26,532 families were selected for rehabilitation. The scheme involves different activities such as land development, irrigation, agriculture, horticulture, cottage industries, fisheries, social and fuel-wood forestry and minimum housing programmes. During Eighth Plan 67 thousand hectare area was treated through treatment packages. During Ninth Plan upto March 2002, 1.5 lakh hectares had been treated. The new guidelines for the scheme on the basis of new watershed to common approach has been effective from November 2000. During Tenth Plan, an area of 0.4 lakh hectares has been treated upto 2003-04.

All India Soil and Land Survey Organisation is using remote sensing technology to keep itself abreast of the latest trends.

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CHAPTER 8

Natural Hazards and Disasters

Man has been facing natural hazards and disasters since the dawn of civilisation. The earth has been undergoing various changes; both slow and catastrophic from the very beginning. It is worth understanding some of the basic terms before we make a detailed study of the natural hazards and disasters and their effects on human beings.

HAZARDS

Changes that affect humans adversely are called *hazards*. A hazard comprises a dangerous condition or event, natural or manmade, that could cause injury, loss of life or damage to property, livelihood or environment. In other words, hazards are defined as ***"phenomena that pose a threat to people, structures or economic assets and which may cause a disaster. They could be either manmade or naturally occurring in our environment."*** (Disaster Preparedness Training Manual, Philippine National Red Cross 1954). A *natural disaster* pertains to a natural phenomenon which occurs in proximity and poses a threat to people, structures and economic assets caused by biological, geological, seismic, hydrological or meteorological conditions or processes in the natural environment.

TYPES OF HAZARDS

The list of hazards is very long and hazards can be classified in a number of ways. Generally hazards are classified depending upon their causes, mitigation strategies or their effects on societies. We shall confine ourselves to classification of disasters depending upon their causes only.

Types of Hazards depending upon their causes

Hazards could be caused by nature or man and are consequently called natural and manmade. A third type of hazards are caused both by nature and man are called ***socio-natural hazards***.

1. Natural Hazards. These are caused by the forces of nature and man has no role to play in such hazards. Following are the main examples of natural hazards :

- Earthquakes
- Volcanic eruptions
- Cyclonic storms
- Tsunamis
- Floods
- Droughts
- Landslides

2. Man-made Hazards. These are caused by undesirable activities of man. Such hazards include :

- Explosions
- Leakage of toxic waste
- Pollution of air, water and land
- Dam failures
- War and Civil Strife
- Terrorism

3. Socio-natural Hazards. These are caused by the combined effect of natural forces and misdeeds of man. For example, the frequency and intensity of floods and droughts may increase due to indiscriminate felling of trees, particularly in the catchment areas of the rivers. Storm surge hazards may be worsened by the destruction of mangroves. Although landslides are normally caused by natural forces, yet they may be caused and their frequency and impact may be aggravated as a result of building roads in mountainous areas, excavating tunnels and by mining and quarrying.

DISASTER

Extreme form of hazard leads to disaster. Disaster (French *des* meaning 'bad' and *aster* meaning 'star') is a manmade or natural event which results in widespread loss of life and property. Thus disaster is defined as "*A serious disruption of the functioning of a society, causing widespread human, material or environmental losses which exceed the ability of the affected society to cope using its own resources.*" The United Nations defines disaster as "*...the occurrence of a sudden or major misfortune which disrupts the basic fabric and normal functioning of a society (or community).* The World Bank defines disaster *as an extraordinary event of limited duration which causes serious disruption of the economy of the country.* It is an event or a series of events which gives rise to casualties and/or damage or loss of property, infrastructure, essential services or means of livelihood on a scale that is beyond the normal capacity of the affected communities to cope with unaided.

Hazards and disasters are closely related and are sometimes used as synonymous with each other. *Hazard is a threat, while disaster is an event.* The latter is a calamity or tragedy or a consequence of a hazard. *Natural hazards that cause great loss to human life and economy are known as **disasters** and **catastrophes**.* The term ***disaster*** is sometimes also used to describe a "*catastrophic situation in which the normal patterns of life (or eco-systems) have been disrupted and extraordinary emergency interventions are required to save and preserve human lives and/or the environment.*"

Classification of Disasters

Disasters are generally classified on the basis of their origin as tectonic (earthquakes, volcanoes), topographical (landslides, avalanches), meteorological (hurricanes, cyclones, tornadoes, floods, droughts), infestic (locust invasion of crops, epidemics) and human (industrial accidents, nuclear bombs).

VULNERABILITY

Hazards and disasters are unevenly distributed with respect to time and space. The terms like ***'earthquake prone'***, ***'drought prone'*** or ***'flood prone'*** areas are used to describe the distributional effect of the concerned hazards. People living in such areas are vulnerable to hazards and disasters of varied types. **Thus vulnerability is the extent to which an individual or a community or an area is exposed to the impact of a hazard.** According to National Institute of Disaster Management (formerly National Centre for Disaster Management), vulnerability is defined as the extent to which a community, structure, service or geographic ***area is likely to be damaged or disrupted by the impact of particular a hazard on account of either nature, construction and proximity to hazardous terrain or disaster prone area.*** Thus, vulnerability implies a measure of risk combined with the level of social and economic ability to cope with the resulting event in order to resist major disruption or loss. In other words, vulnerability is "***a set of prevailing or consequential conditions composed of physical, socio-economic and/or political factors which increase a community's susceptibility to calamity or which adversely affect its ability to respond to events.***"

NATURAL HAZARDS AND DISASTERS IN INDIA

Because of its subcontinental dimensions, geographical situation and behaviour of the monsoon, India is exposed to various natural hazards and disasters like drought, flood, cyclone, earthquake, etc. year after year. While all the states and union territories in the country are likely to face one or a combination of disaster situations, 27 states/union territories are more vulnerable to these disasters. Four major disasters which adversely affect different parts of the country are drought, flood, cyclone and earthquake. Only one state (West Bengal), faces all four types of disasters, seven states face three types of disasters, ten face two types of disasters and nine states face one type of disaster. It is not uncommon to experience more than one or two types of disasters affecting different parts of the country at the same time. For example, there may be flood in the Brahmaputra Valley, drought in Rajasthan and cyclonic storm in some coastal area.

Disasters occur with unfailing regularity and despite better preparedness to meet all such contingencies, the economic and social costs on account of losses caused by the natural disasters continue to mount year after year. The main hazards in India are caused by earthquakes, droughts, floods and cyclones. Since the beginning, they have been causing heavy losses of life and property forcing man to ***'learn to live'*** with natural disasters.

INDIA'S KEY VULNERABILITIES

- 55 per cent of total area is in Seismic Zones III-IV and vulnerable to earthquakes.
- 68 per cent of net sown area is vulnerable to drought.
- 40 million hectares of land is vulnerable to floods.
- 8 per cent of the total land area particularly along the eastern coast and Gujarat coast is vulnerable to tropical cyclones.
- Sub-Himalayan region and Western Ghats are vulnerable to landslides.
- Of the 7,516 km long coastline close to 5,700 km is prone to tropical cyclones and tsunamis.

The most disturbing factor is that these hazards and disasters are hitting different parts of the country with increased frequency and with greater force.

EARTHQUAKES

Earthquake is a violent tremor in the earth's crust, sending out a series of shock waves in all directions from its place of origin. If you throw a stone in a pond of still water, a series of concentric waves are produced on the surface of water. These waves spread out in all directions from the point where the stone strikes the water. Similarly, any sudden disturbance in the earth's crust may produce vibrations in the crust which travel in all directions from the point of disturbances. Earthquakes constitute one of the worst natural hazards which often turn into disaster causing widespread destruction and loss of human lives.

Earthquake Hazards in India

India has a very long history of earthquake occurrences. The most vulnerable areas according to the present seismic zone map of India are located in Himalayan and sub-Himalayan Regions, Kachchh and the Andaman and Nicobar Islands. Depending on varying degrees of seismicity, the entire country can be divided into the following seismic regions :

1. **Kashmir and Western Himalayas.** This region covers the states of Jammu and Kashmir, Himachal Pradesh and sub-mountainous areas of Punjab.
2. **Central Himalayas.** This region includes the mountainous and sub-mountainous regions of Uttarakhand, Uttar Pradesh and the sub-mountainous parts of Punjab.
3. **Northeast India.** This region comprises the whole of Indian territory to the east of northern West Bengal.
4. **Indo-Gangetic Basin and Rajasthan.** This region comprises of Rajasthan, plains of Punjab, Haryana, Uttar Pradesh and West Bengal.
5. Khambhat and Rann of Kachchh.

TABLE 8.1. Region-wise Earthquake (M > 5.0) Occurrence in India (1897–2014)

Sl. No.	Seismic Region	No. of Earthquakes of Magnitude				Return Period
		5.0–5.9	6.0–6.9	7.0–7.9	8.0 +	
1.	Kashmir & Western Himalayas	25	8	2	2	2.5–3 years
2.	Central Himalayas	68	28	4	1	1 Yr.
3.	North East India	200	128	15	4	< 4 months
4.	Indo-Gangetic Basin and Rajasthan	14	6	—	—	5 Yrs
5.	Khambhat and Rann of Kutch	4	4	1	1	20 Yrs
6.	Peninsular India	31	11	—	—	2.5–3 Yrs.
7.	Andaman & Nicobar	90	80	1	1	< 8 months

* Numbers of earthquake under category 5.0–5.9 are approximate.

6. Peninsular India including the Islands of Lakshadweep.
7. The Andaman and Nicobar Islands.

The distribution of magnitudes equal to or more than 5.0 in these regions and their average return periods are represented in the **table 8.1**.

Based on intensities of the earthquakes recorded on MM Scale the Indian Standards Institute has published a map of India showing seismic zones. Map given in **Figure 8.1** shows five Seismic zones based on MM Scale.

Zone I — Intensity V or below (Instrumental, feeble, slight, moderate, rather strong)
Zone II — Intensity VI (Strong)
Zone III — Intensity VII (Very strong)
Zone IV — Intensity VIII (Destructive)
Zone V — Intensity IX and above (Ruinous, disastrous, very disastrous, catastrophic)

According to seismologists, one part of India or the other experiences one earthquake almost everyday. But most of them are of low intensity, are harmless and go unnoticed. However, major earthquakes of higher intensity are strong enough to wreck havoc and result in great loss of life and property.

Depending upon the frequency and intensity of the earthquakes, the whole country can be divided into three broad seismological zones.

1. Himalayan Zone. The areas most prone to earthquakes in India are the fold mountain ranges of the Himalayan zone. The states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Bihar, the Bihar-Nepal border and the north eastern states, especially Assam fall in this zone. The earthquakes in this zone are primarily due to plate tectonics. The Indian plate is pushing in the north and north-east direction at an annual rate of 5 cm subducting the Eurasian plate along the Himalayas. The Himalayas have not yet attained *isostatic equilibrium* and are rising. The region along the Himalayas where two plates meet is highly earthquake-prone. This is known as the ***zone of maximum intensity***. The absence of Nepal from the list of earthquakes shows that the whole of Himalayas are not dangerous. The Himalayas between Mount Everest and Badrinath are almost stable. This patch of tremendously huge landmass, having great heights and width rests with perfect calm and peace. The patches towards and beyond this patch are, however, very violent because of their hurried movement. Areas north-east of the arc joining Mussoorie, Shimla, Kangra, Dalhousie, Gulmarg and areas of Bihar, Assam, south of south-east Nepal, Sikkim, Bhutan, Arunachal Pradesh and western part of Nagaland, Manipur are susceptible to high magnitude earthquakes.

2. The Indo-Gangetic Zone. To the south of the Himalayan zone and running parallel to it is the Indo-Gangetic zone. Most of the earthquakes striking this zone are of moderate intensity of 6 to 6.5 on Richter scale. Therefore, this zone is called the ***zone of comparative intensity***. The earthquakes along the foothill are of medium to high intensity. However, the earthquakes of this zone are more harmful due to high density of population in this area.

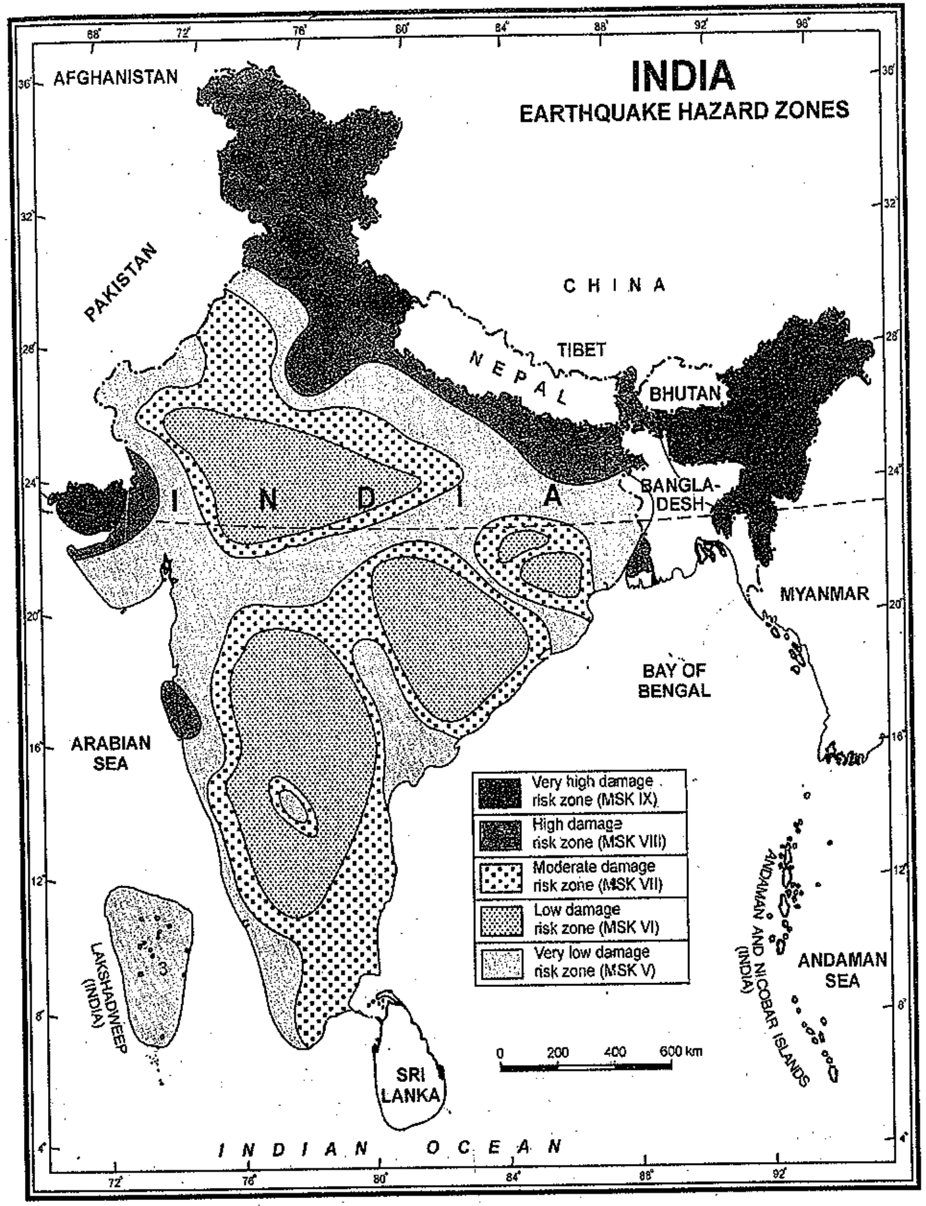


FIG. 8.1. India : Seismic Zones

3. The Peninsular Zone. The Peninsular India has presumably remained a stable landmass and only a few earthquakes have been experienced in this region. This region is, therefore, called the ***zone of minimum intensity***. But severe earthquakes of Koyna (1967), Latur (1993) and Jabalpur (1997), have raised

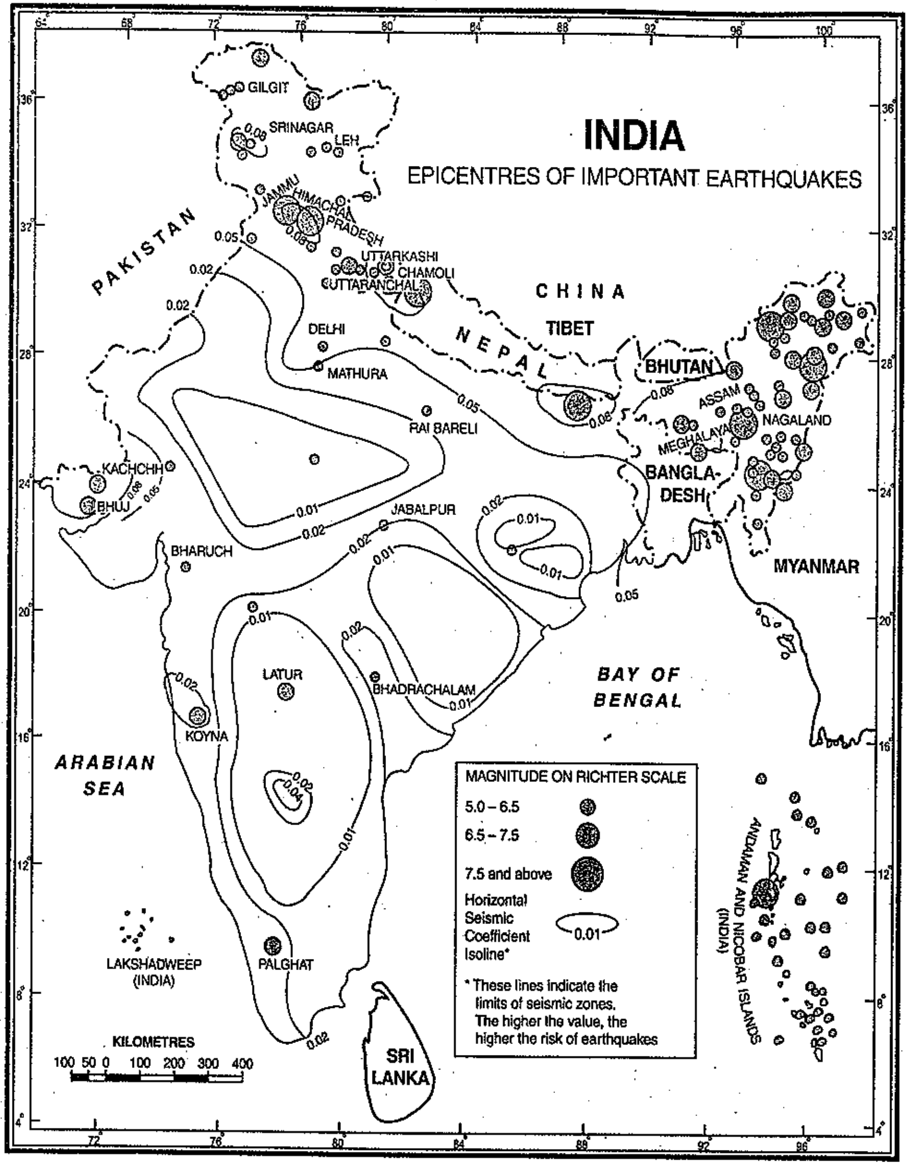


FIG. 8.2. India : Epicentres of Important Earthquakes

doubts about the seismic stability of this landmass. While the Koyna earthquake was caused due to excessive loading of water in the Shivaji Sagar reservoir formed by damming the Koyna River, the earthquake that hit Latur is supposed to be the result of plate tectonics. The northward drift of the Indian Plate had put pressure on the Tibetan Plate which caused pressure to mount at the centre of the Indian plate, leading to earthquake. The earthquake of Jabalpur also occurred under similar conditions.

Epicentres of major earthquakes (magnitude more than 5 on Richter scale) are shown in **Figure 8.2**. The country as a whole has been divided into zones by ***horizontal seismic coefficient isolines***. This coefficient varies from 0.01 to 0.08. The low horizontal seismic coefficient zone (0.01–0.02) constitutes the areas that are quite secure from earthquakes. This zone is mainly spread over extensive parts of peninsular India, Madhya Pradesh and Rajasthan areas having medium horizontal seismic coefficient (0.04–0.05) are spread over the Satluj-Ganga plain, Godavari basin of Andhra Pradesh, Ratnagiri and Raigad districts of Maharashtra and some parts of Gujarat. The areas that come under the high seismic coefficient zone are situated in Jammu and Kashmir, Himachal Pradesh, Uttarakhand, northern parts of Bihar, north-eastern states, Kachchh region of Gujarat and Andaman and Nicobar Islands. These regions are highly susceptible to earthquakes.

Earthquake Risk. The earthquake risk to a structure or system can be considered to be made up of four components as follows :

Seismic Risk =
Hazard × Exposure × Vulnerability × Location

Hazard means the occurrence of a terrifying earthquake of sufficient magnitude (hence peak intensity at the point of occurrence) capable of causing damage to the weakest manmade structures.

Exposure indicates the objects and structures made by man which are exposed to the effects of the 'hazard' and will include buildings, bridges, dams, power plants, life-line structures etc.

Vulnerability indicates the damageability of the 'exposure' under the action of the hazard, weaker constructions being more vulnerable and 'risky' than stronger ones.

Location means how far 'exposure' is situated from the location of the 'hazard', the nearer ones being in greater danger than those far away.

Hazardous Effects of Earthquakes

The hazardous effects of earthquakes do not depend only upon their magnitude and intensity alone but on so many other factors such as population, nature of rocks, type of buildings, etc. Even a weak earthquake can do great damage if it strikes a densely populated area, an area of weak structure or an area where buildings are weak. The direct and indirect disastrous effects of earthquakes include deformation of ground surface, damage and destruction to human structures such as buildings, rails, roads, dams, bridges, factories, destruction to towns and cities, loss of human and animal lives, fires, floods, landslides, etc.

Major hazards of earthquakes are briefly described as under :

1. Loss of Life and Property. There is devastating loss of life and property if the intensity of the earthquake is more than 5 on the Richter scale. Buildings, roads, railways, bridges, dams, etc., suffer severe damage when an earthquake strikes them. Several villages, towns and cities are completely ravaged. The towns of Bhuj, Bhachau, Anjar, Gandhidham, and Ratnal were completely destroyed by the earthquake which struck Bhuj on 26th January, 2001. Property worth ₹ 2,000 crore was destroyed. The maximum damage is noticed near the epicentre of the earthquake. This damage is reduced as we move away from the epicentre. An earthquake becomes a hazard or disaster only when it strikes populated area and causes unaccountable loss to life and property.

2. Topographical Changes. The main effects of earthquakes on topographical features are seen in the form of offsets along known faults, fissures, scarps, elevation and depression of coasts, etc. Earthquakes are often followed by landslides in hilly areas. Due to earthquake vibrations, the looser material at or near its maximum static stable angle may become unstable and move along the slope of hill. Cracks and fissures which occur as a result of a severe earthquake facilitate landslides. The severe earthquake which struck Uttarkashi in Uttarakhand (1991) caused many cracks and fissures in *Varunavat Parvat*. This gave birth to landslides which caused heavy damage to Uttarkashi town in the year 2003. Large masses of dry earth and rock, called ***earth avalanches***, slide over considerable distances. If wet soil slips down the hill side, a ***slump*** occurs. ***Earthflow*** is another phenomenon which is primarily restricted to ground water. The earthquake is either accompanied or succeeded by a sudden burst of water from a locality where it normally appears in springs.

3. Liquefaction. Soil liquefaction is a phenomenon where low density saturated sands of relatively uniform size inside the earth start behaving like a jelly with no strength to hold a building up, and the building just sinks or gets tilted on one side. The phenomenon of liquefaction is particularly important for dams, bridges, underground pipelines and buildings close to river banks, sea shore or large lakes. Vast tracts of plains of Uttar Pradesh and Bihar where soil is generally soft and the water table is high, offer favourable conditions for such effects. The great Bihar-Nepal earthquake of 1934 produced a belt of slumping extending from Bettiah in north-west to Purnea in the south-east (a distance of nearly 320 km), surrounding the epicentral tract, in which all buildings either tilted or sank in soft alluvium. Widespread subsidence over large area was observed. There were innumerable fissures through which large quantities of sand and water were thrown up to the surface, thereby causing large scale destruction to standing crops. The soil became totally unfit for cultivation. Rann of Kachchh also covers a vast area where large scale liquefaction of ground was observed during the Bhuj earthquake of 2001.

Pattern and Causes of Damage

Buildings. Great damage is done to buildings by the earthquakes particularly if the buildings are constructed with brick, mud or timber. Reinforced concrete buildings suffer least damage, while effected adobes and unreinforced brick buildings are severely damaged by the earthquakes. Projecting cornices, balconies, towers and arcades render the building more vulnerable.

An earthquake causes damages to the buildings by setting up oscillating (backward and forward) motion of the ground. As the part of the earth's crust affected by the earthquake oscillates, the buildings on the ground start responding to oscillation in varying degrees depending upon how these have been designed and constructed. Close to the epicentre, there is also a vertical movement. Due to oscillatory movements caused by the earthquake, the foundations of the building move with the ground, but the inertia of the rest of the building prevents it from moving instantaneously and there is a slight delay before the upper portions start moving. This delay leads to differential stresses and subsequent cracking because the roof tends to separate from the support and the walls tend to be torn apart. The force exerted on the building depends upon the movement of the ground caused by the earthquake and the weight of the building. It is axiomatic *that earthquakes do not kill—collapsed buildings do*. The Muzaffarabad earthquake in October 2005 hit Pakistan and India with a magnitude of 7.4 in Pakistan and 6.8 in India and killed over one lakh persons. Several buildings collapsed like a pack of cards. In contrast a magnitude of 7.1 earthquake in October 2004 in Hokkaido (Japan) caused only 17 injuries. The main reason for the low Japanese casualties was their seismically engineered buildings. Therefore, it is advisable to construct light weight buildings with lighter roofs in earthquake prone regions. Rapid progress in earthquake engineering has standardised techniques for earthquake resistant design of buildings in different seismic zones. India has been classified in five seismic zones based on Modified Mercalli Intensity Scale. In zones III, IV and V destruction and damage to buildings is considerable. Zone II could also have minor damage in rural buildings. but collapse of housings in this zone is not considered probable, while zone I may be taken as non damaging seismicity.

The extent of damage is dependent on a number of factors; the intensity of the earthquake, distance from the epicentre, soil condition, type of structure (mass, permissible stress, elasticity, dynamic load response and durability of materials), design of building and quality of construction.

Shape of the building has a great bearing on its resistance to earthquake risk. Geometric shapes such as square or rectangle usually perform better than buildings in the shape of L, T, U, H, +, O or a combination of these.

Damage to Transport System. Damage to transport system includes damage to highways, railways, airports, marine and river systems, water supply and sewage, fuel and oil, energy transmission and communication systems. The facilities of transport may be built either on surface or underground. The earthquake affects differently on these two types of structures. The underground structures such as oil pipelines are mainly governed by the strain in the surrounding ground caused by the propagation of earthquake waves, while the surface structures like bridges are governed by vibrating response of the structure to earthquake ground motion. The second category of damage arises due to the blocking of road by jammed cars, fire, uprooted poles and collapsed buildings. Blocking of highways may stop various activities needed for earthquake relief and rescue.

Fire. In the event of an earthquake, short circuits, contact with live electrical wires, damage to blast furnaces and other fire related appliances are the major causes of fire.

Floods. Often earthquakes lead to distortion and displacement of the surface rocks which block the flow of a river. This causes floods in the upper course of the river. Often dams and embankments develop cracks and the course of the river lower down the dam site is flooded.

Public Health. People suffer multiple injuries and many become permanently disabled. Hazards of disease on pollution of water bodies, breakdown of sewage and sanitary pipes and other unhygenic conditions could lead to epidemics. Many people die of heart attack.

Civic Services. Civic services like water pipes, sewers, electric connections, etc. are disrupted. Fire hydrants supply lines, if vulnerable, could hamper service operations.

Economic Activities. Economic activities like agriculture, industry, trade, transport and other services may be severely affected by widespread damage to infrastructure in the event of an earthquake. It becomes one of the major causes of civic unrest.

Earthquake Safety Rules

Before an earthquake

1. Keep stock of drinking water, some foodstuffs, first-aid equipment, a crow bar, shovel, pick and rope, electric torch and some candles and a helmet for every member of the family.
2. Ensure that water heaters and other gas appliances are firmly fixed and shut off when not in use, as broken gas pipes or appliances are likely to cause fire hazards.
3. Securely fasten fixtures, refrigerators and shelves to the wall and place large and heavy objects on the lower shelf. Top heavy object should be braced or anchored.
4. Find out the location of the nearest first-aid post, Warden Post and Fire Station and approach for help if required.
5. Join the Civil Defence Organisation and train yourself and the members of your family in first-aid, rescue fire fighting etc., which will help you, your family and neighbours.
6. Conduct occasional home earthquake drills so that your family has the knowledge to avoid unnecessary injuries and panic in the event of an earthquake.
7. More responsible members of the family may be taught how to turn off electricity, gas and water at the main switches or valves.
8. Be aware of what to do in various situations so that you are prepared in the event of an earthquake, *e.g.*, at home, whilst driving a car, at work in a shop, a public theatre, cinema hall, etc.
9. Avoid the risk of an epidemic which usually follows earthquakes by using safe water and clean food.
10. Evacuate old dilapidated buildings as they are sure to timble first.

Certain other precautions, which are necessary in case of fire, should also be taken as far as possible :

1. Keep adequate water/dry sand stocked in accessible places.
2. All lofts and attics should be kept free from inflammable material.
3. Keep all inflammable stores, which are required, as much dispersed as possible.

During the earthquake

1. Do not panic. The motion is frightening, but unless it shakes something down on top of you it is harmless. The earth does not yawn open, gulp down a neighbourhood, and close up. So keep calm.

2. In the event, the safest place is an open space away from building. However, when this is not suitable do not try to run from a building during earthquake.
3. If it catches you indoors, take cover under a desk, table, bench or in doorways, halls, and against inside walls or staircase. Stay away from glass.
4. Do not use candles, matches, or other open flames, either during or after the earthquake. Put out all fires.
5. If the earthquake catches you outside, move away from buildings and utility wires. Once in the open stay there until the tremor stops.
6. Do not run through or near buildings. The greatest danger from falling debris is just outside doorways and close to outer walls.
7. If you are in moving car, stop as quickly as safety permits, but stay in the vehicle. A car is an excellent seismometer, and will jiggle on its springs during the earthquake, but it is a good place to stay until the earthquake stops.

After an earthquake

1. Keep calm, switch on the transistor radio and obey any instructions you hear on the radio.
2. Keep away from beaches and low banks of rivers. A huge wave may sweep in.
3. Expect aftershocks.
4. Turn off the water, gas and electricity.
5. Do not smoke and do not light matches or use a cigarette lighter. Do not turn on switches. There may be gas leaks or short-circuits.
6. Use a torch.
7. If there is a fire, try to put it out. If you cannot, call the fire brigade.
8. If people are seriously injured, do not move them unless they are in danger.
9. Immediately clean up any inflammable products that may have spilled (alcohol, paint, etc.)
10. If you know that people have been buried, tell the rescue teams. Do not rush and do not worsen the situation of injured persons or your own situation.
11. Avoid places where there are loose electric wires and do not touch any metal object in contact with them.
12. Do not drink water from open containers without having examined it and filtered it through a sieve, a filter or an ordinary clean cloth.
13. Eat something. You will feel better and more capable of helping others.
14. If your home is badly damaged you will have to leave it. Collect water containers, food, and ordinary and special medicines (for persons with heart complaints, diabetes, etc.).
15. Do not re-enter badly damaged buildings and do not go near damaged structures.
16. Do not walk around the streets to see what has happened. Keep clear of the streets to enable rescue vehicles to pass.

TSUNAMI

Introduction and Definition

Tsunami is derived from Japanese word '*tsu*' meaning harbour and '*nami*' meaning wave. According to Report of High Powered Committee on Disaster Management (2001). "Tsunami is an ocean wave produced by an event at the sea, like an earthquake, landslide or volcanic eruption" (**Fig. 8.3**). A tsunami is not a single wave but a series of waves generated by the geological changes near or below the ocean floor. These waves may reach enormous size and have been known to travel across the oceans.

Formation of Tsunamis

(i) Undersea earthquakes

Although tsunami may be caused by landslides, volcanic eruptions or even by the impact of a large meteorite falling on the ocean, most destructive tsunamis are generated by massive undersea earthquakes, occurring at depth less than 50 km with the epicentre or fault line near or on the ocean floor. A strong undersea earthquake with magnitude greater than 7.5 on the Richter scale tilts and deforms large areas of the sea floor ranging from a few kilometres to 1000 kilometres and even more. As the sea floor is tilted or deformed by the tectonic earthquake (earthquake associated with the earth's crustal deformation), the sea water above is displaced from its equilibrium position. Waves are formed as the displaced water attempts to regain its equilibrium under the influence of gravity. It is this vertical movement of the entire water column that generates destructive tsunami waves.

The displacement of sea floor, and occurrence of an earthquake and formation of tsunamis can best be explained on the basis of plate tectonics. When two converging lithospheric plates come closer together, then heavier plate is thrust under the lighter plate and displacement of the crust takes place at the subduction zone. A fault is created and an earthquake occurs, giving rise to tsunamis.

It must be noted that a tsunami is usually not generated if the sea floor movement is horizontal. Besides, not all undersea earthquakes create tsunami, as it depends upon the nature and degree of displacement of seawater column. It is only the vertical displacement of the seawater due to abrupt, jerky movements of fault blocks on seabed that gives birth to tsunamis. Once formed, the monstrous waves soon begin their journey towards the nearest coastline, ringing the bells of doom (**Fig. 8.4**).

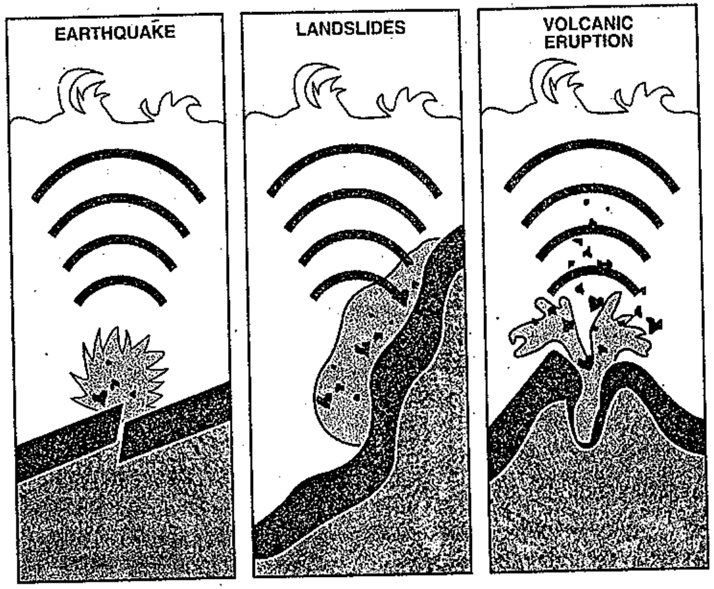


FIG 8.3. Triggering of Tsunami

(ii) Landslides

Tsunami waves are also generated by displacement of seawater resulting from landslides as well as rock falls, icefalls etc. Construction work of an airport runway along the coast of Southern France in the 1980s caused an underwater landslide. This triggered the destructive tsunami waves in the harbour of Thebes. Underwater landslides may also occur when a strong earthquake shakes the sea floor, thus forming tsunamis. These waves rapidly travel away from the source due to dissipation of energy, and create havoc in the nearby coastlines.

(iii) Volcanic Eruptions

Whenever a violent volcanic eruption takes place under the sea, it causes sudden displacement of a large volume of seawater and tsunami waves are formed. Similarly, when the roof of a volcano collapses that has a large empty magma chamber owing to continuous flow of lava, a crater sometimes as large as one kilometre in diameter is formed. As the seawater gushes into this crater, the water column of the sea is disturbed which gives rise to tsunami waves.

One of the largest and the most destructive tsunami ever recorded was generated on August 26, 1883 after the explosion and collapse of the volcano of Krakatoa in Indonesia. This explosion generated waves with a towering height of about 40 m, that wrecked havoc on the coastal areas along the Sunda Strait in both the islands of Java and Sumatra killing more than 36,000 people. It is believed that the destruction of the Minoan civilisation in Greece in 1490 B.C. was caused by tsunamis which were formed by the explosion of the volcano of Santorin in the Aegean Sea.

(iv) Meteorites and Asteroids

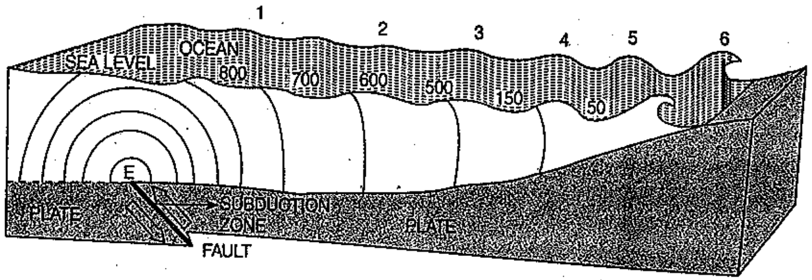
There is a potential danger of a tsunami being formed by the fall of meteorites and asteroids in the ocean. Researchers in California have developed a computer simulation depicting the ocean impact of asteroid 1950 DA, a gigantic space rock that would be very close to the earth in 2880. Although the possibility of such an impact is very remote, the computer model definitely gives the researcher an insight into the destructive power of tsunami caused by near-Earth object. Some of the meteorites have been uncomfortably close to the earth and could wreck havoc in different forms including tsunamis.

Propagation of the Tsunamis

Tsunamis consist of a series of very long waves which travel outwards on the surface of the ocean in all directions away from their place of origin. Their movement is just like ripples created by throwing a pebble into a pond of water. In deep sea the tsunamis travel at very very high speed (say 500–800 km per hour), almost as much as the speed of a jet aircraft. Their wavelength is very long which often exceeds 500–700 km. However, the amplitude of tsunamis in deep sea is very low and rarely exceeds 1 metre. Physically they propagate as long waves with speed given by

$$(\text{Water depth} \times \text{gravitation acceleration})^{1/2}$$

Since the tsunamis have very long wavelength and very low amplitude in deep ocean, they cannot be seen or detected from the air. Therefore, passengers on boats cannot feel or see the tsunami waves as the killer waves pass by underneath at high speeds. It may only appear as a gentle rise and fall of the sea. Thus tsunamis are always deceptive and are able to conceal their killing capacity in the deep water of open area. For example, the Great Sanriku tsunami, which struck Honshu in Japan on June 15, 1896 was completely undetected by fishermen as its deep water height was only about 40 cm. A monster in disguise, this tsunami transformed into huge waves when it arrived on the shore and ravaged 275 km of coastline



E : EPICENTRE OF THE EARTHQUAKE

: DIRECTION OF MOVEMENT OF PLATES

800 : SPEED OF TSUNAMI IN Kmph

1–6 : SERIES OF WAVES

FIG. 8.4. Origin and Propagation of Tsunamis

killing 28,000 people. So from the sky tsunami waves cannot be distinguished from ordinary ocean waves. But beneath, a tremendous amount of energy lurks. Since the rate at which the wave loses its energy is inversely related to its wavelength, tsunamis not only propagate at high speeds, they can also travel great transoceanic distances with limited energy losses.

As the tsunamis leave the deep water of the open ocean and travel towards the shallow water, they are transformed in two ways. Firstly their speed is reduced considerably and secondly they attain enormous height often exceeding 10 metres and occasionally may reach 30 metres. **Figure 8.4** shows the origin of tsunamis and their propagation from deep water of open sea to the coast.

Effects of Tsunamis

Tsunami pose serious danger to the inhabitants of the coastal areas. They attack the sea shore as gigantic waves, moving with great force, appearing without a warning and hitting the coastline like a water bomb. Loaded with enormous energy, the killer waves wreck havoc by flooding hundreds of metres inland, past the typical high water level. They flatten houses and wipe out villages, uproot electric poles, throw cars into swirling waters and toss boats ashore all in mad fury, and finally drag thousands of hapless victims out to sea as they recede. Large rocks weighing several hundred tonnes and other debris can be moved hundreds of metres inland by a tsunami. Tsunamis can even travel up rivers and streams that lead to the ocean.

Tsunamis in the Indian Ocean

Tsunamis have been generated in the Indian Ocean at a number of times. In 1883, eruptions from the Krakatoa fueled tsunamis which killed 36,000 people in Java and Sumatra islands of Indonesia. During the earthquake in 1880 which had its epicentre near the centre of the Bay of Bengal, tsunamis were reported. During the earthquakes of 1819 and 1845 near the Rann of Kachchh, there was rapid movement of water into the sea. Tsunamis 12 to 15 metres high were generated in the Persian Gulf by 1945 Mekran earthquake. The estimated height of waves was about 2 metres at Mumbai.

Tsunamis of 26th December 2004 in the Indian Ocean

On 26th December 2004, the Indian Ocean was hit by tsunamis which is considered to be the most catastrophic in the living memory of the inhabitants of the coastal areas of this ocean. It was caused by a severe earthquake which measured 8.9 on the Richter scale. Seismologists at Northwestern University in Illinois later upgraded the earthquake to magnitude 9.3 on Richter scale. This is perhaps the highest magnitude for any earthquake ever recorded anywhere in the world. This earthquake had its epicentre off the coast of Sumatra (Indonesia) at 3.5° north latitude and 95° east longitude. This place happens to be at the tri-junction of the Indian, Australian and Burmese (Myanmarese) plates. The earthquake was triggered by the collision of the Indian plate with Burmese plate. It occurred at the point where the Indian plate subducts below the Burmese plate due to the northward movement of the Indian plate (**Fig. 8.5**). Seismologists have noted a 15 metre slip in the vertical direction along the crack that is about 1000 km long extending upto Andaman and Nicobar Islands in the northern direction.

Damages Caused by Tsunami

This tsunami had been the most damaging in the world history. It had wrecked havoc to as many as 11 countries of south and southeast Asia and East Africa extending from Indonesia to Somalia. Hence it is rightly called the ***tragedy of international dimensions.*** Various types of damages caused by the tsunami of 26th December 2004 are briefly described as under.

1. Death Toll

The tsunamis that hit the Indian Ocean on 26th Dec. 2004 claimed over 1.84 lakh lives in different countries of Asia and Africa. The soaring waves killed people of at least 40 nationalities including tourists from various countries of the world.

Table 8.2 shows that Indonesia has been the worst sufferer with death toll of over one lakh persons. Sri Lanka, India and Thailand also suffered heavy tolls. The other countries which suffered loss of life include Myanmar, Bangladesh, Maldives and the distant African countries of Somalia, Kenya, Seychelles and Tanzania.

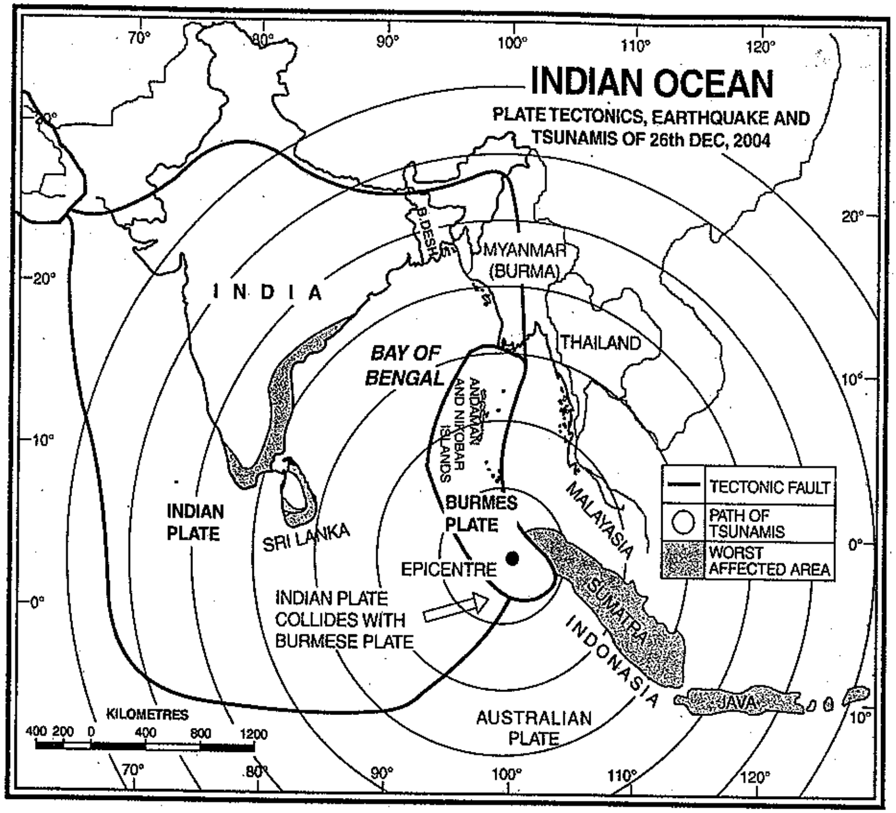


FIG. 8.5. Plate Tectonics, Earthquake and Tsunami of 26th December, 2004.

Surprisingly Malaysia suffered only a fraction of destruction despite its being located so near to the epicentre of the earthquake. This is because of the location of Sumatra which acted as buffer for Malaysia.

Besides over one million people were affected and several others were rendered homeless.

In India, the Andaman and Nicobar Islands were the closest to the epicentre of the earthquake and hence the origin of tsunamis, and were the worst sufferers. Areas like Car Nicobar, Katchal, Nancowry, Campbell Bay, Champion Island, Chowra and Teresa Island have been badly affected. In Car Nicobar, half of the total population of about 20 thousand was reportedly missing.

On the mainland of India, the main attack of tsunamis was on the coastal areas of Tamil Nadu, Andhra Pradesh and Kerala and the union territory of Pondicherry. Of these three states, Tamil Nadu suffered the most. This was followed by Andhra Pradesh and Kerala.

TABLE 8.2. Number of Persons killed by Tsunamis

Country	Number of Dead Persons
1. Indonesia	1,13,306
2. Sri Lanka	30,196
3. India	15,160
4. Thailand	5,186
5. Other countries	20,842

The countries which reported death toll higher than India were Indonesia and Sri Lanka. In Indonesia, Sumatra and Java including Aceh Province were the worst sufferers. In Sri Lanka, Matara, Galle, Weligma, Hambantota, Batticaloa and Colombo reported heavy casualties.

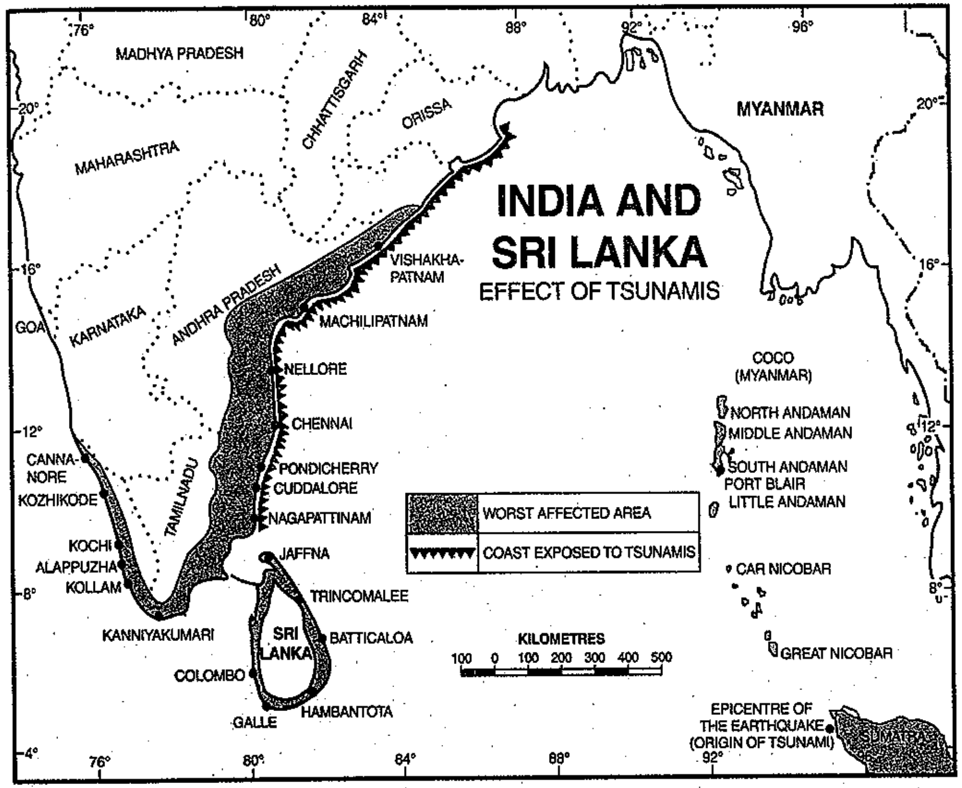


FIG. 8.6. India and Sri Lanka : Effect of Tsunamis

Besides a large number of tourists from Europe, North America, South America and Australia who had come to the tsunami affected countries to celebrate Christmas and New year also lost their lives.

2. Loss of Property

Property worth crores of rupees has been damaged as a result of attack by tsunamis. Infrastructural elements like houses, public buildings, transport and communication system etc. had been damaged almost beyond repair. Sea water even entered the nuclear power plant at Kalpakkam which was closed for a number of days. In Sri Lanka, rail tracks were twisted near Colombo and a train was derailed in which about 1,000 persons were killed.

According to preliminary findings of the government of India, the coastal areas of India, which include large coastal tracts of Tamil Nadu, Andhra Pradesh, Pondicherry and Kerala, have suffered financial losses of billions of rupees. The financial loss in the Andaman and Nicobar Islands was pegged at ₹ 2,500 crore (see **Table 8.3**).

TABLE 8.3. Estimates of Financial Losses in India caused by Tsunamis

State/Union Territory	Loss ₹ crores
1. Tamil Nadu	2730.70
2. Andaman and Nicobar Islands	2500.00
3. Kerala	1358.62
4. Andhra Pradesh	720.73
5. Puducherry	512.00

3. Physiographical Changes

Tsunamis of 26th December 2004 were so strong that they could bring about drastic physiographic changes in different parts of the world. Satellite pictures of the tsunami affected areas show conspicuous changes in Chennai (particularly Adyar river course) as well as Trinket Katchall and Camorta Islands of the Andaman and Nicobar. Water level in many islands had risen, number of beaches in many islands like Campbell Bay had vanished and Trinket Island was split into two. Car Nicobar, which was worst affected sank to some extent. Indira Point, the southern-most tip of the Indian Union, was almost completely washed out, shrinking the coastline inland. These islands are hardly 125 to 200 km from the origin of tsunamis and had to face the worst fury of the killing waves.

Several other physiographic changes had been reported from Indonesia, Maldives and large areas of sea bed.

4. Motion of the Earth

The US Geological Survey expressed the opinion (as expressed by Ken Herdnut) that tremendous energy released by the earthquake made the earth wobble on its axis. According to Richard Gross, a NASA geophysicist, the earthquake might have permanently accelerated the earth's rotation due to shift of mass towards the earth's centre. This had caused the planet to spin 3 microseconds or one millionth of a second faster and to tilt about 2.5 cm on its axis. In other words, day is shortened by about 3 microseconds and the north pole has shifted towards east Siberia by 2.5 cm. Besides earth's oblateness (flattering at the poles and bulging at the equator) decreased by one part in 10 billion.

5. Decline in Soil Fertility and Agricultural Production

Vast low lying coastal areas were submerged under sea water which increased the salinity of the soil and reduced agricultural production. Cuddalore and Nagapattinam districts in Tamil Nadu were the worst affected. Tests conducted on soil samples from these districts showed that sea water had seeped to a depth of about 90 cm of soil, thereby totally affecting the root zone (15–30 cm below ground). Soil profile tests showed high salinity varying from 6.8 to 9.10 pH value (neutral value for pH is 7). This is highly saline condition in which no paddy crop could be cultivated. In Nagapattinam district alone, more than 9,500 hectares of land had been rendered unfit for cultivation by increased salinity. Horticulture also suffered heavy losses. The total loss in Nagapattinam district was estimated at ₹5.2 crore. This land could be reclaimed by flushing the soil with fresh water from the Cauvery river and by administering about two metric tonnes of gypsum per hectare. This process normally takes about 3 to 4 years to show the desired results. Farmers had been advised to sow plants like cashewnut which are saline-resistant.

6. Effect on Marine Life

The killer tsunamis had badly affected the marine life of the Indian Ocean. A large section of the coral reefs of the Andaman and Nicobar Islands archipelago had been destroyed, while others suffered extensive damages. According to marine biologists, satellite pictures showed that 45 per cent of the fragile coral reefs had been destroyed. The surviving reefs were damaged by the debris washed into the sea from the islands. Experts say it would take at least 700 to 800 years for reefs to re-form. The coral reefs around the Andaman and Nicobar Islands are of fringing type *i.e.*, they lie just off the coastline. Hence they have suffered extensive damage. Some of the species that were unique to the archipelago could have become extinct.

Fishing also suffered heavy losses at the hands of the powerful tsunamis. Sea beaches along the coasts of the Indian Ocean became graveyards of the dead fishes after the tsunami swept across the ocean. Mangrove areas that acted as nursery habitats to fish and shrimp were also damaged. The breeding, feeding and other activities of large sea mammals such as whales, dolphins etc. were also adversely affected.

Marine exports from India to the tune of US $ 1.3 billion were severely hit owing to wreckage caused by tsunamis. Since hatcheries and aquaculture ponds of coastal areas from Kerala to Odisha have been adversely affected, the marine production and hence the marine exports were badly hit. Fish, prawns and shrimps form a major chunk of India's marine exports.

Tsunami Distaster Management and Mitigation

Tsunamis are so powerful oceanic waves that it is not in man's hands to control or check them. However, following few tips may be helpful if forewarning about advancing tsunamis is received.

1. Get off the beaches and head for higher ground.
2. Stay away from rivers leading into the ocean.
3. Wait for all clear as there can be several giant waves in succession.

Advance Warning about Tsunamis

The best way of escaping the fury of the killing tsunami waves is to give advance warning of impending tsunamis to the vulnerable communities. Following few tips will help the common man to apprehend the danger of tsunamis.

(*i*) If there is a major undersea earthquake, beware of the danger because tsunamis could reach the coast in a few minutes.

(*ii*) Shaking of ground is a sufficient warning for the people living in the coastal areas about the impending tsunami.

(*iii*) A perceptible rapid rise or fall in coastal water can also be taken as a forewarning about an approaching tsunami.

(*iv*) Coastal areas less than eight metres above sea level run the greatest risk of an attack by tsunamis. They should be immediately evacuated if there is danger of an approaching tsunami.

It is possible to predict the onslaught of tsunamis by studying their speed, wavelength and depth of the sea. Tsunamis often take some time to reach the sea coast from their place of origin (**Fig. 8.7**) because the wave length and speed of tsunamis is drastically reduced when they approach the shallow sea. But on reaching the coastal shallow waters, their energy is compressed and they attack the coastal population as lethal waves. Thus a correct warning a few hours before the arrival of tsunamis can save thousands of lives and property worth millions of rupees.

Tsunami Warning System in India

Unfortunately India and other Indian Ocean rim countries did not have tsunami warning system before 26th December 2004 when the deadly tsunamis hit the coasts of Indian Ocean. Had public warnings been issued about the killing tsunami waves across the Indian Ocean, thousands of lives and property worth billions of rupees could be saved as the tsunami which hit the Sumatra Island took about three hours to crash into the Indian Coast. After the catastrophe, India decided to install her own tsunami warning system at the cost of ₹125 crore rather than becoming a part of the Pacific Warning System. It was planned to install the warning system by the end of the year 2007 and was inaugurated on 15th October, 2007. The system comprises a real-time network of seismic stations, bottom pressure recorders (BPR) and the tide gauges to monitor earthquakes in the sea and tsunamis triggered by them. The centre receives the data from

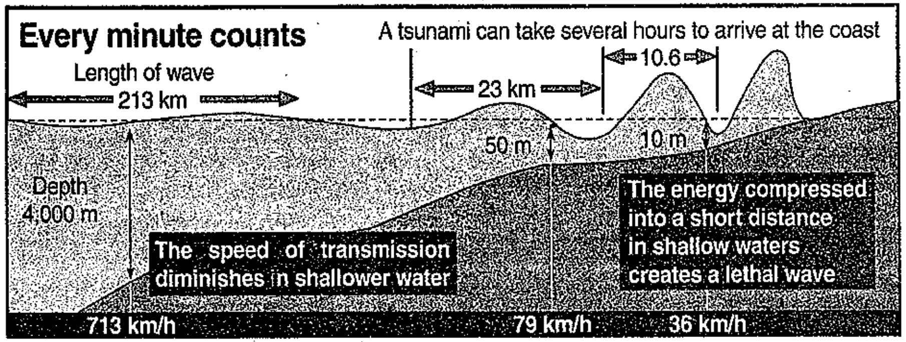


FIG. 8.7. Study of movements of Tsunamis can help in warning the people about the coming waves

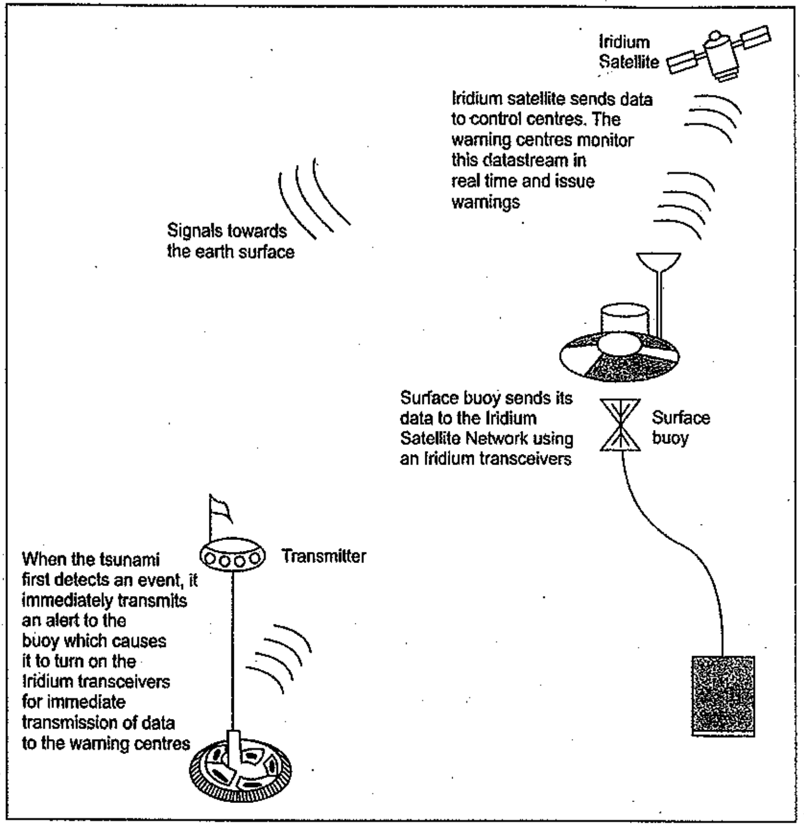


FIG. 8.8. India's Tsunami warning system.

Source : NOAA Centre for Tsunami Research.

the seismic network of the Indian Meteorological Department and other international set ups.

The system can detect earthquakes above 6 magnitude occurring the Indian Ocean in less than 20 minutes and alert agencies within 13 minutes. This is done with the help of the BPRs—the key sensors that confirm the triggering of the tsunami. Six BPRs, have been installed in all out of which four are in Bay of Bengal and two are in the Arabian Sea. The system was successfully tested during the 8.4 magnitude earthquake that hit Indonesia on September 12, 2007.

The centre generates and disseminates timely advisories to the control room of the Home Ministry which issues an alert to the public. To warn the ministry, a satellite based network for disaster management support has been established. This

HOW INDIA'S TSUNAMI WARNING SYSTEM WORKS

- The system comprises a network of real-time seismic stations and bottom pressure recorders (BPRs) installed in deep sea to detect disturbances.
- It senses all tremors in the Indian Ocean measuring over 6 on Richter scale in less than 20 minutes.
- The system can sound an alert 13 minutes after an undersea quake.
- After equipment sends data to the early warning centre, a computer generates alerts.

enables the centre to also issue alerts to the state emergency operations centres. The messages are to be sent by telephone, fax, SMS and e-mails to the authorised officials.

It has been acclaimed as the ***"most modern"*** tsunami warning system in the world by **Peter**

Koltermann, the head of the tsunami co-ordination unit intergovernmental oceanographic commission, UNESCO.

Unusual Animal Behaviour and Tsunamis

As in case of earthquakes, animals start behaving in unusual manner, before tsunamis actually strike the coast. At the time of catastrophic tsunamis which wrecked havoc in Indian Ocean on 26th December 2004, elephants in Thailand started wailing. They soon calmed down, but started wailing again about an hour later. This time they could not be comforted despite their ***mahauts***' efforts. The elephants just kept running for the hill. The elephants that were not working, broke their hefty chains. Soon the area was attacked by devastating tsunamis caused by the earthquake (8.9 on Richter scale) of Sumatra.

Abnormal behaviour of birds and animals was also observed in the coastal belt of Tamil Nadu (the worst hit area in India). Animals in forests were feeling restless. Birds stopped crying and there was unusual silence. About two months before the tsunamis struck the Indian coast, fishermen of Puducherry found fish with reddish tails, called ***Red Bait***, in their trawler nets. The sighting of this fish had always preceded a natural calamity. Catches of similar type in 1977, 1979 and 1996 were followed by major cyclones. It is a fishermen's instinct that Red Bait portends disaster and it has often come true. According to Central Marine Fisheries Research Institute (CMFRI), the Red Bait (measuring about 12 cm when fully grown and is edible) is a deep water fish which surfaces during 'upwelling' of water (a phenomenon of water at the bottom coming-up). This phenomenon is more pronounced on the Western Coast of India. But this time upwelling happened on the East Coast and that too during the non-upwelling season. Still CMFRI was not alarmed, since unlike cyclones, tsunami was completely unknown. Some of the other instances of abnormal behaviour of animals and birds noticed on that fateful day were as under.

- Crows flew into CMFRI's fish hatchery in Chennai and didn't budge.
- Cows on the Chennai beach ran like mad away from the coast.
- At Point Calimere Wildlife Sanctuary, black bucks and deer fled towards higher ground.

Vegetation. Impact of tsunamis can be considerably reduced by growing sea coast vegetation. Sea vegetation can be effective protection if the vegetation cover along the coast exceeds 70 per cent of the area. Unfortunately most of the natural vegetation has been destroyed for obtaining fodder and fuel. In Tamil Nadu only 110 km stretch out of a total coastal length of 1,076 km has sufficient vegetation cover.

Structural Protection. Structures like walls, ridges etc. can act as protective devices to some extent. Tamil Nadu government has proposed to construct a sea wall along the entire 1,076 km long coastline from Chennai to Kanniyakumari. But it will have its own financial and ecological limitations.

Although tsunamis constitute a natural tragedy and man has hardly any control on such a powerful natural phenomenon yet man's own misdeeds have made the situation very dangerous and helped in aggravating the fury of tsunamis. For example, no construction is allowed within 500 metres of the coast. There is legal obligation in India to leave this stretch of land vacant but all sorts of constructions residential, commercial, recreational etc.) is carried on without caring for the law. People living in this belt are most vulnerable to tsunamis and other sea related hazards.

Mining of sand and other minerals from the sea, as is done in Kanniyakumari, makes the concerned area highly vulnerable to tsunamis. The sand deposited on the sea coast absorbs much energy of the waves, and saves much of the coastal areas from their fury. There is urgent need to check unwanted construction and mining in ecologically sensitive coastal areas.

DROUGHTS

Introduction and Definition

Drought is a temporary reduction in water or moisture availability significantly below the normal or expected amount for a specific period. According to High Powered Committee on Disaster Management Report, "Any lack of water to satisfy the normal needs of agriculture, livestock, industry or human population may be termed as a drought." This condition occurs either due to inadequacy of rainfall, or lack of irrigation facilities, under-exploitation or deficient availability of water for meeting the normal crop requirements in the context of the agro-climatic conditions prevailing in any particular area. This has been scientifically computed as Moisture Index (MI). Drought, in this context, can be defined as adverse MI or adverse water balance which may be attributable not only to a prolonged dry spell due to lack of sufficient rainfall but also due to such other factors as excessive evapo-transpiration losses, high temperature, low soil holding capacity, etc. The inadequacy is with reference to the prevailing agro-climatic conditions in any particular area. Therefore, there is a drought in Jaisalmer (Average rainfall 200 mm) if rainfall is not sufficient to grow grass and paltry coarse-grains, whereas in Bolangir or Koraput (Odisha-rainfall above 1000 mm) there is a drought if there is not enough rainfall for bringing the paddy crop to maturity.

Drought is a distress situation caused by lack of rainfall. The failure of rains may be reviewed from two aspects. Firstly, the rainfall may be insufficient. Secondly it may be sufficient for the region as a whole but with wide gap, separating two wet spells. Thus both the amount as well as time of rainfall are important. In other words, drought is a relative phenomenon. Therefore, the amount of rainfall is not that important as its effectiveness.

Types of Drought

Following main types of drought may be recognised.

1. Meteorological Drought

It describes a situation where there is a reduction in rainfall for a specific period (days, months, seasons or year) below a specific amount (long term average for a specific time). The India Meteorological Department (IMD) has defined drought as a situation occurring in any area when the mean annual rainfall is less than 75% of the normal rainfall. IMD has further classified droughts into two broad categories *viz*. a ***severe drought*** when the deficiency of rainfall exceeds 50% of the normal rainfall and ***moderate drought*** when the deficiency of rainfall is between 25 and 50% of the normal rainfall.

It is worth noting here that the effectiveness of rainfall is more important then the amount of rainfall so far as meteorological drought is concerned. On an average India receives 118 cm annual rainfall which is considered to be highest anywhere in the world for a country of comparable size. But the uncertain, unreliable and erratic nature of rainfall by south-west monsoons creates drought conditions in different parts of the country. The major causes of meteorological drought may be summed up as under :

(*i*) Lean monsoons and below average rainfall due to absence of depressions over India.

(*ii*) Late onset or early withdrawal of monsoons.

(*iii*) Prolonged breaks in monsoon.

(*iv*) Re-establishment of southern branch of jet stream.

2. Hydrological Drought

Hydrological drought is associated with reduction of water. A meteorological drought often leads to hydrological drought. Generally it takes two successive meteorological droughts before the hydrological drought sets in. There are two types of hydrological droughts *viz*., (*i*) surface water drought and (*ii*) ground water drought.

(*i*) ***Surface-water Drought.*** It is concerned with drying up of surface water resources such as rivers, streams, lakes, ponds, tanks, reservoirs, etc. There are many processes, besides meteorological drought, which lead to surface water drought. Large scale deforestation is the main cause of surface water drought. Some other unwanted human activities have led to the enhancement of flood/drought duo. Important among them are ecologically hazardous mining, indiscriminate road construction, and spread of non-terraced agriculture. In the Doon valley limestone quarrying has drastically changed the surface water flow in the valley turning several perennial rivers into carriers of monsoon floods which go dry after the monsoon.

(*ii*) ***Ground-water Drought.*** Ground-water drought is associated with the fall in the ground water level. This happens due to excessive pumping of ground water without compensatory replenishment and creates more or less irreversible ground water drought even in normal rainfall conditions. Ground water replenishment depends upon the availability of surface water obtained from rainfall and nature of soil. The Northern Plain of India has soft and porous alluvial soils. These soils permit percolation of water and help in ground water replenishment. In contrast, the peninsular plateau area is made up of hard and impervious rocks which hinder the process of ground water replenishment.

3. Agricultural Drought

Agricultural drought is concerned with the impact of meteorological/hydrological drought on crop yields. When soil moisture and rainfall conditions are not adequate enough to support a healthy crop growth to maturity thereby causing extreme moisture stress and wilting of major crop area, it leads to agricultural drought. Agricultural drought may occur even when there is no meteorological drought and *vice-versa*. It is worth noting that agricultural drought is a relative category, depending upon the value of plant and soil. What could be a drought condition for the cultivation of rice, could well be a suitable condition for wheat and a condition of excess soil moisture for dry crops like bajra or jowar. Thus the choice of crops evolve according to variations of climatic and soil conditions. The indigenous dry-crops prove very high-yielding when there is optimum use of water. However, under extreme condition of soil water drought, no plant can survive and this condition is termed as ***desertification.***

With the onset of green revolution in India in 1960s, High Yielding Varieties (HYV) of seeds have replaced the traditional drought resisting seeds. The use of fertilisers has also increased the water requirements of different crops. The agriculture based on the Green Revolution technology is precariously dependent on irrigation and any delay in supply of water will cause serious agricultural drought. It has been found that the organic matter content of HYV seeds is quite less. Organic matter input to soil increases its water holding capacity and soils rich in organic content don't dry quickly. Hence the use of HYV seeds has increased the risk of agricultural drought to a great extent. Recent studies have revealed that with the addition of manure and organic fertiliser, the water retentivity in the soil increases by 2 to 5 times.

Change in cropping pattern, particularly with the introduction of Green Revolution technology, has also led to soil water drought. The indigenous cropping pattern was in tune with the agroclimatic conditions of the concerned region. With the introduction of an alien cropping pattern, more water demanding crops have gained importance which has led to soil water drought. For example, rice cultivation was practically unknown in Punjab, Haryana and Western Uttar Pradesh before Green Revolution and this region is not suitable for rice cultivation considering the amount of rainfall received by this region. The area receives an average annual rainfall from 50 to 75 cm whereas minimum amount of rainfall for any successful cultivation of rice is 100 cm. This change in the cropping pattern has put heavy strain on meagre water resources leading to acute occasional droughts.

In the drought affected areas of Maharashtra, Karnataka and Andhra Pradesh there is a change in the cropping pattern in which cash crops are given more importance than the traditional crops. Thus while the staple crops are denied water, cash crops like sugarcane and grapes are given priority with respect to irrigation. This leads to a condition of soil water drought which is created not by absolute scarcity of water but by preferential diversion of limited water resources.

4. Soil Moisture Drought

This is a situation of inadequate soil moisture particularly in rainfed areas which may not support crop growth. This happens in the event of a meteorological drought when the water supply to soil is less and water loss by evaporation is more.

5. Socio-Economic Drought

It reflects the reduction of availability of food and income loss on account of crop failures endangering food and social security of the people in the affected areas.

6. Famine

A famine occurs when large scale collapse of access to food occurs which, without intervention, can lead to mass starvation.

7. Ecological Drought

Ecological drought takes place when the productivity of a natural eco-system falls significantly as a consequence of distress induced environmental damage.

Causes of Droughts

Droughts in India occur in the event of a weak south-west monsoon. A weak monsoon results in deficient rainfall and droughts occur. Droughts also occur due to late arrival or early withdrawal of the monsoons. Prolonged breaks in the monsoon during rainy season also result in droughts. Although a drought may occur at any time and in any part of the country, most of the drought prone areas are those having marginal rainfall and high variability of rainfall.

Following are indications of a drought with respect to monsoon rainfall.

TABLE 8.4. Rainfall Vagaries and Drought Conditions

1. Deficient rainfall	A drought occurs when the rainfall is less than 75% of the normal.
2. Delay in onset	Maximum of three weeks from the normal date of arrived for a given region
3. Timely onset and sudden break	A maximum break of two weeks after the timely onset of the monsoon
4. Early withdrawal	A drought occurs when the monsoons withdraw from north-west India by the last week of August

Effects of Droughts

Droughts have a wide range of effects on the masses in a developing country like India. The impact of droughts is specifically conspicuous in view of the tropical monsoon character of the country. Rainfall by the south-west monsoon is notorious for its vagaries. The impact of droughts in India can be summed up under the following headings :

(i) Physical Impact. Meteorological drought adversely affects the recharge of soil moisture, surface runoff and ground water table. Soils dry up, surface runoff is reduced and ground water level is lowered. Rivers, lakes, ponds and reservoirs tend to dry up, wells and tube-wells are rendered unserviceable due to lowering of the ground water table.

(ii) Impact on Agriculture. Indian agriculture still largely depends upon monsoon rainfall where about two-thirds of the arable land lacks irrigation facilities and is termed as ***rainfed***. The effect is manifested in the shortfalls of agricultural production in drought years. History is replete with examples of serious shortfall in cultivated areas and drop in agricultural productivity. Severe shortage of foodgrains had been felt and the country had to resort to import of foodgrains to save the poor people from hunger and starvation. However, India has been able to build a buffer stock of foodgrains and threat from droughts is not as serious as it used to be before the Green Revolution.

It is worth mentioning here that the shortfall in agricultural production may be the direct impact of meteorological droughts but the succeeding hydrological and agricultural droughts have a long range and far reaching impact on agriculture. This impact may be in the form of changes in the cropping patterns and impoverishment on cattle.

(iii) Social and Economic Impact. Social and economic impact of a drought is more severe than the physical and agricultural impacts. A drought is almost invariably associated with famine which has its own social and economic consequences. The impact of drought manifests itself in the following sequence :

1. Decline in cultivated area and fall in agricultural production (including crops and milk).
2. Fall in employment in agricultural sector.
3. Fall in purchasing power.
4. Scarcity of drinking water, foodgrains and fodder.
5. Rise in inflation rate.
6. Distress sale of cattle and loss of cattle life.
7. Low intake of food and widespread malnutrition.
8. Ill health and spread of diseases like diarrhoea, dysentery, cholera and opthalmia caused by malnutrition, hunger and starvation.
9. Distress sale and mortgage of land, jewellery and personal property.
10. Migration of people from drought hit areas to other areas in search of livelihood and food.

11. Death due to malnutrition/starvation/diseases.
12. Slowing down of secondary and tertiary activities due to fall in agricultural production and decline in purchasing power.
13. Low morale of the people.
14. Social stress and tension, disruption of social institutions and increase in social crime.
15. Growth of fatalism and belief in supernatural powers and superstitions.

The greatest impact of a drought is seen on the weaker sections of society. These include landless labourers, small and marginal farmers as well as artisans like weavers. Such people live in hand to mouth economy and do not have enough stock to sustain in the event of a drought. Whatever little stock they have, it is quickly exhausted and they are compelled to go in for distress sale or mortgage their belongings to rich landlords. Thus whereas a drought situation brings miseries and sufferings for the poor people, the rich people take undue advantage of the situation and exploit the poor people. Often the poor becomes poorer and the rich becomes richer in a drought situation. A series of bad harvest plunges the small and marginal farmers in a vicious circle of poverty making them landless and penniless. The money-lender charges high rates of interest and the inability of the farmers to repay the loan compells them to forfeit their mortgaged property. In extreme cases, the farmers tend to commit suicide. Cases of suicide by farmers in Andhra Pradesh, Telangana, Karnataka, Odisha, Maharashtra and even in agriculturally rich states of Punjab and Haryana have been reported from time to time.

Drought Prone Areas

A drought prone area is defined as one in which the probability of a drought year is greater than 20 per cent. A chronic drought prone area is one in which the probability of a drought year is greater than 40 per cent. A drought year occurs when less than 75 per cent of the normal rainfall is received.

In India, the hard core of recurring drought affects 16 per cent of the total area and 12 per cent of the population, although the total average drought prone area may be as much as 10 lakh sq km or about one third of the total land area of the country. The areas regularly haunted by droughts are those receiving low (generally below 75 cm annually) and highly unreliable (variability over 40 per cent) rainfall and with inadequate irrigation facilities. In all 77 districts receiving less than 75 cm of rainfall per annum are drought prone. This accounts for 34 per cent of the net sown area. In addition, there are 22 districts in Maharashtra, Gujarat, Madhya Pradesh, Karnataka, Rajasthan and Uttar Pradesh accounting for 9 per cent of the cultivated area of the country which receives 75 to 85 cm of rainfall per annum. This rainfall is of doubtful efficacy and as such these districts should also be considered vulnerable to drought. However, the severest droughts have occurred in comparatively wet areas such as West Bengal, Bihar and Odisha where rainfall is normally plentiful enough to allow high density of population and where failure of rainfall can affect millions of people.

There are some well defined tracts of drought which are briefly described as under (**Fig. 8.9**).

(*a*) The desert and semi-desert region covering about 6 lakh sq km. It is more or less a rectangle formed by lines from Ahmedabad to Kanpur on one side and from Kanpur to Jalandhar on the other. Some areas in this region are without irrigation and comprise the worst famine tracts of the country.

(*b*) The dry region lying in the leeside of the Western Ghats upto a width of 300 km stretching eastwards up to 100 km from the East Coast and reaching right upto the southern tip of the peninsula. It covers an area of about 3.7 lakh sq km.

(*c*) Outside the above mentioned two major regions, there are isolated pockets which experience frequent droughts and are termed as drought prone areas. They are (*i*) Coimbatore and Nellai Kottabomman districts in Tamil Nadu; (*ii*) Saurashtra and Kachchh regions; (*iii*) Jhansi, Lalitpur, Banda, Mirzapur, Pilibhit, Kheri and Bahraich districts of Uttar Pradesh; (*iv*) Palamau plateau of Jharkhand; (*v*) Purulia district of West Bengal and (*vi*) Kalahandi region of Odisha, (*vii*) Large parts of Uttarakhand, and (*viii*) Jammu and Uddampur in Jammu and Kashmir. These scattered pockets account for about one lakh sq km.

Frequency of Droughts

Frequency of droughts refers to the number times droughts occur in a given duration of time. Different

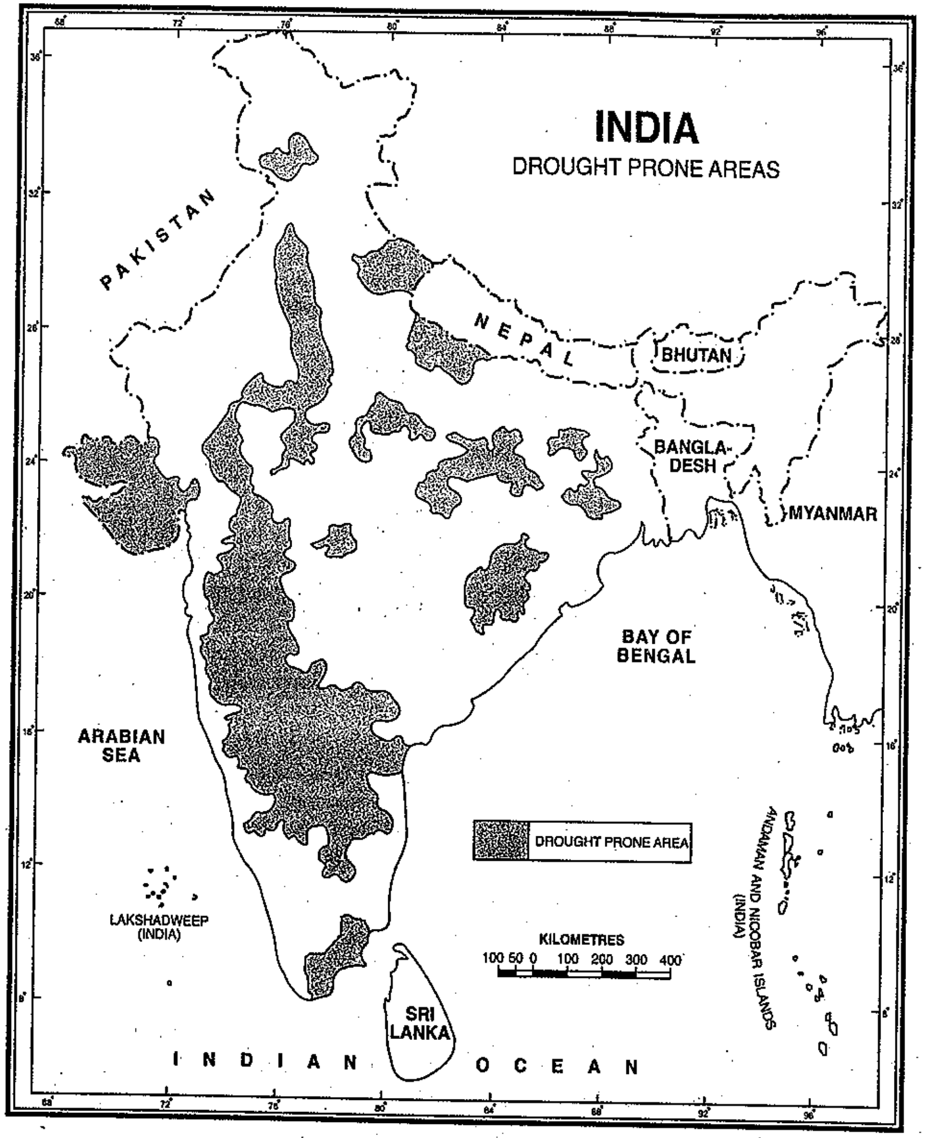


FIG. 8.9. India : Drought Prone Areas

parts of the country experience different frequencies of droughts depending on the amount of rainfall, variability of rainfall and water requirements. **Table 8.5** shows that areas with higher rainfall are less prone to droughts while the arid and semi-arid regions suffer from frequent droughts.

Drought Management

Among the various natural disasters the one which has received the greatest attention is the occurrence of drought. A drought often leads to total loss of crops or sharp drop in the production of foodgrains and creates conditions of famine. History

TABLE 8.5. Frequency of droughts in India

Meteorological sub-divisions	Recurrence of the period of highly deficient rainfall
1. Assam	Very rare, once in 15 years
2. West Bengal, Chhatisgarh, Bihar, Madhya Pradesh, Coastal Andhra Pradesh, Maharashtra, Konkan, Kerala, Odisha	Once in 5 years
3. South interior Karnataka, Eastern Uttar Pradesh, Vidarbha	Once in 4 years
4. Gujarat, Eastern Rajasthan, Western Uttar Pradesh, Tamil Nadu, Kashmir, Rayalseema, Telangana	Once in 3 years
5. Western Rajasthan	Once in 2.5 years

Source : India Meteorological Department.

is replete with great famines in the country and the strategies adopted to face the challenges. Drought is a slow onset natural hazard and offers sufficient time and opportunity to mitigate its impact. The first systematic attempt at famine relief measures could be traced to Great Famine or the Orissa Famine of 1866. The first Famine Commission was appointed by the then Government of India under the Chairmanship of Sir George Cambell. The second step was the appointment of a Famine Commission in 1880 following the famines of 1873 and 1876-78. Following the recommendations of the Famine Commission, the administration decided to promulgate Famine Codes from 1883 onwards which ushered in the modern policy of relief administration.

Moving from Drought Relief to Drought Management. After Independence, India experienced major droughts in the years 1965-67, 1972-73, 1979-80 and 1985-88. The analysis of India's drought response efforts reveals that the pre-1987 efforts to mitigate droughts were primarily focused to intervene at later stages, particularly at the socio-economic drought stage. The approach was to deal with ultimate consequences of the drought thus preventing the deterioration drought leading to famine conditions, essentially providing employment opportunities to the affected population through relief projects and distribution of foodgrains through public distribution system (PDS). The contingent drought relief expenditure imposed a serious strain on public finances as huge amounts had to be divested from development for undertaking relief projects. Analysis of the drought relief expenditure incurred by the Rajasthan Government in 1980s reveals that the drought relief outlays exceeded development outlays.

By incorporating contingency crop planning with drought response efforts through relief approaches acquired the status of Drought Management Strategies in early 1970s. The drought management approach differed from drought relief approach with regard to objectives, reliance of early warning indicators and timing of public intervention. The objective of relief approach was to protect entitlements of the affected population by ensuring physical and economic access to food through relief projects and public distribution system of foodgrains. As against this, the drought management approach aimed at ensuring entitlement to produce food so as to obviate the need for taking up *ad hoc* relief projects. While drought relief approach relied on socio-economic indicators like crop production data, price rise, migration of the people and increased rate of petty crimes, etc., for drought declaration and intervention, drought management approach relied on hydro-agro indicators like rainfall, water level reservoirs and progress of cropping pattern to detect early signs of developing drought situation. While drought relief approach enabled the government to intervene only in the month of November/December when the rainy season is over and the kharif crops have been harvested, the drought management approach enabled the government to intervene in the monsoon season itself.

According to report of the High Powered Committee on Disaster Management (2002), "Drought management is generally by focus on employment generation, water conservation and power supply, standing crop saving and public distribution supplies of essential commodities". However, drought management may conveniently be discussed under the following heads.

1. Drought Prone Area Programmes (DPAP)

This programme was initiated in 1974. The intention was to change DPAP from a relief and employment oriented programme into one aimed at 'drought proofing' through adoption of an integrated area development approach which sought to mitigate the impact of future droughts by stabilizing both production and employment. The programme was conceived as a long term measure for restoration of ecological balance by conserving, developing and harvesting land, water, livestock and human resources. The objectives of the programme are :

(*i*) To minimise the adverse effects of drought on production of crops and livestock and productivity of land, water and human resources through integrated development of the natural resource base of the area and adoption of appropriate technologies.

(*ii*) To conserve, develop and harness land, water and other natural resources including rainfall for restoration of ecological balance in the long run.

DPAP is under implementation in 629 blocks of 96 districts in 13 states. The total area covered under this programme is about 5.54 lakh sq km.

2. Establishment of Crop-weather Watch Group

This watch group was set up during 1979 drought by the Ministry of Agriculture. It consists of representatives from the Department of Agriculture, India Meteorology Department, Indian Council of Agricultural Research, Ministry of Information and Broadcasting, and others. A two pronged strategy was adopted which focused on curative and preventive measures. They were to provide weekly reports of rainfall, agricultural operations, employment and other activities for occurrences affected by drought. The twelve-point programme was created to avert *Trikal* (*Akal, Jalkal, Tinka*), which means to take care of food, water, and fodder. Although drought affected 240 districts and 220 million people, the severity was not widely felt and no starvation deaths were reported because of the buffer stocks of food grains available with the government.

3. Integrated Watershed Management

Integrated watershed management as a preventive measure plays a key role in moderating drought conditions. This approach ensures planning on the basis of the total available water resources, conjunctive use of surface and groundwater, allocating priority for rational use of water and also the preparation of a coordinated plan. Thus, watershed management hold the promise of conservation of land and water resources and their optimal utilization in reality. Under the National Watershed Programme for Rainfed Areas, a large number of watersheds have been established in different rainfed regions of the country.

FLOODS

Definition and Introduction

Flood is a state of high water level along a river channel or on coast that leads to inundation of land which is normally submerged. Flood is an important component of hydrological cycle of a drainage basin. As a matter of fact droughts and floods are two extreme ends of the hydrological cycle. While droughts occur due to failure of rainfall caused by the southwest monsoons, floods occur in the event of excessive rainfall. Flood is a natural hazard which occurs in response to heavy rainfall and it *becomes a disaster when it inflicts heavy loss to life and property.*

Causes of Floods

Floods are generally caused by one or more unfavourable meteorological and physical factors. A combination of unfavourable meteorological and physical factors working together leads to a serious flood situation resulting in a disaster. In recent times, the impact of meteorological and physical factors has been accentuated by unwanted human activities. Following are the major causes of floods in India.

A. ***Meteorological Factors***

1. Heavy Rainfall
2. Tropical Cyclones
3. Cloud Burst

B. ***Physical Factors***

1. Large Catchment Area
2. Inadequate Drainage Arrangement

C. ***Human Factors***

1. Deforestation
2. Siltation
3. Faulty Agricultural Practices
4. Faulty Irrigation Practices
5. Bursting of Dams
6. Accelerated Urbanisation

Effects of Floods

Floods have multipronged effects on human life. A more frightening fact is that floods are becoming more damaging as their frequency, intensity and magnitude increases with the passage of time. The most damaging effect of floods is the colossal loss of life and property. The other losses include damage to crops, cattle loss, break down of communication, dislocation of transport system and disruption of essential services.

Earlier the impact of floods was not as intense and widespread as it is now. There are several reasons for this deteriorating condition. Floods are becoming more frequent and furious due to ecological degradation such as deforestation. Moreover, the population in India is increasing at a rapid pace and even the areas prone to floods, such as flood plains and even river beds are inhabited by the people. The principle '*where a river has the right of way stay out of its way*' is not followed by the people who have little option in setting themselves or locating industrial projects. In fact floods cause more damage than any other single disaster. India is the most flood affected country in the world next only to Bangladesh. About 20 per cent of the global deaths caused by floods in the world are in India. Bangladesh accounts for about 5 per cent of the total. The most severely affected are generally the poor people because they live on the periphery of human habitat. **Table 8.6** gives an idea of flood damages in India.

TABLE 8.6. Annual Average Flood Damages (based on data from 1953 onwards)

Damage Head	Magnitude
1. Land area affected	7.56 million hectare
2. Population affected	32.03 million
3. Human lives lost	1,504 number
4. Livestock lost	96,713
5. Houses damaged	11,683 (₹ 136.615 crore)
6. Crop damaged	₹ 460.07 crore
7. Public utilities damaged	₹ 377.248 crore
Total Losses	₹ 982.126 crore

Source : Manual on Natural Disaster Management in India, NDM Division (2001), p. 29.

Flood Prone Areas

The Rashtriya Barh Ayog (RBA) or National Commission on Floods, set up by the Government of India in 1976, provided statistical evidence of flood problem in the country. The commission took the maximum area affected by floods in a state in any one year, as its flood prone area and added up the flood prone areas of all the states to get the flood prone area of the country. This proved to be erroneous method as it underestimates the severity of the problem. This is due to the fact that there is no guarantee that floods in any year will affect only those areas which were affected during the maximum flood year. On several occasions, flood waters have inundated areas which were never flooded before. Yet the commission found that the country's flood prone area increased from 25 mha in 1960s to 34 mha in 1978. At present 40 mha or one eighths of the total land area of the country is assessed to be flood-prone. This shows that there has been a rapid increase in he flood-prone area of the country. A glance at **Fig. 8.10** will show how the flood prone areas are distributed. It is estimated that over three-fourths of the total damage done to crops and property is in the plains of Northern India comprising of Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal and Assam. The geographical distribution of flood prone areas in India is as under :

The Ganga River Region

In Uttar Pradesh and Bihar, the mighty Ganga receives a large number of tributaries such as the Gomati, the Ghaghra, the Gandak and the Kosi from the left bank as well as the Yamuna and the Son from the right bank. This brings huge quantities of water to these areas both from the Himalayan region and from the Peninsular India resulting in devastating floods. River Kosi often shifts its course flooding new areas and converting once fertile areas into wasteland. The Kosi which means *kosna* (curse), brings flood fury to

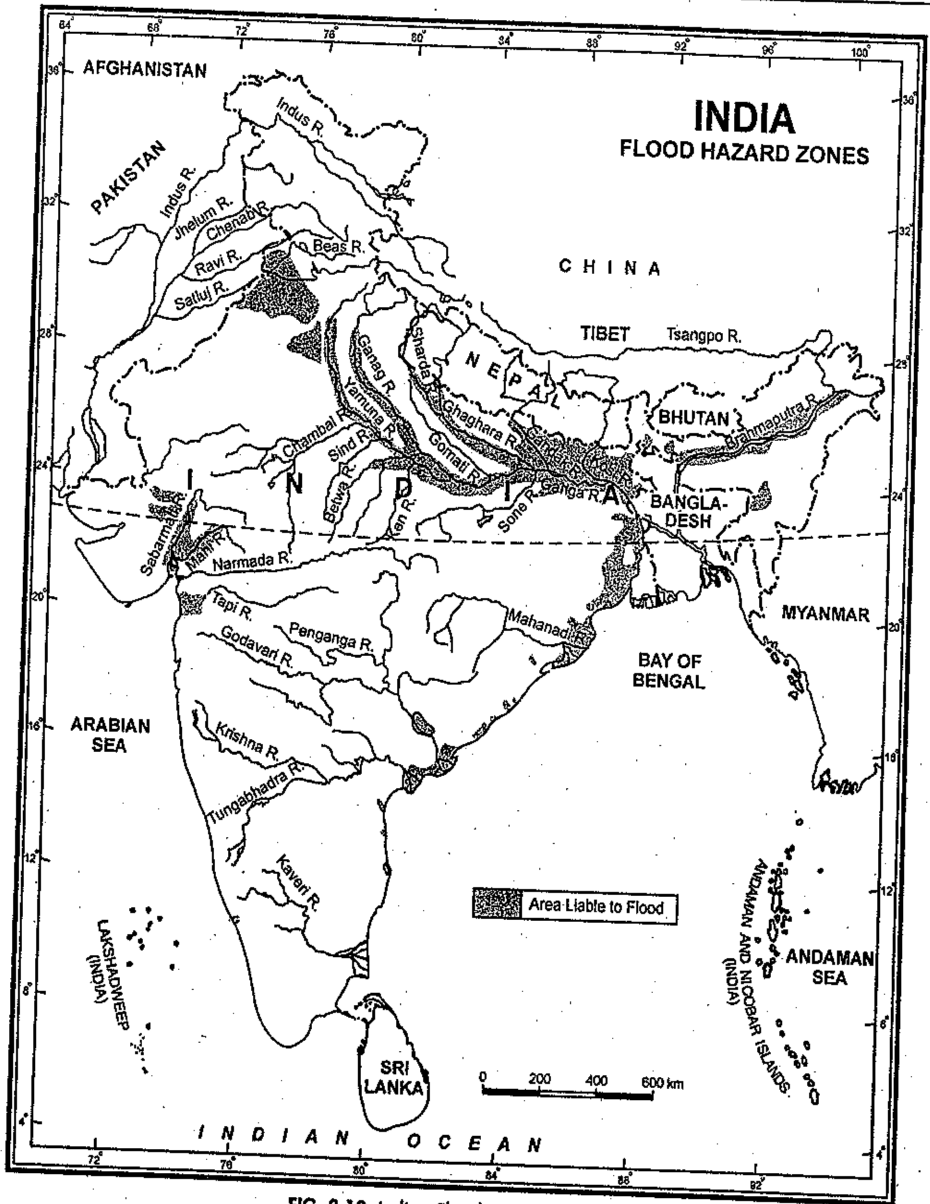


FIG. 8.10. India : Flood Hazard Zones

vast area every year and is living upto its name. The Yamuna is an important right bank tributary of the Ganga and floods large areas in Uttar Pradesh and Haryana. The Chambal and the Betwa meet the Yamuna and add to the flooding capacity of the Yamuna.

In *Uttar Pradesh* floods are frequent in the eastern districts, mainly due to spilling of the Rapti,

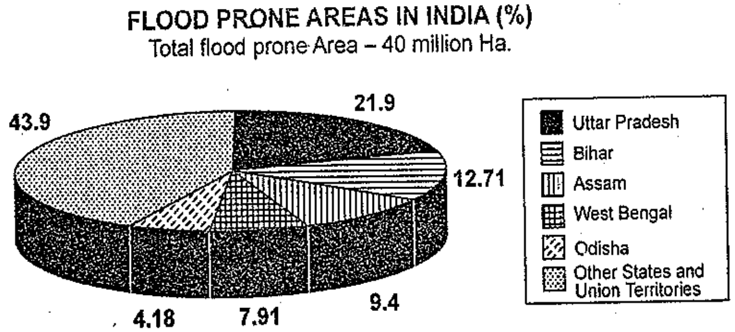


FIG. 8.11. Flood Prone Areas in India (%)

the Sharda, the Ghaghra and the Gandak. The problem of drainage congestion exists in the western parts of Uttar Pradesh, particularly in Agra, Mathura and Meerut districts. Erosion is experienced in some places on the left bank of the Ganga and on the right banks of the Ghaghra and the Gandak.

In *Bihar* the floods are largely confined to the northern part of the state where occurrence of floods is almost an annual feature. The rivers such as the Burhi Gandak, the Bhagmati and the Kamala and other smaller rivers of the Adhwara Group, the Kosi in the lower reaches and the Mahananda spill over their banks causing considerable damage to crops and dislocation of traffic.

Uttar Pradesh and Bihar are the worst flood affected states and account for over one-third of the flood prone area of the country.

In *West Bengal* the southern and central parts are flooded by the Mahananda, the Bhagirathi, the Ajoy, the Damodar etc. due to an inadequate capacity of river channels and tidal effect. There are occasional floods caused by the Damodar river even after the construction of four dams and a barrage under the Damodar Valley Project. In 1956, about 25,000 sq km of area was flooded in Southern districts of West Bengal by this river. The Ganga delta is often flooded. There is also the problem of erosion of banks of some of the rivers and on left and right banks of the Ganga upstream and downstream respectively of the Farakka Barrage.

Cloudburst and Floods in Uttarakhand

The torrential rainfall caused by a cloudburst on June 16, 2013 led to a flood situation which was never experienced in the meteorological history of the state of Uttarakhand. Districts of Uttarkashi and Rudraprayag were the most affected areas where 479 mm rainfall was recorded in a short span of just three hours. The Himalayan tributaries of the Ganga like Alaknanda, Mandakini, Bhagirathi, Kali Ganga, Gauri Ganga were in spate. According to National Disaster Management Authority (NDMA), these floods left about 15,000 dead, 436 injured and 1800 missing. As many as 1,07,670 people had to be evacuated from the flooded areas and were taken to be safer places. Moreover, 2,232 houses, 154 bridges and 1520 roads were damaged. The flooding was so fierce and disastrous and the loss of life and property was so colossal that it was named as ***Himalayan Tsunami.***

Natural or Manmade Disaster?

Like all other weather events, cloudbursts and the consequent floods are natural phenomena as these area caused by unusual behaviour of monsoon winds. The abnormally higher amount of rainfall (more than 400 per cent) in Uttarakhand was caused by fusion of westerlies with monsoon at cloud system. The westerlies reached the Himalayan states via Afghanistan to collide with the monsoon, triggering deadly rains. Besides the rain water, a huge quantity of water was probably released from melting of ice and glacious due to high temperature during the months of May and June. The water not only filled up the lakes and rivers but also caused breaching of moraine dammed lakes in the upper reaches of the Himalayas.

Although cloudburst, heavy rainfall and devastating flood are primarily natural phenomena, several environmentalists term this as a ***man-made*** *disaster*. Unwanted human activities leading to environmental changes have aggravated the problem and reduced the natural defense system. In the last few decades the region has witnessed large scale demographic changes in the form of growth and composition of population, rapid urbanisation, deforestation and expansion of roads. The Uttarakhand Himalayas have undergone large scale slope destablization, particularly along the roads where widening of roads was in progress. Unabated expansion of hydroelectric power stations and rapidly increasing tourism, particularly pilgrimage, are some of the reasons of unprecedented devastations. Mindless illegal construction of resorts, hotels, guest houses and roads has been undertaken in this ecologically fragile region. Buildings have been constructed over flood ways, old drains and streams blocking the natural pathway of water. Human greed has forgotten the fact that these ecologically fragile mountainous areas have limited carrying capacity which should not be exceeded at any cost.

It is estimated that as many as 70 hydal projects in three major river basins *viz*. Alaknanda, Mandakini and Bhagirathi have been proposed to be constructed. Of them, 23 are mega projects (more than 100 MW) 22 medium (10-100 MW) and 25 small (less than 10 MW). Hydroelectric projects require large scale blasting of hills to build dams and tunnels, disturbing the rock structure, which starts rolling down once the top soil is uprooted by rains. The muck fills the river bed and flows down with water, intensifying the river's rage. Huge diversion of forest cover for these dams also reduces the capacity of the local ecology to retain rain water. Further 640.25 kilometres of natural flow of the rivers, about half the length of major rivers the region, is diverted. This leads to catastrophic floods when the rives tend flow in their natural courses.

The anthropogenic factors have led to the increased frequency and severely of floods in the whole of the Himalayan region. For example, Uttarkashi had just one flash flood between 1978 and 2005 but bad to suffer from four major flash floods between 2005 and 2013.

Glacial Lakes Outburst Flood (GLOF). A glacial lake is a water mass existing in a sufficient amount and extending with a free surface in, under, beside and/or in front of a glacier and originating from glacier activities and/or retreating process of a glacier. Triggering events for an outburst can be moraine failures induced by an earthquake, by increase of permafrost (permanently frozen ground) and increased water pressure, or a rock or snow avalanche slumping into the lake causing an overflow.

The mechanism that triggers floods from glacial lakes depends on the nature of the damning materials, the position of the lake volume of water, nature and position of the mother glacier, physical and topographical condition and physical conditions of the surrounding areas. The important chain reaction in this context is the danger from avalanches, debris flows, rock fall or landslides reaching the lake and provoking a lake outburst.

Since the beginning of the 19th century, the number of glacial lake outburst floods (GLOFs) has increased in the Himalayas. It is estimated that there are about 20,000 glacial lakes in the Himalayas which have been formed by melting of glaciers, perhaps due to global warming. Of these, over 200 glacial lakes have the potential of causing catastrophic outburst floods. This fact has been established by the International Centre for Integrated Mountain Development (ICIMOD) at Kathmandu which used satellites-based geographical information system (GIS) and high resolution remote sensing technology to locate these glacial lakes in the Himalayas. According to a recent study by ICIMOD as many as 20 glacial lakes in Nepal, and 24 in Bhutan have become potentially dangerous as a result of climate change. In India, there are 14 lakes in the Tista river basin and 16 in Himachal Pradesh. Nepal and Bhutan are among the first countries in the world to make glacial outburst floods a national priority. But in India, information on basic glaciology and more specifically the threat from GLOF is scatter and of little value. The main reason for such a situation is that such lakes are situated in remote and inaccessible areas and findings of remote sensing and GIS to be cross checked on the basis of ground studies is difficult. However, a report compiled by scientists at Delhi University for the Ministry of Environment and Forests in 2008 showed the existence of 366 glacial lakes in Sikkim's Tista basin; which is much more than reported by ICIMOD.

The most significant chain reaction in connection with GLOF is the danger from avalanches, debris

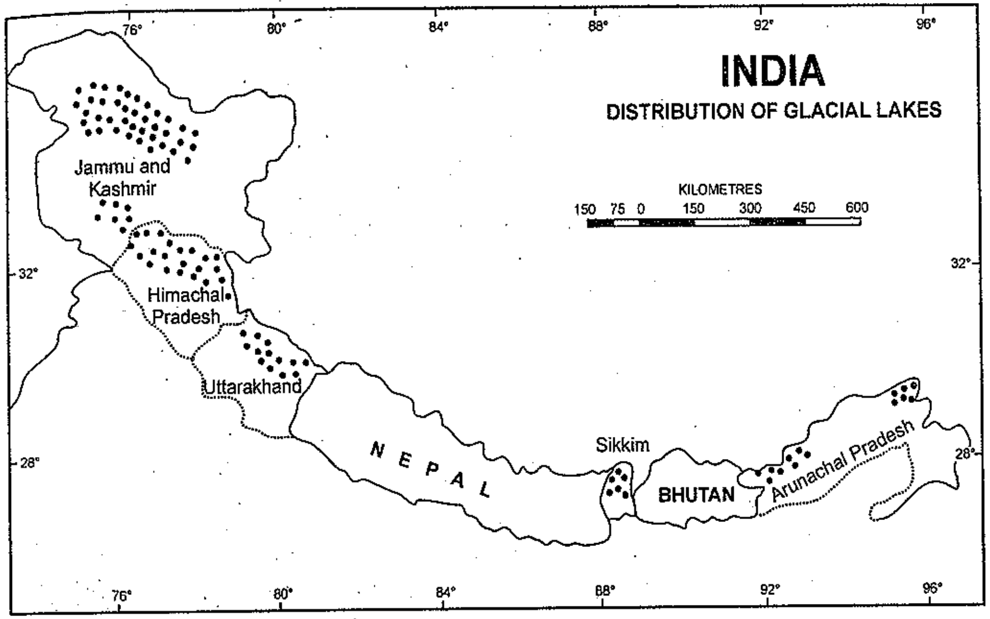


FIG. 8.12. India : Glacial Lakes in the Himalayas

flow, rock fall or landslides reaching the lake and thus provoking the lake outburst. Only Moraine Dammed Lakes, Ice Dammed Lakes and Ice-cored Dammed Lakes are considered to be vulnerable from the GLOF point of view. Breaching and instantaneous discharge of water from glacial lakes can cause flash floods which are big enough to create enormous damage in the downstream areas. Such floods pose severe geomorphological hazards and can wreak havoc on all manmade structures located along their path. Huge damage created during GLOF events is associated with large amounts of debris that accompany the flood waters. GLOF evens have resulted in a large number of deaths as well as destruction to houses, bridges, agricultural, fields, roads, etc. Such damages are almost unrecoverable and can take place at long distances from the outburst source.

GLOFs are like ticking time bombs which are capable of releasing billions of cubic metres of glacial water, in a few hours or even in a matter of a few minutes and virtually without warning to those living downstream. Unfortunately, the danger from GLOFs is increasing due to increase in size and number of glacial lakes resulting from global warming.

Researchers, till the catastrophic flood of 16-17 June, 2013 in Kedarnath, were of the opinion that this area is not prone to GLOFs. However, heavy downpour on June 16, 2013 rapidly filled up Chorabari Tal, a glacial lake less than 4 km upstream from Kedarnath and continued heavy rainfall next morning caused lake to overflow and possibly burst out from its loosely packed rim of moraines. This event re-inforced the already serious situation and destroyed almost whole of Kedarnath town and several other areas downstream.

Mitigation

1. Damages by cloudburst or GLOFs can be considerably reduced by forecasts and early warning system. It appears that warnings issued by India Meteorological Department were not taken seriously and the precious warning time was not used.
2. Large areas of the Himalayas are at the risk natural hazards like intense rainfall, earthquakes, landslides, avalanches, GLOFs etc. Mapping and monitoring of said areas is of paramount importance.

3. Principles of hydro-ecology and engineering should be strictly followed in planning and designing of infrastructure and disaster preparedness. Huge damage in Uttarakhand in June, 2013 is partly attributed to large scale illegal construction of buildings in the river beds and other flood prone areas.
4. Comprehensive reports of the entire Himalayan region for better planning and management are urgently needed.
5. Periodic review of water level in the glacial lakes, lake overflows, movement of moraines, activation of dormant river channels, etc. can go a long way to reduce the impact of natural hazards like GLOFs.

The Bhrahmaputra River Region

In the Brahmaputra basin, floods are almost an annual feature. The main cause of floods here is heavy rainfall amounting to over 250 cm during the rainy season. Large amount of silt is deposited here by the Brahmaputra and its tributaries which makes the river channel shallow and its capacity to carry large amount of water is reduced. This results in flooding of vast areas in and around the valley. Earthquakes, which occur at frequent intervals, cause change in the level of river course and the flow of water in the river is obstructed. This leads to inundation of large areas in this region. Landslides are very common here. Huge rock material falling as a result of landslides acts as a temporary dam across the river and vast area is submerged under water. Later it gives way under the pressure of water and floods large area downstream. The Assam Valley is considered to be one of the worst flood-affected areas of India. The main causes of floods in the Brahmaputra river system can be summed up as under :

(*i*) There are 34 major tributary rivers of the Brahmaputra. These bring huge quantities of water and silt which cause floods.

(*ii*) Very heavy rainfall exceeding 250 cm per annum.

(*iii*) Narrowness of the Brahmaputra valley with a maximum width of about 81 km surrounded by hills.

(*iv*) Heavy deposit of silt has raised the river bed considerably which has reduced the water accommodating capacity of the river.

(*v*) Occasional earthquakes, such as those of 1897, 1930, 1950 and 1984 have brought about changes in the course of the river.

(*vi*) Very high population pressure, primarily due to migration from Bangladesh and some other Indian states has forced people to live in the flood prone area.

According to the reports of the Assam government, all the districts of the Brahmaputra valley are inundated almost every year.

Though most of the flood affected areas in Assam are rural in character, yet some urban areas are also affected by floods each year. The worst flood affected area of the Brahmaputra valley is the world's largest river island, Majuli. The urban areas of Assam, namely Dhubri, Guwahati, Dibrugarh, Tezpur etc. ate frequently flooded. It has been estimated that an area of 30 lakh hectares out of 78 lakh hectares *i.e.*, about 45 per cent of Assam's total area is flood prone.

The North West Rivers Region

The flood problem in this region is less serious as compared to the one prevailing in the Ganga and the Brahmaputra river regions. The major problem is that of inadequate surface drainage which causes inundation and waterlogging over vast areas. In the Punjab-Haryana plain rain water in the waterlogged and poorly drained areas inundate large parts. Major and minor rivers like the Satluj, the Beas, the Ghaggar and the Markanda are in spate during the rainy season and bring flood havoc to vast areas.

In *Punjab* floods are an annual feature though intense floods are experienced at an interval of 4-5 years. The main reason of floods in Punjab is obstruction of poor natural drainage by man made features. Some of the major canals (the Bhakra System) do not follow the natural flow and create obstacles. Secondly, National Highway No. 1 and the main railway line run almost perpendicular to the natural flow. Cultivation of area near river banks and construction activities in low lying areas, especially in cities like Ludhiana, Patiala, etc. have together created obstacles in the natural flow of water.

The state of *Haryana* experiences severe flood once in a decade. The saucer shaped topography of the state does not permit free flow of surface runoff and even a moderate rainfall can cause floods. Sometimes, floods are caused by the Ghaggar river also. This river used to disappear in the sands of Rajasthan after flowing through Punjab and Haryana. In recent years, besides flooding Punjab and Haryana areas, it has become active in Rajasthan territory also, occasionally submerging large areas.

In the north-western river basin covering Jammu and Kashmir and Himachal Pradesh, the Satluj, the Beas, the Ravi and the Chenab often flood large areas. Floods occur periodically in Jhelum and its tributaries in the Kashmir Valley causing a rise in level of the Wular Lake thereby submerging marginal areas of the lakes and sometimes threatening Srinagar and other areas along the river banks. Similarly the Chenab and its tributaries like Tawi are often in spate endangering several densely populated areas in Jammu and Akhnoor.

The Central India and the Deccan Region

The southern states of Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, Odisha, Jharkhand, Chhattisgarh, Maharashtra, the state of Gujarat and parts of Madhya Pradesh are included in this region. The floods do not pose a serious problem in this region because most of the rivers have well defined and stable courses. However, the deltas of the Mahanadi, the Godavari, the Krishna and the Cauvery suffer from occasional floods owing to the large scale silting and the consequent change in the river courses. Indiscriminate felling of trees in the catchment areas of major rivers has complicated the flood problem. High tide at the time of flood aggravates the flood situation. Lower courses of the Narmada and the Tapi in Gujarat are also prone to floods.

The small rivers of *Kerala*, originating in the Western Ghats and flowing to the Arabian sea, cause considerable damage when in spate.

The above description of flood prone areas reveals that one or other part of the country is affected by floods and flooding is almost an annual phenomenon.

FLOOD DISASTER MANAGEMENT

Flood disaster management implies not letting the excess runoff water flow suddenly and intensively in the drainage network. After the unprecedented floods of 1954, flood management works were taken up in a planned manner by the State Governments. The main thrust of managing floods in different river basins was to modify the floods through specific structural measures such as reservoirs, embankments, channel improvement, town protection and river training works. The various measures adopted for flood mitigation may be categorised into two groups *viz.*, structural and non-structural. The main steps for flood disaster management are briefly discussed below.

(1) Flood Forecasting

Flood forecasting involves giving prior information regarding the occurrence of floods. This is essential and is extremely useful for taking timely action to prevent loss of human lives, livestock and movable property. The Central Water Commission (CWC) started flood forecasting in November 1958 when the first forecasting station was established at Old Railway Bridge, Delhi. Since then it has been extended to cover almost all the major inter-state flood prone rivers of the country. At present there are 175 flood forecasting stations on various rivers in the country which includes 147 river level forecasting and 28 inflow forecasting stations spread over nine major river basins.

These centres issue daily-flood forecasts and warnings throughout the flood season from May to October. For achieving greater accuracy, the Central Water Commission recently established a procedure of carrying out a self-analysis and appraisal of the forecasting network at the end of the monsoon season.

Flood forecasting involves the following four main activities :

(*i*) Observation and collection of hydrological and hydro-meteorological data;

(*ii*) Transmission of data to forecasting centres;

(*iii*) Analysis of data and formulation of forecast; and

(*iv*) Dissemination of forecast.

On an average, 7,500 forecasts at various places in the country are issued during the monsoon season every year with over 98 per cent accuracy. A forecast is considered accurate if forecast water level is within ±15 cm of actual water level and the inflow forecast (*i.e.*, discharge) is within ± 20% of actual discharge.

A Memorandum of Understanding was signed by India and Nepal in 1988 according to which 45 Hydrological and Hydro-meteorological Stations were to be set up in India and Nepal for issuing flood forecasts to benefit both the countries.

A Memorandum of Understand with China has also been signed according to which China provides hydrological information with respect to Brahmaputra and Satluj rivers during the monsoon season. The MoU is renewed from time to time for regular flow of information. This information is utilised in the formation of flood forecasts by the Central Water Commission.

Bulletins are also updated on CWC Website www.cwc.nic.in for wider publicity among user agencies during flood season.

Forecast Bulletins

Flood forecasts and warning which are formulated by various flood forecasting centres are supplied in the form of "DAILY WATER LEVEL AND FLOOD FORECAST BULLETINS" to concerned Civil and Engineering Authorities on Wireless/Telephone/by Special messenger/Priority Telegrams, depending upon the urgency and available mode of communication media.

Control Rooms

Generally, the State Governments set up "Central Control Rooms" at State and District Headquarters which receive these forecasts and disseminate the warning to the affected areas and organise relief as well as rescue operations. The forecasting centres also send the forecasts to the "ALL INDIA RADIO" stations, "DOORDARSHAN" and the local "NEWSPAPER" for wider publicity.

On receipt of "Fresh Information" a revised forecast is issued, if the situation warrants. During high flood stages the "Control Room" of the forecasting centre works round the clock and keeps informed the flood fighting agencies about the latest river position. They work in close collaboration.

2. Reduction of Runoff

Reduction of runoff is one of the very effective methods of flood disaster management. Runoff can be reduced by inducing and increasing infiltration of the surface water into the ground in the catchment area. This can be done by large scale afforestation particularly in the catchment area. Afforestation helps in reduction of runoff in the following ways :

(*i*) The canopy of the forest cover intercepts the falling raindrops and the roots, the leaf litter and humus are capable of holding water.

(*ii*) Together these encourage infiltration and reduce runoff.

(*iii*) Runoff reduction helps in reducing soil erosion which leads to reduced sediment load of the streams.

(*iv*) Reduction in stream sediment load reduces siltation and helps in maintaining the water accommodating capacity of the rivers.

In the Indo-Gangetic plain, the runoff can be reduced by artificially inducing infiltration by digging wells along the beds of ephermal channels. A series of dug wells helps in storing and channelising the surface water. There is vast scope of using this method in the Northern Plain of India due to soft soil and vastness of aquifers.

3. Reducing Flood Peaks by Volume Reduction (Constructing Dams and Detention Basins)

The flood peaks can be reduced by construction of dams and detention basins. Dams have the capacity of holding huge quantity of water during the flood period and help in reducing flood peak volume of water. Water stored in reservoirs created by constructing dams can be allowed to flow down the stream under controlled conditions depending upon the accommodating capacity of the river downstream the dam. A number of reservoir projects have been completed in India since the launching of the National Flood Control Programme in 1954. These dams have helped in mitigating flood-peak in the down stream reaches. Notable among these are Tilaiya, Konar, Maithon and Panchet Hill dams in the Damodar Valley System, Bhakra Dam on the Satluj, Hirakud Dam on the Mahanadi, Pong Dam on the Beas, Nagarjun Sagar and Tunghbhadra on the Krishna and

Ukai Dam on the Tapi. All these dams have afforded reasonable degree of protection to about 13.64 lakh hectares of land.

Apart from dams as described above ponds, tanks and surface storage structures also check flood and help in harvesting water for dry seasons. Other types of detention basins include natural depressions such as marshes in plains and old quarries and mines.

4. Reducing Flood Levels

Flood levels can be reducing in the following ways.

(*i*) Stream Channelisation. A close network of canals reduces flood hazard to a great extent because flood water flowing in the river can be diverted to canals. Canals serve as temporary storage and hold water as its flood waves move downstream. Thus they help in reducing the severity of the flood.

(*ii*) Channel Improvement. Channel improvement is done by deepening, widening, straightening, lining and cleaning out of vegetation and debris from the river channel. These changes in the river channel increase the flood conveyance capacity of the river. Channel improvement is supplemented by bank stabilisation by constructing ripraps, dykes or spurs and planting deep root trees on embankments. In a meandering river, meander loops impede drainage and retard disposal of flood water. Whenever, the river meanders become extremely sharp, they can be straightened by artificially cutting individual or a series of bends. This method can be applied to the meandering courses of the rivers like the Gandak, the Gomati, the Rapti, the Kosi, etc.

(*iii*) Flood Diversion. Flood diversion is the process of diverting the flood water in marshes, lakes, the depressions and spreading it thinly over paddy fields and desert drylands. One such scheme is the Ghaggar Diversion Scheme which diverts 340 cumecs (cubic metres per second) of water before its entry into Rajasthan into the depressions and the areas between the sand dunes. In this way, discharge of water in the Ghaggar river is kept within the safe limits during the flood period.

5. Protection against Inundation (Construction of Embankments)

Building of embankments was considered to be the only way of controlling floods in 1940s. It is still considered to be one of the very effective devices against inundation of the inhabited areas and agricultural land. Construction of embankments has been taken up on a large scale in India. Between 1954 and 1978, 10,821 km long embankments had been built. By March 2000, more than 33,630 km of new embankments had been constructed. Most of the embankments have been constructed in north India where the Brahmaputra valley of Assam, northern parts of Bihar, Uttar Pradesh (Ganga, Yamuna and Ghaghara) and Punjab (Satluj, Beas and Ravi) are the main beneficiaries. In south India, embankments have been constructed mainly in the deltaic parts of the Mahanadi, the Godavari, the Krishna and along the banks of Penneru (**Fig. 8.13**).

As mentioned earlier, the Brahmaputra valley in Assam is the most frequently and severely flooded part of India. As such it is also the most heavily embanked part of the country. About one third of the total embankments of India have been constructed in Assam alone. The largest construction of embankments has taken place along the Brahmaputra river itself. Efforts have been made to control floods in the Brahmaputra river by constructing embankments at several places. At present the total length of embankments along the Brahmaputra is 934 km and 2,400 km on its various tributaries. These embankments provide protection to an area of 13.27 lakh hectares out of a total flood-prone area of 30 lakh hectares.

Next to Assam, Bihar is the most heavily embanked state. About 20 per cent of the total embankments of India have been constructed in Bihar. With the increase in flood prone area over the years from 2.5 million hectares in 1952 to 6.89 million hectares in 1994, the length of embankments has also grown from 160 km in 1952 to 3,465 km in 1998 *i.e.*, an increase of almost 22 times. The Kosi, and the Burhi Gandak are the most heavily embanked rivers. The Gandak, the Bhagmati, the Son and the Mahananda also have long stretches of embankments. These embankments have provided considerable protection to large areas particularly in north Bihar.

However, there are severe limitations of embankments as a flood control device. As a matter of fact, they are not so much a method of flood control as flood transfer. Embankments may protect the neighbouring areas but they often cause floods in

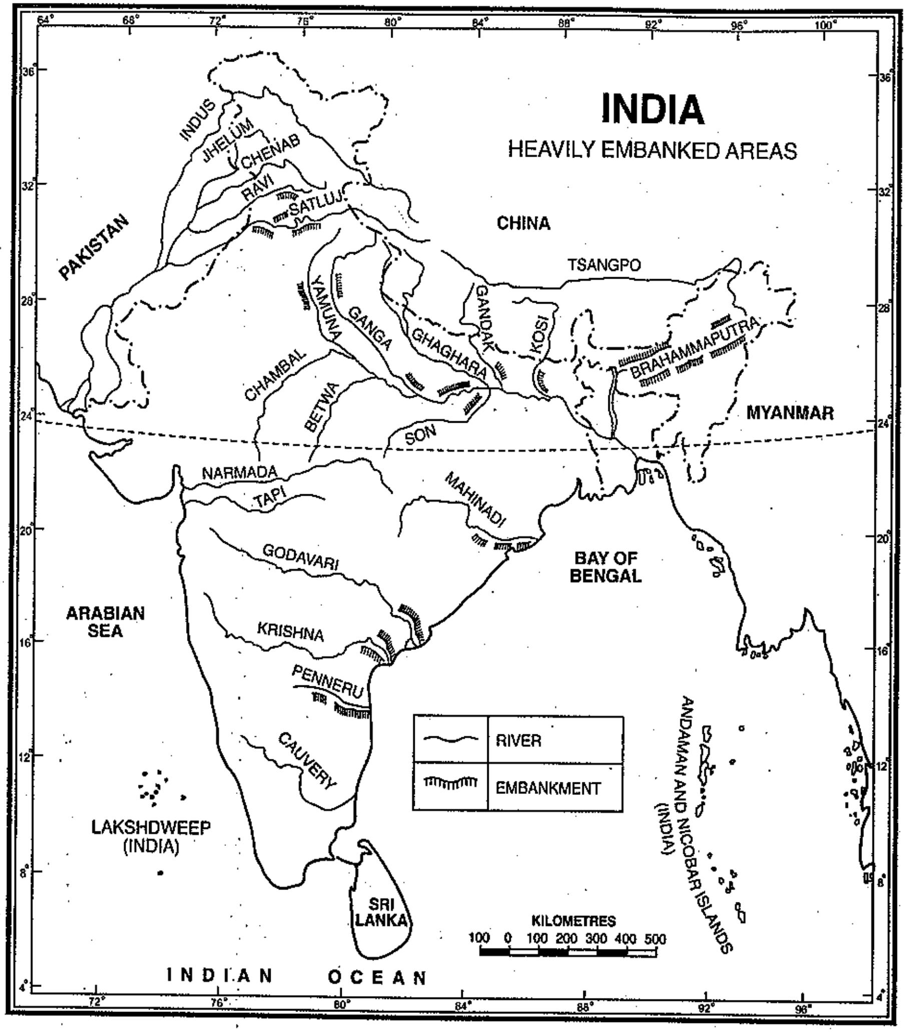


FIG. 8.13. India : Heavily Embanked Areas

the downstream areas. In the event of high flood levels, the embankments may develop breaches and floods cause heavy damage to life and property in the low lying areas near the embankments. Construction of embankments puts limits to the river channel. The sediment which was to be deposited in a much wider area in the absence of embankments, is deposited in the limited river channel. Thus the river bed rises at an accelerated rate and consequently the flood water level rises. Under such circumstances the flood water may overflow the embankments or there may be breaches in the embankments due to intense hydraulic pressure. Under both the circumstances, the flood situation takes a serious turn and causes untold miseries to the people living in the neighbouring areas. Thus whereas constructing embankments is a very useful method of flood control it can lead to a very serious flood situation. The *Rashtriya Barh Ayog*

report states. "Embankments are not a feasible measure of flood protection in cases where the country runoff draining into the river is so large as to inundate appreciatively the area protected by the embankments from river spills, during periods when the river is running at high flood stages.".

6. Flood Plain Zoning (FPZ)

Flood plain zoning is another very effective method of flood management. It is based on information regarding flood plains, particularly the identification of floodways in relation to land use. Detailed maps of flood prone areas are prepared after a thorough study of flood cycles. Some areas are more prone to floods than the others. Different zones are identified and demarcated. After that necessary control is exercised with respect to land use.

Recognising the significance of FPZ as an effective device upon flood control, the Central Flood Control Board mooted the idea in 1957 to demarcate flood zones to prevent indiscriminate settlement in flood plains. The increasing trend in flood damages was observed in India even during the 1970s and the State Governments were requested to give due attention to development of flood plains in a regulated manner. A model bill on Flood Plain Zoning was circulated to State Governments as early as 1975 with a request to enact suitable legislation for restricting the encroachment of flood plains and for their development in a regulated manner. The main features of the model bill were :

(*a*) flood zoning authority,
(*b*) delineation of flood plain,
(*c*) notification of limits of flood plains,
(*d*) restrictions on use of flood plains,
(*e*) compensation, and
(*f*) power to remove constructions after prohibition.

FLOOD CONTROL PROGRAMMES AND POLICY

After devastating floods in 1954, the Government of India announced a National Flood Management Programme. The programme was divided into three phases—immediate, short term and long term.

(*a*) **Immediate phase** extending over a period of 2 years was adopted for intensive collection of data and execution of emergent flood protection measures.

(*b*) **Short term measure** covering next 4 to 5 years, included construction of spurs and embankments at selected sites.

(*c*) **Long term measures** included the construction of storages, reservoirs on rivers/tributaries and additional embankments.

It has been estimated that out of 40 million hectares of flood prone area only 32 million hectares can be provided with reasonable degree of flood protection by structural measures.

Since the launching of the National Programme of Flood Management in 1954, 45 million hectares of land has been provided with a reasonable degree of protection against floods by construction of embankments, drainage channels, town protection works and by raising villages.

Post Flood Management

Post flood management includes the following :

1. Speedy restoration of transport system particularly roads and railways and postal services.
2. Supply of safe drinking water to the affected areas either by tankers or by fire tenders.
3. Repair of power, telephone and sewerage lines.
4. Proper arrangement for supply of food, shelter and clothing to affected people.
5. Adequate supply of necessities of life.
6. Constitution of a survey team to assess the loss and compensation to be given to the affected people.
7. Assistance for repair/rebuilding of private properties.
8. Desilting and dewatering of inundated areas.
9. Taking up appropriate measures according to Contingency Plan for agricultural sector.

TROPICAL CYCLONES

The World Meteorological Organisation (WMO) uses the term ***"Tropical Cyclone"*** to cover weather systems in which winds exceed 'gale force' (minimum of 34 knots or 63 kph). Over warm water in the tropical ocean, little away from the equator within the belt of 30°N and 30°S, the occurrence of tropical cyclones is almost a worldwide phenomenon. However, their characteristics like frequency, intensity and coastal impact vary from region to region. Tropical cyclones are the most destructive of the seasonally recurring rapid onset natural hazards. Between 80 and 100 tropical cyclones occur around the world each year. But these have been the deadliest when crossing the coast bordering the north Bay of Bengal (coastal areas of Tamil Nadu, Andhra Pradesh, Odisha, West Bengal and Bangladesh) mainly because of serious storm surge problem in this area.

Characteristics and Destructive Power of Tropical Cyclones

Tropical cyclones are characterised by destructive winds, storm surges and exceptional levels of rainfall, which may cause flooding. Wind speeds upto 200 km/h, rainfall of upto 50 cm/day for several consecutive days and storm surges of 7 m high are not uncommon. A mature cyclone releases energy equivalent to that of 100 hydrogen bombs. Cyclone is a heat engine whose heater is the oceanic water. The released heat after condensation converts into kinetic energy for the cyclone. Yet it is described as a poor heat engine since it converts only 3% of the heat generated into kinetic energy.

Destructive Winds

The strong winds that blow counter-clockwise in the Northern Hemisphere, while spiralling inward and increasing toward the cyclone centre are highly destructive. Wind speeds progressively increase towards the core. As the eye arrives, winds decrease to become almost calm but rise again just as quickly as the eye passes and are replaced by hurricane force winds from a direction nearly the reverse of those previously blowing.

Wind speeds greater than 120 kmph are characteristic of severe cyclonic storms with a core of hurricane winds. All physical structures are vulnerable to the extreme pressures exerted by winds and thus collapse or are damaged. Wind speeds of cyclonic storms have been incorporated into the building code for coastal areas.

Damages due to wind are not confined to the coastal areas only. Damage can occur well in the interior. For example, a number of structures around Vijayawada (which is about 100 km from the coast) were damaged in a cyclone. Almost the whole east coast of India from Tamil Nadu to West Bengal is vulnerable to wind hazard. The coasts of Kachchh and Kathiawar in Gujarat are also highly vulnerable to wind hazard. Such wind hazards are mostly associated with tropical cyclones. High wind velocity of 50 m/s is not uncommon in these coastal regions.

Storm Surges

One of the peculiar characteristics and having a very high damage potential is storm surge. Storm surges are an abnormal rise of seawater due to tropical cyclone and are greatly amplified where the coastal water is shallow, in the estuarian region and where the shape of the coast is like a funnel.

The major factors include

- A fall in the atmospheric pressure over the sea surface
- The effect of wind
- The influence of the sea bed
- A funnelling effect
- The angle and speed at which the storm approaches the coast
- The tides.

The coastal areas of north Bay of Bengal satisfy most of the above mentioned criteria and the storm surge gets enormously amplified there. Due to several favourable factors in these areas, the world's highest storm surge of 41 feet (over 13 metres) was reported from the area in 1876 near Bakerganj. Cyclonic storms are sometimes accompanied by tidal waves with heights of five metres and sometimes hit 20 km inland with wind speed of 150 kmph.

The low-pressure area or "eye" of the cyclone allows the sea level to rise. The high-speed winds surrounding the "eye" drive more water over this rise. The sloping bed of the sea and contours off the shoreline add further to the height. A further contribution to the height of the storm surge is added if the cyclone arrives at high-tide time.

Storm surges are not waves though they may look like them. A storm surge is a mass of water,

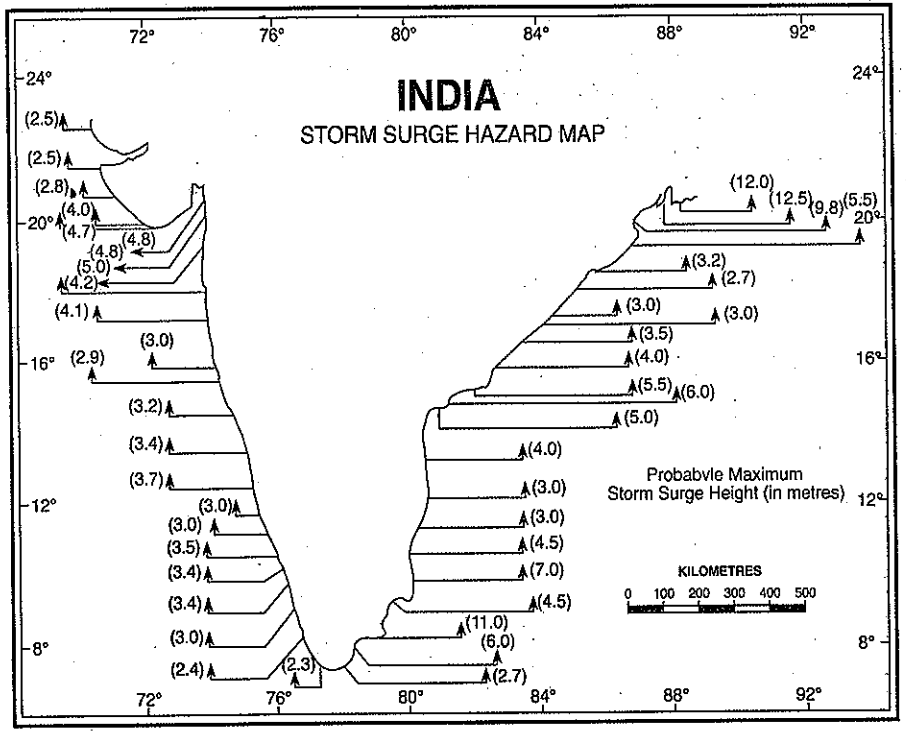


FIG. 8.14. India : Storm Surge Hazard Map

which will submerge everything in its path, till it recedes back into the sea. It moves at the same speed as that of the cyclone. It travels upto the point where the ground height is equal to the height of the surge. The period of submergence of the land may be as long as 45 minutes or more depending on the depth it reaches inland. Map in **Fig. 8.14** shows that the entire coast of India is influenced by storm surges caused by cyclones and tides.

As the leading edge of the surge crashes against the coastline and the water continues to travel inland there will be surface waves created which criss-cross each other and carry much under water turbulence. The destruction caused by the surge is tremendous. Houses are the worst affected. First the speed of the surge places great stress on the walls. The turbulence and currents created destroy the foundations of the structure. The debris like uprooted trees, fences and parts of broken houses act as battering rams, which cause further damage. The sand and gravel carried by the fast moving currents at the bottom of the surge can cause sand papering action on the foundations. The huge volume of water can cause such pressure differences that the house "floats" and once the house is lifted from the foundations water enters the structure and causes collapse of the building.

Damage occur to every kind of assets built above the ground level due to the above characteristics and crops get affected very badly.

Exceptional rainfall occurrences

The world's highest rainfall spread over one or two days has occurred during tropical cyclones. The very high specific humidity condenses into exceptionally large raindrops and giant cumulus clouds, resulting in high precipitation rates. When a cyclone makes landfall, the rain rapidly saturates the catchment areas and the rapid runoff may extensively flood the usual water sources or create new ones.

Rainfall is generally very heavy and spreads over a large area thus leading to excessive amount of water, which leads to flooding. The size of drops, in a rainfall, increases with increase in rainfall intensity. Soil erosion results on a large scale as raindrops strike the ground with energies substantially greater than those in ordinary rainfall. The heavy rains waterlog the ground and cause softening of the earth due to soaking. This contributes to weakening of tank embankments, the leaning over of utility poles or collapse of pole type structures.

TROPICAL CYCLONES IN INDIA

With about 6 per cent of the world wide cyclones, the Indian subcontinent is one of the worst cyclone affected areas of the world. About 8 per cent of the total land area, particularly along the eastern coast and Gujarat coast is vulnerable to tropical cyclones. In fact, Indian ocean is one of six major cyclone prone regions of the world. On an average, about 5-6 tropical cyclones are formed in the Bay of Bengal and the Arabian Sea every year, out of which 2 or 3 may be severe. More cyclones form in the Bay of Bengal than in the Arabian Sea. As such, the eastern coast is more prone to cyclones and about 80 per cent of the total cyclones generated in the Indian Ocean strike the east coast of India. There are two definite seasons of tropical cyclones in the North Indian Ocean. One is from May to June and the other from mid-September to mid-December. May, June, October and November are known for ***severe storms***. The entire east coast from Odisha to Tamil Nadu is vulnerable to cyclones with varying frequency and intensity. Along the west coast, the Gujarat and Maharashtra coasts are more vulnerable as compared to the southern part. Most of the cyclones have their origin between 10°N and 15°N during the monsoon season. Almost all storms in the Bay of Bengal have their genesis between 16°N and 21°N and west of 92°E in June. By July, the Bay storms form north of 18°N and west of 90°E. It is also noteworthy that most July storms move along a westerly track. They are generally confined to the region between 20°N and 25°N and recurvature to the Himalayan foothills is comparatively rare. **Figure 8.15** shows the direction and seasonal distribution of cyclonic storms as well as the areas affected by the cyclonic storms. The frequency of cyclones and severe cyclones in the Bay of Bengal and the Arabian Sea during the period from 1897 to 2014 is shown in **Table 8.7**.

TABLE 8.7. Frequency of Tropical Cyclones (1897-2014)

Month	Bay of Bengal		Arabian Sea	
	Cyclonic storm	Severe cyclonic storm	Cyclonic storm	Severe cyclonic storm
January	4	2	2	0
February	0	1	0	0
March	2	3	0	0
April	11	11	2	4
May	15	34	4	15
June	33	6	6	12
July	33	7	3	0
August	27	3	2	0
September	24	15	5	3
October	44	35	14	11
November	40	54	6	21
December	23	20	5	2
Total	256	191	49	68

Source : India Meteorological Department, New Delhi.

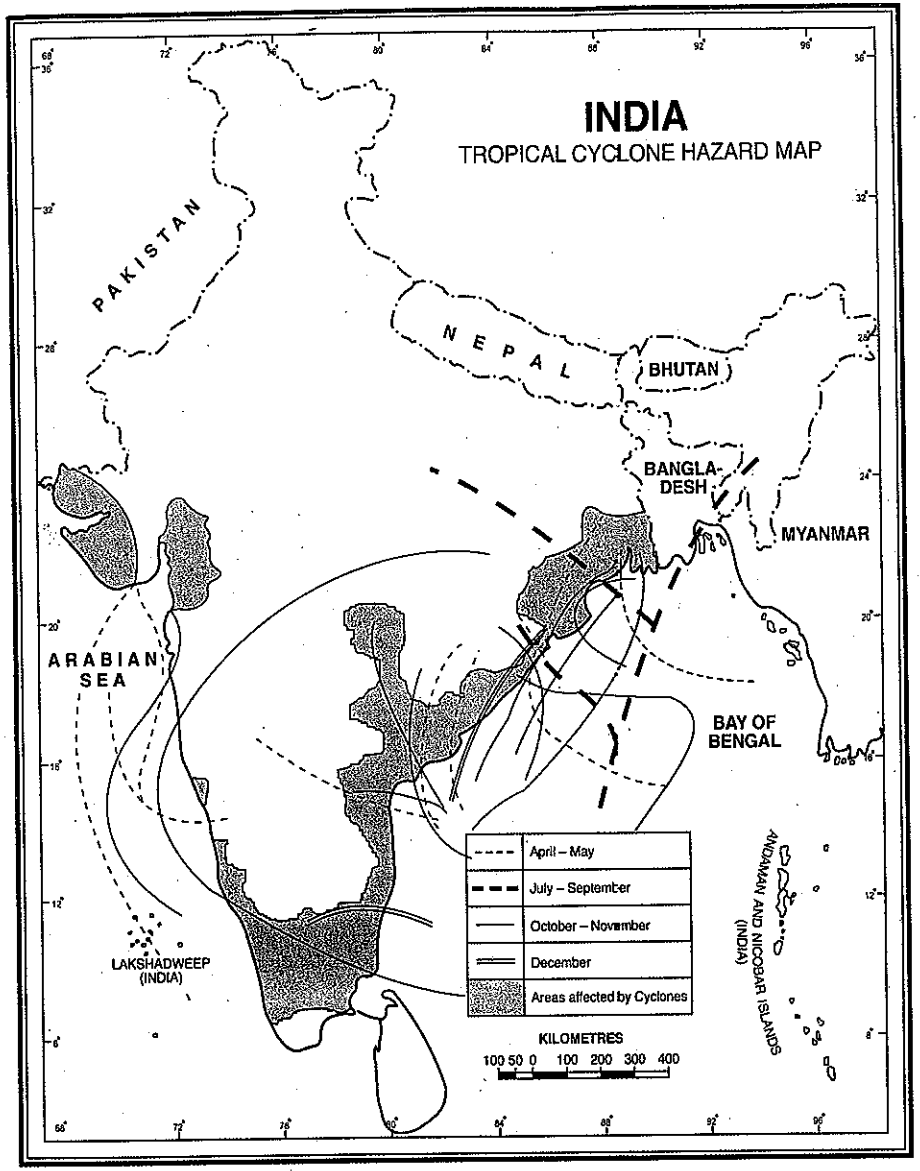


FIG. 8.15. India : Tropical Cyclone Hazard Map

The distructive effect of cyclonic storms is confined to coastal districts, maximum destruction being within 100 km from the centre of the cyclones and on the right of the storm track. Principal dangers from a cyclone are : (*i*) Gales and strong winds, (*ii*) Torrential rain, and (*iii*) High tidal waves (also known as 'Storm surges'). Most casualties are caused by coastal inundation by tidal waves and storm surges. Maximum penetration of severe storm surges varies from 10 to 20 km inland from the coast. Heavy rainfall and floods come next in order of devastation. They are often responsible for much loss of life and damage to property. Death and destruction purely due to winds are relatively less. The collapse of buildings, falling trees, flying debris, electrocution, rain and aircraft accidents and disease from contaminated food and water in the post-cyclone period also contribute to loss of life and destruction of property. **Table 8.8** gives a chronological account of the devastating effects of some severe cyclonic storms in India. This table and **Figure 8.15** bring us to the conclusion that the states of Andhra Pradesh, Odisha on the east coast and Gujarat on the west coast of India are extremely vulnerable to tropical cyclones. These three states deserve a brief description with respect to their vulnerability to the tropical cyclones.

Andhra Pradesh. Andhra Pradesh has a long coast line of 1,030 km from Srikakulam in the north to Nellore in the south along the east coast of India and bordering the Bay of Bengal. Nine coastal districts of Srikakulam, Vizianagram, Vishakhapatanam, East Godavari, West Godavari, Krishna, Guntur, Prakasam and, Nellore are highly vulnerable to tropical cyclones. This state has a very long history of cyclones and has experienced 71 cyclones from 1892 to 2014. The geographical set up of the state particularly makes it most vulnerable to tropical cyclones. The terrain is sloping generally from west to east and most of the area is plain except for portions of the northern districts. The Geographical location of India and the position of Andhra Pradesh between latitudes 13° north to 19° north with Bay of Bengal in the east is also a major contributing factor for the predicament nature has placed the state in.

TABLE 8.8. Some Severe Cyclones in India

Location	Date	Damages
Bengal	Oct., 1847	75,000 people and 6,000 cattle killed. Damage to property and communication system.
Bengal	Oct., 1874	80,000 people killed, heavy loss to property and communication disrupted.
Andhra Coast	Nov., 1946	750 people and 30,000 cattle lost life. Damage to property and roads also reported.
Tamil Nadu	Dec., 1972	80 people and 150 cattle killed and communication disrupted.
Bengal	Sept., 1976	10 people and 40,000 cattle lost life. Damage to property including communication
Andhra Coast	Nov., 1977	8547 people and 40,000 cattle lost life. Communication disrupted heavy loss to property.
Tamil Nadu	May, 1979	700 people and 3,00,000 cattle lost life. Communication disrupted
Odisha	Sept., 1985	84 people and 2,600 cattle lost life. Land damaged.
Andhra Coast	Nov., 1987	50 people and 25,800 cattle lost life, 8,400 houses destroyed, roads and other communication disrupted.
Odisha	June, 1989	61 people and 27,000 cattle lost life, 145,000 houses destroyed, communication disrupted.
Andhra Coast	May, 1990	928 human lives lost, 14,000 houses damaged.
Tamil Nadu	Nov., 1991	185 people and 540 cattle dead. Property including roads worth ₹300 crore damaged.
West Bengal	April, 1993	Over 100 casualties, communication system including roads disrupted and damaged.
West Bengal	Nov., 1994	More than a thousand houses damaged in 26 villages, damage to lakes and fisheries, disrupted all communication.
Andhra Coast	Oct., 1996	1,057 casualties, 647,000 houses damaged, road network completely damaged.
Andhra Coast	June, 1996	2,000 killed, 900 went missing near Kakinada.
Gujarat	June, 1998	3,500 casualties, 2.0 lakh houses damaged.
Odisha	Oct., 1999	10,086 casualities, 21.6 lakh houses damaged, 1.3 million displaced.
Odisha and Andhra Pradesh	Oct. 2013	30 dead, 8 million affected.

The entire coastline of Andhra Pradesh is likely to be visited annually by one or two cyclonic storms on an average, most probably during May, October and November. These storms are sometimes accompanied by tidal waves as high as 5 metres or even more. If the land is flat as in the case with the deltas of Krishna and Godavari, the storms can hit 20 km inland, wind speeds exceeding 150 kmph along with heavy rains of the order of 30-50 cm in 24 hours, overflowing rivers and rivulets, inundating vast areas and causing heavy damage to life and property.

The coast of Andhra Pradesh is dotted by more than 2,500 villages having a population of over six million. The people living in the belt of 20 km from the coast are generally comprising of fishermen and weaker sections and the majority have thatched type houses which are very vulnerable to strong cyclonic storms. There are very few permanent buildings by way of temples, churches, and schools. Under such circumstances, the ability of people to cope with disasters is *ad hoc* based only on the experience of those in the community who may have faced a similar disaster in the past.

Odisha. Like Andhra Pradesh, its neighbouring state Odisha is also vulnerable to tropical cyclones. In the recent years, Odisha has been hit by tropical cyclones in 1985 and 1989. The latest was the **'Super Cyclone of Odisha** which hit the state on 29th October 1999. It was the most devastating cyclone in the living memory of Odisha. This cyclone left the state in a virtual paralysis with its communication system and infrastructure totally wrecked. It severely affected more than 13 million people in 97 blocks, 28 urban local bodies in 12 districts including the state capital Bhubaneshwar and the old city of Cuttack. Overnight, the state seemed to have slipped into stone age. The agriculturally rich districts of Khurda, Puri, Cuttack, Jagatsinghpur, Kendrapara were devastated due to storm while districts like Jajpur, Bhadrak, Keonjhar, Balasore and Mayurbhanj were severely affected by unprecedented flood.

According to Meteorologists, it was the strongest cyclone in India's memory. It was a cyclone of catastrophic intensity with sea waves upto 7 metre high, which had rushed in and at places, travelled upto 15 km inland. Bhubaneshwar gets no more than an average of 1,200 mm of rainfall annually, but on that fateful day, the city received incessant rainfall of 426 mm.

Cyclone Phailin. A severe cyclone hit the Odisha coast on the night of October 12, 2013 affecting vast coastal areas of Odisha and Andhra Pradesh. It was the second deadliest cyclone to hit the eastern coast of India, next only to the Super Cyclone of Odisha which hit the Odisha coast in October, 1999. Thus it was the strongest cyclone in a span of 14 years. It caused massive damage in the districts of Ganjam, Gajapati, Khurda, Puri and Jagatsinghpur. Districts of Balasore, Nayagarh, Keonjhour, Kendrapara, Jajpur, Kandhamal, Cuttack, Karaput, Nabaranghur and Bhadrak were also affected. As many as 1,45,014 villages and more than 3.75 lakh houses were destroyed. Paddy crop worth ₹ 2,400 crores over 6.2 lakh hectares of land was also destroyed. In addition, the cyclone caused heavy damage to large parts of Coastal Andhra Pradesh. With wind speed varying from 210 to 240 kmph, this cyclone was rated at number 4 on Saffir-Simpson scale as against number 5 given to Super Cyclone of 1999.

However, the redeeming factor was that the death toll was limited to 30 only. This unique feat was accomplished by virtue of combined efforts of India Meteorological Department (IMD), National Disaster Management Authority (NDMA), Army, IAF Navy and NGOs. IMD tracked Phailin from the time it formed on October 8, 2013 and gave advance warning of implending cyclone. This gave sufficient time to government machinery for taking safety measures and about one million people were evacuated and taken to safer places. Cyclone warnings issued on radio, TV and via loudspeakers played a crucial role in public awareness and helped the concerned authorities to take timely action in the right direction.

Gujarat. The state of Gujarat is the worst sufferer at the hands of cyclones on the west coast of India. According to vulnerability Altas of India, Kachchh, Jamnagar, Porbandar, Junagadh, Ameri and Bhavnagar districts lie in the **Very High Damage** zone for wind and cyclone hazards. Data collected for storm winds and cyclones crossing inland between 1877 and 1991 indicate that Jamnagar, Porbandar and Junagadh districts have faced severe cyclone storms four times, Kachchh has faced it 2 times and other coastal districts 3 times. In recent times, Gujarat was hit by a severe cyclone on 9th June 1998. This was caused by an unusual phenomenon when a low-pressure depression was created on the western side of the country. This gave rise to strong winds taking the shape of cyclone in the Arabian Sea. This cyclone hit the coastal areas of Gujarat. Strong winds of this a cyclone reached a peak of 235 km per hour. The worst affected area was the Kachchh district as it lay directly on the movement track of the cyclone. The death toll was abnormally high due to very high migrant labour population working in the salt pans and the port area and staying in temporary structures. The physical damage felt due to the cyclone was accentuated more in the rural areas. The urban areas, with closely packed structures having permanent flat roofs, channeled high velocity winds along roads and other open space corridors.

Typically, rural structures with (*i*) unburnt brick walls sloping or flat roofs, (*ii*) stone walls with sloping or flat roofs, and (*iii*) light structures made of wood, GI sheets and bamboo are highly vulnerable to high wind velocity, exceeding 180 kmph. In the district of Jamnagar 50% of the structures in the rural areas belong to the first and the second categories mentioned here. Kachchh is still worse off where over 70% of the structures belong to the first and second categories. The estimated damages caused by this cyclone were 3,500 dead, 20,000 families affected and 200,000 houses damaged.

MAIN MITIGATION STRATEGIES

1. Cyclone Shelters

One of the most successful means of reducing loss of human lives during cyclones is the provision of cyclone shelters. In densely populated coastal areas, where large scale evacuation is not always feasible, community buildings and buildings used for gathering of large number of persons, like schools, *dharamshalas*, hospitals, prayer halls, etc. can be used as cyclone shelters. These buildings can be so designed, as to provide a blank facade, with a minimum of apertures in the direction of the prevailing winds. The shorter side of the building should face the storm. Alternately these buildings can be designed on a circular/ellipsoidal plan, so as to impart least wind resistance. Earth berms and green belts can be used in front of these buildings to reduce the impact of the storm. These shelters should be located in relatively elevated areas with provision for community kitchen, water supply and sanitation.

Another alternative, though expensive, is to have individual cyclone shelters attached to dwelling units. The shelter is fabricated in concrete and steel and designed for installation on flat ground adjacent to the house. The shelter is installed 4 feet in the ground, the soil from the excavation is placed around the shelter to help increase the shelter's effectiveness in protecting its occupants. The cyclone relief shelter can take care of population ranging from 50 to 300 people (men, women and children). Several multi-purpose cyclone shelters have been built in vulnerable areas of coastal Odisha, particularly after the super cyclone of 1999.

2. Engineered Structures

Cyclone proof structures which can withstand the force of winds and torrential rains can be of several types. Such facility is generally lacking due to widespread poverty of the people living in coastal areas. However, following precautions can be taken :

(*i*) Kachha house with thatched roofs should be avoided in coastal areas. Instead, loans should be given to vulnerable people for constructing cyclone proof houses and proper guidance should be given to them. As far as possible, houses should be constructed on stilts or on earth mound.

(*ii*) Houses can be strengthened to resist wind and flood damage. All elements holding the structures need to be properly anchored to resist the uplift or flaying off of the objects. For example, avoid large overhangs for roofs and projections should be tied down. Trees planted in a row can act as a shield, because such a provision reduces the energy of the cyclones.

3. Flood Management

Cyclones are accompanied with torrential rainfall which causes flooding of widespread areas. Therefore, flood mitigation measures (as mentioned earlier in the chapter) should also be taken.

4. Coastal Shelter Belts

Rows of strong rooted trees with needle like leaves are planted in the direction facing the wind. The trees in first few rows are provided fenced support to save them from being uprooted. These shelter belts can be grown all over the coastal area. Tidal forest trees and other hardwood trees are also recommended. Shelter belts grown along the coastline is a powerful tool to mitigate the impact of strong cyclonic winds. They also help in checking the soil erosion and inward sand drift, thereby protecting cultivated fields, houses and homesteads near the coast.

CYCLONE WARNING

Giving advance warning about a coming cyclone is one of the most effective methods of reducing the disastrous effects of cyclones. India Meteorological Department is the pioneer institute which issues such warnings.

A cyclone warning division has been set up in New Delhi to coordinate and supervise the totality of cyclone warning programmes in the country.

Cyclone Tracking

Cyclone tracking in India is done with the help of the following :

(*i*) Regular observations from weather network of surface and upper air observing stations
(*ii*) Reports from ships
(*iii*) Cyclone detection Radars
(*iv*) Satellites
(*v*) Reports from commercial aircrafts

Communication Network (Dissemination of Cyclone Warnings)

Cyclone warnings are communicated to Crisis Managers and other concerned organizations by high priority telegrams, telex, telephones and Police wireless. Cyclone warnings are provided by the IMD from the Area Cyclone Warning Centres (ACWCs) at Kolkata, Chennai and Mumbai and Cyclone Warning Centres (CWCs) at Vishakhapatnam, Bhubaneswar and Ahmedabad. Cyclone warning bulletins for All India Radio/Doordarshan, and cyclone advisories for the north Indian Ocean to Bangladesh, Myanmar, India, Maldives, Pakistan, Sri Lanka and Thailand are being issued from Meteorological Office in New Delhi. This office also issues tropical cyclone advisories for the tropical cyclones in the south west Indian ocean to Mauritius. There is also a Satellite based communication system called the Cyclone Warning Dissemination Systems (CWDS) for transmission of warnings. There are 250 such cyclone-warning sets installed in the cyclone prone areas of east and west coast. The general public, the coastal residents and fishermen, are also warned through the Government machinery and broadcast of warnings through AIR and Television.

Recently India Meteorological Department has developed a system known as ***"Disaster Warning System" (DWS)*** to transmit cyclone warning bulletins through INSAT-DWS to the recipients.

Post Disaster Assistance

Post disaster assistance is very essential for rescue and rehabilitation of the people in distress. It includes the following.

- Evacuation
- Emergency shelter
- Search and rescue
- Medical assistance
- Provision of short term food and water
- Water purification
- Epidemiological surveillance
- Provision of temporary lodging
- Reopening of roads
- Re-establishment of communications networks and contact with remote areas
- Debris clearance
- Disaster assessment
- Provision of seeds for replanting

LOCAL SEVERE STORMS

Local severe storms are small scale disturbances which are formed due to strong convective motions in a moist and unstable atmosphere and originate from well grown cumulonimbus clouds. The destructive effects of local severe storms are thunderstorms, strong winds, hail storms, lightening, heavy rains and tornadoes

Thunderstorms

Thunderstorms are a meso scale phenomena covering an area of tens to hundreds of square kilometres and lasting a few minutes to a few hours. They occur when there is instability in the atmosphere under adequate moisture conditions and a mechanism exists to release the instability. Thunderstorms constitute an important form of local severe storms which cause considerable damage to life and property every year. They occur over all parts of India and there is no month when one part or the other of the country is not affected by thunderstorms. The period of least thunderstorm activity is December to March. However, the most widespread thunderstorm activity all over the country occurs during the hot weather period from middle of March to middle of June. This is also known as the ***pre-monsoon period***. The main regions of the pre-monsoon thunderstorm activity are (*i*) Northeast India (*ii*) Northwest India, (*iii*) Central parts of the country and (*iv*) Southwest Peninsula. The maximum activity is during March-September in northeast India while it is April-May and October-November in southwest peninsula. Severe thunderstorms occur generally during the afternoon and evening hours, **Figure 8.16** shows the average annual frequency of thunderstorms.

Thunderstorms of West Bengal, Chhotanagpur plateau of Jharkhand and northeast India during March-June are often accompanied by violent destructive squalls reaching 100 km per hour. They are known as ***'Norwesters'*** in meteorological language in India as their modal direction is from northwest. They are also called ***'Kalbaisakhis*** which means *evil or black storms of month of Vaisakh*. They cause widespread damage to crops and kill cattle and at times, people too. During March-June the thunderstorms of northwestern and central India are often preceded by dust storms. There are thundersqualls which raise walls of dust and sand rendering visibility to practically nil and are locally known as ***'andhis'*** (blinding storms). Significant duststorm activity begins in April and reaches maximum in June.

During the post-monsoon (October and November) period thunderstorms occur in association with cyclonic storms and depressions mostly over peninsular India.

Basic parameters leading to the development of thunderstorm are observed through conventional synoptic surface and upper air meteorological observations. Frequency of their observation varies from two to six over the surface and two to four over upper air. Hourly observations are taken in some selected areas and are used for forecasting severe thunderstorms. The most reliable tracking of severe storms is through radar surveillance. As soon as the thunderstorm cells or squall lines are observed on the radar screen, their speed and direction of movements can be measured by marking their progress over the radar screen. Indications are also available on the radar screen regarding the severity of the thunderstorm and its potential for producing rain and hail. Such information is used for forecasting local severe storms. Cloud observations from geostationary satellites and polar orbiting satellites are useful in demarcating broadly the areas of potential for the convective development where severe storms may occur.

At present there is provision for issuing warnings based on certain known facts for high speed wind, hail and heavy rain associated with the thunderstorms generally 24 hours in advance to the warnees listed with different meteorological offices in the country. In addition, such warnings are issued on radio, television and other news media from different meteorological offices in India.

Hailstorms

Hail is precipitation in the form of ice pellets. Thunderstorms producing hail are known as ***hailstorms***. The size of hailstorms may vary from less than a centimetre to about 5 cm or even more in diameter. Hail is the product of violent convection, formed in a cumulonimbus (Cb) cloud. A storm starts its life as an ice crystal. It grows progressively as it

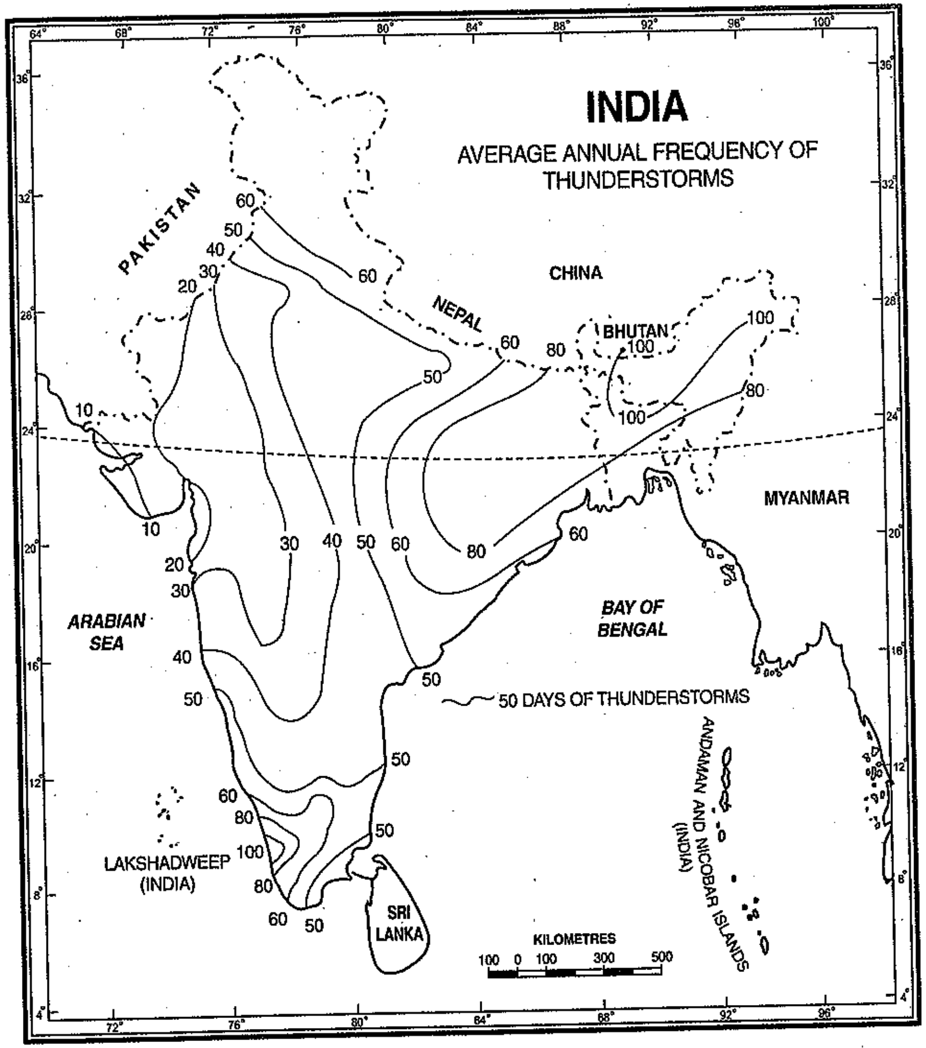


FIG. 8.16. Average Annual Frequency of Thunderstorms

comes into contact with ice crystal and water droplets alternately in up and down currents in the Cb cell. This is evident from the study of its structure. A cut section of a hailstone resembles an onion with alternate layers of glaze ice and opaque rim. The glaze ice layers of the hailstone are formed during its downward journey in the region of super-cooled water while the opaque rim layers form at higher levels where smaller drops predominate. Once the hailstones become too large to be supported by the vertical updrafts, they start falling on the ground. They fall with great speed which is often accentuated by the squall. Sometimes the hailstones attain large size (as large as a golf ball) and cause heavy damage to crops, property and life. Hail is a grave hazard to aircraft in flight.

During the period from March to May thunderstorms over northern India, particularly the submountain areas are accompanied by hail. Hailstorms also occur in association with western disturbances during the winter months from December to February. However, hail is rare in the southwest monsoon period. The annual frequency of hail is the highest in extreme northeast of the Brahmaputra valley with nearly 15 occasions. The other high incidence areas are Tripura, Dumka and Pakaur (Santhal Parganas) of Jharkhand, West Bengal and submontane regions of Uttarakhand. However, no region is free from hail.

Tornado

Tornadoes are extremely severe vortices of very small dimensions occurring in association with intense and large cumulonimbus (Cb) clouds or cyclonic storms. They comprise the most destructive meso-scale convective phenomena which builds up in thunderstorm. The visible symptom of a tornado is a small funnel extending down from a Cb cloud with winds reaching several hundred kilometres per hour, revolving tightly around the core. Actual records of wind speed are not available because anemometers cannot withstand such high speeds. From the sound etc. is presumed that the speed of the wind in a tornado may exceed the speed of sound. Wind speeds of as high as 400 to 500 kmph are not uncommon. Tornadoes travel along narrow paths with lengths from a few km to 100 km or more. The width of the path is small, ranging from 30 to 100 metres. The diameter of the funnel touching the ground may vary from less than a metre to a few tens or hundreds of metres. The entire disturbance moves at speed varying between 100 to 150 kmph.

In view of their severe intensity, tornadoes have high potential for destruction. They cause immense damage and devastation to life and property. Because of vortex, they suck everything in their path. They are also known as ***"twisters"***. The pressure may be lower by 10% inside the vortex than at the periphery. Hence, when the funnel passes over, buildings seem to explode. The debris and even persons may be sucked and carried aloft by the tornado. On 24th March, 1998, tornadoes claimed 200 lives in West Bengal and Odisha. Tornadoes occurring over sea suck water up to the base of the mother cloud. The cloud becomes linked with water body and the phenomena is termed as ***'water spout'***.

The most probable regions of tornado occurrence in India are Assam and adjoining states, West Bengal, Odisha, the Ganga plain, Punjab and Haryana.

Considering the random occurrence of tornadoes, their short life period and very low frequency in India (1 to 2 per year), the warning services for tornadoes are not seriously attempted as yet. In fact, advance warning of tornadoes is a difficult task. The radar comes in quite handy for tornado monitoring and warning. Unless the warning of tornado occurrence is disseminated to public at large, due to its short life, adequate steps cannot be taken by public to get away from the path of tornado. Various state governments in the target region have promulgated building laws which specify design of houses capable of withstanding tornado fury.

Cloudburst

Cloudburst is andher extreme natural hazard which causes large scale loss of life and property within a span of a few minutes.

WHAT IS A CLOUDBURST ?

A cloudburst refers to a sudden downpour within a radius of a few kilometres. The area affected by a cloudburst typically does not exceed 20-30 sq km. The downpour does not last more than a few minutes but is capable of causing heavy loss of life and property and leading to untold miseries to human beings, animals etc. Over 100 mm of rain in an hour is the basic criteria for a cloud to be called a ***cloudburst***.

Highly concentrated rainfall over a limited area in a short duration of time is the main criteria for any weather event to be termed as cloudburst. Following are some of the major events of heavy rainfall over a limited area in a short duration of time.

Area/Place	Date	Amount and duration of rainfall
Uttarkashi and Rudraprayag	June 16-17, 2013	479 mm in three hours
Leh	August 2,1010	250 mm in one hour
Mumbai	July 26, 2005	1448 mm in 10 hours

Source : India Meteorological Department.

Meteorologists believe that cloudbursts occur due to rapid lifting of clouds by the steep orography of the region. The clouds get vertically lifted. Such clouds are generally called ***connective clouds*** which can extent upto 15 kilometres in the air above the ground. This process is called the ***"cumulonimbus connection condition"*** which results in formation of towering vertical dense clouds. The lifting is generally dynamic which causes thermodynamic instability resulting in rapid condensation and highly concentrated heavy downpours.

HOW A CLOUDBURST COMES INTO BEING ?

1. Warm and humid air is pushed up along the mountain slope.
2. The air mass keeps rising and forms large thunder clouds.
3. Lack of upper-level wind prevents dissipation of the thunder clouds.
4. Concentrated localised rainfall occurs.

Further, it is believed that in the Himalayan region, the clouds which are being lifted up at a fast rate are also accompanied by soil moistened by earlier precipitation. This moistened soil acts as an additional source of moisture and might also have an important role in the frequent cloudbursts in the Himalayan region. Cloudbursts are more frequent in the monsoon season.

The above discussion and table 8.9 make it clear that most cloudbursts occur in the Himalayan region.

TABLE 8.9. Major Cloudburst in India since 1988

Date	Place/Area	Extent of Loss
December 29, 1988	Kinaur district of Himachal Pradesh	35 persons dead and hundreds of houses destroyed.
August 15, 1997	Chirgaon in Shimla district of Himachal Pradesh	1,560 people killed.
August 17, 1998	Malpha village in Kumaon division of Uttarakhand	250 people, including 60 Kailash Mansarover pilgrims in Kali valley were killed.
August 22, 2000	Kinaur (Himachal Pradesh)	200 people killed due to heavy flooding in the Satluj river.
July 29, 2001	Baijnath in Kangra district	10 persons killed.
July 16, 2003	Shilagarh in Gursa area of Kullu (Himachal Pradesh)	40 persons killed
August 8, 2003	Kullu and Shimla	100 dead
July 6, 2004	Alaknanda river basin Uttarakhand	17 killed, 28 injured and more than 5000 pilgrims stranded near Baridanath shrine area in Chamoli district.
August 16, 2007	Bhavi village in Ghanvi, Himachal Pradesh	52 people dead.
August 7, 2009	Nachni area near Munsigari in Pithorgarh district of Uttarakhand	37 people dead
August 6, 2010	Leh town of Ladakh region in Jammu and Kashmir	Series of cloudbursts left over 1,000 persons dead and over 400 injured.
July 20, 2011	Upper Manali, Himachal Pradesh	2 dead and 22 missing.
September 14, 2012	Rudraprayag, Uttarakhand	39 people dead
June, 16, 2013	Uttarkashi, Uttarakhand	15,000 dead, 436 injured, 1,800 missing.
July 31, 2014	Tehri, Uttarakhand	Several people died and many houses flattened.

Source : (*i*) IMD, (*ii*) Science Reporter, August, 2013, p. 17.

But that does not mean that other parts of the country are free from the fury of cloudbursts. Western ghats, western coastal areas, central and western India are also prone to cloudburst. In these areas, cloudbursts occur rarely but they strike with tremendous force and heavy downpour in a short duration of time. For example cloudburst in Musi river (a tributary of the Krishna river) in 1908 claimed 15,000 lives and destroyed 80,000 houses in Hyderabad. Cloudburst in 1979 was responsible for breaching the Machu dam following incessant rain which resulted in heavy flooding of the downstream area. Morvi town was almost completely destroyed.

On July 26, 2005, Mumbai received 1,448 mm of rain in 10 hours by a cloudburst; throwing entire life of the city out of gear. According to India Meteorological Department, Mumbai had never experienced such high rainfall in such a short duration for about 500 years and it may not happen in the coming 200 years.

Heat and Cold Waves

Heat and cold waves are extremes of high and low temperatures above and below normal temperature respectively. These weather associated conditions can also be categorised as disasters since many deaths occur due to them. Poor and weaker sections of society are particularly prone to heat and cold waves as they cannot afford to ensure protection against extreme heat and cold. Human body is acclimatised to a particular limit of temperature. Long exposure to extremes of cold or heat may lead to severe thermal strain and ultimately to death. This needs monitoring of daily maximum temperature in summer and daily minimum temperature in winter. In the summer season (March to July) normal temperatures over most parts of India are very high. Any abnormal increase in maximum temperature during day leads to disastrous consequences. Two to three heat waves are experienced in India during the summer season. Widespread heat waves normally occupy about 10 per cent of the Indian landmass. Generally they develop over northwest India and extend towards east and south.

Cold waves are experienced in winter season (November to March). Most of the cold waves occur in north west India and are associated with western disturbances. No absolute criteria can be laid down in respect to cold waves. They have to be defined with respect to the normal minimum temperatures experienced over a given area. Minimum temperatures 6 to 7°C below normal are considered as moderate cold waves and those of 8°C and more as **'severe cold waves'.** Generally the cold wave start over north-west India and gradually spread eastwards and southwards, at times as far east as West Bengal and as far south as Telangana. Each winter, two to three cold waves may be experienced.

LANDSLIDES

Introduction and Definition

Landslide is a rapid movement of rock, soil, and vegetation down the slope under the influence of gravity. Landslides are generally sudden and sporadic. An earthquake and heavy rainfall may cause large landslides in mountainous areas. Wherever mountain slopes are steep, there is a possibility of large disasterous landslides. They can also result when the base of a slope is oversteepened by excavation or river erosion. Man breaks rocks for constructing roads, railways, buildings, tunnels etc. In such cases rocks become loose and landslides occur. Mining activity by man is also responsible for landslides.

Landslides are very common along the steep slopes of the Himalayas, the Western Ghats and along the river valleys. **Natural removal of soil and rock from slopes is known as mass wasting.** Landslide as a hazard has long been recognised by the people living in the mountains. It becomes specially dangerous when there is heavy rainfall or snowfall on the steep hill sides which makes the rocks to slip and break.

The extent of landslides depends on the steepness of the slope, the bedding plane of rocks, the amount of vegetation cover and the extent of folding and faulting of the rocks. It is the rocks that break and carry with it the soil and debris. A major cause which triggers off the landslide is the weight of the overlying material and the presence of a lubricating material like water, this is known as ***solifluction.*** Freezing and thawing of the rocks on mountain slopes cause them to break and roll down the slopes. The over bearing weight of snow or ice or water which has seeped into the soft permeable rocks also lead to slipping and breakage of hill slopes. Near the sea coast, such as the Kanara coast, cliffs are eroded at the base by sea waves and the rocks jutting out on top break off and fall. Landslides occur frequently during the rains. Deforestation as a result of felling of trees for timber and removal of vegetation cover for development activities are also responsible for soil erosion and destabilization of slopes. It is estimated that the construction of just one kilometre long road requires removal of 40,000 to 80,000 cubic metres of debris, which slide down the slopes, killing vegetation and choaking mountain streams.

A Checklist of Causes of Landslides

1.	***Ground Causes*** 1. Weak, sensitivity, or weathered materials 2. Adverse ground structure (joints, fissures etc.) 3. Physical property variation (permeability, plasticity etc.)
2.	***Morphological Causes*** 1. Ground uplift (volcanic, tectonic etc.) 2. Erosion (wind, water) 3. Scour 4. Deposition loading in the slope crest 5. Vegetation removal (by forest fire, drought etc.)
3.	***Physical Causes*** 1. Prolonged precipitation 2. Rapid draw-down 3. Earthquake 4. Volcanic eruption 5. Thawing 6. Shrink and swell 7. Artesian pressure
4.	***Man-made Causes*** 1. Excavation (particularly at the toe of slope) 2. Loading of slope crest 3. Draw-down (of reservoir) 4. Deforestation 5. Irrigation 6. Mining 7. Artificial vibrations 8. Water Impoundment and leakage from utilities.

Source : Manual on Natural Disaster Management in India (2001), National Centre for Disaster Management, p. 63.

From the above discussion, it can be concluded that landslides can be caused by poor ground conditions, geomorphic phenomena, natural physical forces and quite often due to heavy spells of rainfall coupled with impeded drainage.

Onset-Type and Warning. Generally speaking, landslides occur gradually but often they occur without warning. They may take place in combination with earthquakes, floods and volcanoes. It is difficult to predict the actual occurrence of landslides. The areas of high risk can be determined by using information on geology, hydrology, vegetation cover, post occurrence and consequences in the region.

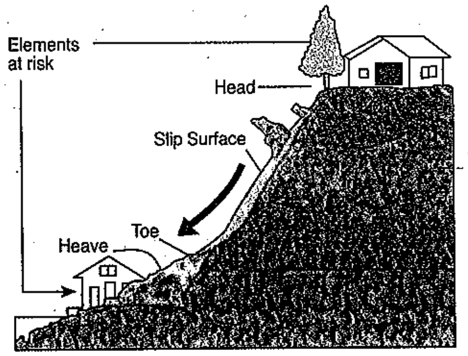


FIG. 8.17. Landslides : Elements at Risk

Elements at Risk. The most common elements at risk are the settlements built on the steep slopes, at the toe, and at the mouths of streams emerging from the mountain valley (**Fig. 8.17**). Buildings constructed without appropriate foundation for a given soil and in sloppy areas are also at risk. Roads, communication lines, and buried utilities are also at risk.

Landslide Vulnerability Zones

Following landslide vulnerability zones are recognised in India :

(*i*) **Very High Vulnerability Zone.** This zone includes young mountains of the Himalayas, Andaman and Nicobar, steep and rainy slopes of the Western Ghats and Nilgiris, the north-eastern regions and areas of intense human activities particularly those related to construction of roads, dams etc.

(ii) **High Vulnerability Zone.** These areas have geographical conditions similar to those areas which have very high vulnerability. The only difference is that the intensity and frequency of landslides is less as compared to areas of very high vulnerability. All the Himalayan States and the States from the north-eastern region except the plains of Assam are included in the high vulnerability zones.

(iii) **Moderate to Low Vulnerability Zone.** These include areas which receive less precipitation such as Trans-Himalayan areas of Laddakh and Spiti, Aravalli hills, rainstorm areas of the Western and Eastern Ghats and Deccan plateau, Landslides due to mining and subsidence are most common in states like Jharkhand, Odisha, Chhattisgarh, Madhya Pradesh, Maharashtra, Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, Goa and Kerala.

(iv) **Other Areas.** The remaining parts of the country especially states like Rajasthan, Haryana, Uttar Pradesh, Bihar, West Bengal (except district Darjeeling), Assam (except district Karbi Anglong) and Coastal regions of the southern States are safe as far as landslides are concerned.

Consequences of landslides

Landslides have serious consequences at the local level. They obstruct the flow of water in the river and cause flash floods. There are frequent floods in the upper courses of the rivers like the Ganga and the Brahmaputra due to landslides. When the mass of landslides falls on roads and railway tracks, it creates hindrance and rail traffic.

Landslide Zonation Mapping is a modern method to identify landslide prone areas and has been in use in India since 1980s. Figure 8.18 shows the landslide prone areas in India.

Casualties. Casualties depend upon the place and time of occurrence of the landslides. Maximum casualties occur in densely populated areas down the slope.

Typical effects of some of the landslides in the recent past are described below :

Landslides in the Hills. Hilly regions of India are most vulnerable to landslide hazards. In fact, landslides are almost an annual and recurring phenomenon in the hilly areas. In the mountainous region there is a closely established link between rainfall, landslides and floods. Hilly areas especially

TABLE 8.10. Major Landslides and their effects

Date/Year	Location	Effects
1993	Ratighat (Uttarakhand)	Nainital hill area remained cut off for about a week. It took five days to clear the debris.
1993	Nilgiri Hills (Tamil Nadu)	Forty people died, over 600 families shifted to safer places. Roads and houses destroyed.
August 12-18, 1998	Malpa (Uttarakhand)	Entire village was washed away. About 384 persons including 60 pilgrims going to Lake Mansarovar were killed.
Sept. 24 to Oct. 10, 2003	Uttarkashi (Uttarakhand)	Boulders from Varunavat Parvat razed several parts of the Uttarkashi town. Landslides affected 362 families and nearly 3,000 people were evacuated. Several portions of the national highway leading to Gangotri were damaged.
July 6, 2004	Badrinath (Uttarakhand)	Landslide blocked the pilgrimage route to Badrinath. Over 2,000 pilgrimage were stranded in the hills near Badrinath. Nearly 1,000 shopkeepers and 2,500 villagers were trapped and remained cut off for 3 days. Roads were blocked. Massive rescue work had to be launched.
June 16, 2013	Uttarakhand	Floods and landslides caused by heavy rains resulted in untold damage to life as property.
July 30, 2014	Malin village 80 km north of Pune	The whole village burried in the debris. More than hundred people feared dead.

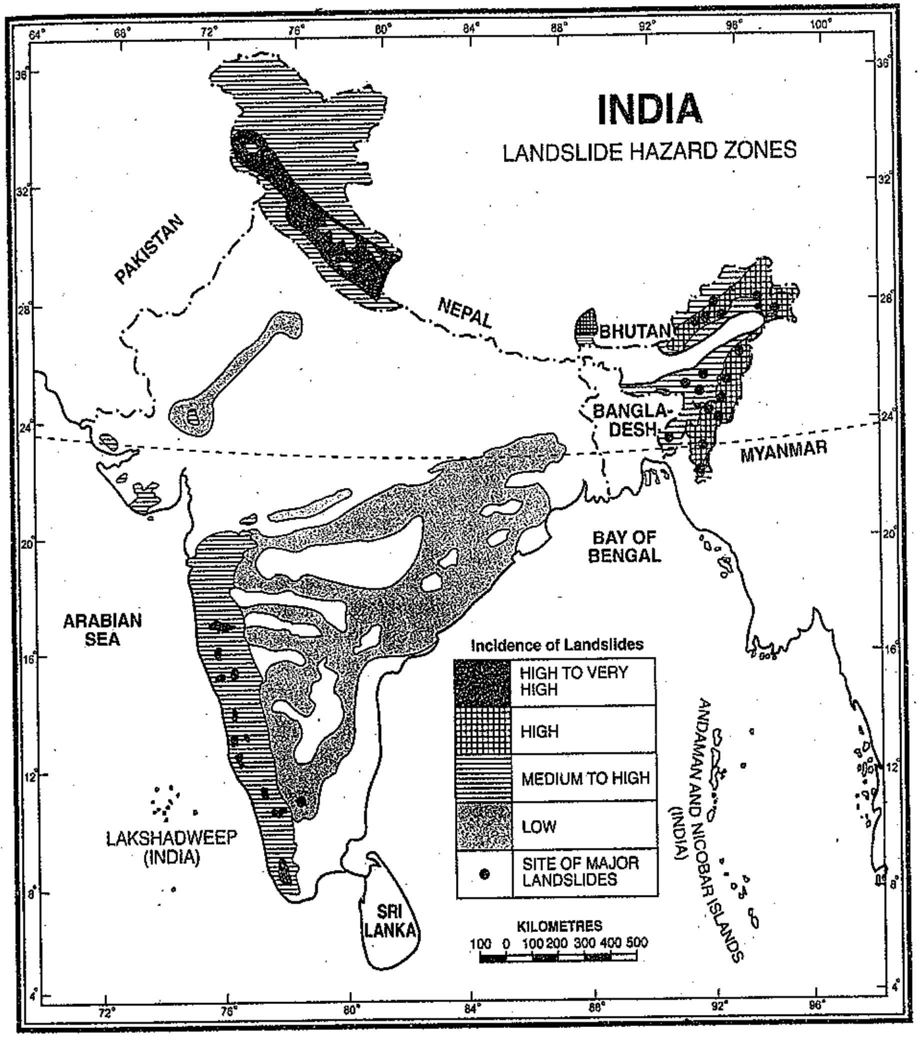


FIG. 8.18. India : Landslide Hazard Zones

in Jammu and Kashmir, Himachal Pradesh, Uttarakhand and Arunachal Pradesh have been experiencing landslides caused by incessant rainfall for many years now.

Landslides in Uttarakhand. Report of The Central team on landslides in hill areas of Uttar Pradesh (now a separate state of Uttarakhand) during 1998 indicates the damages caused due to hailstorms, heavy rains and the resulting crop damage in the state during the months of May to September 1998. The report observes that the Himalayan ecology is extremely fragile and falls under the Seismic Zone V. The main causes for landslides have been unplanned and unscientific development activities in the hilly areas, mindless and indiscriminate felling of trees, urbanisation, etc. which have caused ecological imbalances in the Himalayas. Increasing pressure of human and animal needs, rapid denudation, biotic interference etc., have further aggravated the problem of soil erosion, avalanches, flash floods etc. The damages are caused by nature and induced by human activities.

Every year, the landslides in the region kill dozens of people and cause widespread damage to several villages such that they have become totally unfit for habitation. The landslides have caused havoc and the terraced fields have been destroyed that cannot be renovated or made productive again. The road network remains closed for long periods causing indescribable hardships to the villagers who get their home supplies and provisions from the neighbouring areas. The water course is also disrupted due to landslides as they are breached from several places and are choked by debris. More so, the water channels are affected from the uphill side due to which the villagers are devoid of water for irrigation purpose. This adversely affects agricultural production.

Main Mitigation Strategies

- **Hazard Mapping.** It locates areas prone to slope failure. This helps in identifying areas prone to landslides and avoidance of areas for building settlements.
- **Land Use.** This pertains to preservation of vegetal cover. Denuded path slopes provoke landslides and must be reforested with suitable tree species. Due care must be taken to avoid blockage of natural drainage while constructing roads, buildings and canals.
- **Retaining Walls.** These are built along the road sides to stop debris from slipping. Such retaining walls have also been constructed along the Konkan railway line.
- **Surface Drainage Control Works.** The surface drainage control works are implemented to control the movement of landslides accompanied by infiltration of rain water and spring flows.
- **Engineered Structures.** Buildings and other engineered structures with strong foundations are in a better position to withstand the ground movement forces. Underground installations such as pipes and cables should be made flexible to move in order to withstand forces caused by the landslides.
- **Increasing Vegetation Cover.** This is the cheapest and the most effective way of arresting landslides. This helps in binding the top layer of the soil with layers below, while preventing excessive run-off and soil erosion.

AVALANCHES

Introduction and Definition

The term avalanche generally denotes the descent of material down a mountain slope, but specifically meaning the hurtling down a mountain slope of mass of snow, compounded with ice and rock.

In winter, avalanches are caused when fresh snow falls and slips off the snow surface. In spring, they are produced when partly thawed snow rolls down mountain slopes. Along the way these masses increase in size and acquire a dangerous momentum. Avalanches also occur when edges of glaciers in high mountains break off.

Avalanches are commonly subdivided according to the material involved.

Snow avalanches occur in predictable locations in snowy mountains and create distinctive ground features as they move down the mountain side.

Debris avalanches involve the rapid downslope movement of sediment.

Rock avalanches are very rapid downslope movements of bedrock which become shattered during movement. These avalanches sometimes achieve velocities as high as 400 kmph. They can travel tens of kilometres from their source, sometimes with devastating effects on human life.

Damages by Avalanches

Generally speaking, avalanches cause the following damages :

(*i*) Roads are damaged by snow of the avalanches.

(*ii*) Traffic is blocked when an avalanches falls on a road.

(*iii*) Road structures such as retaining wells are overturned.

(*iv*) Structures coming in the way of an avalanche are damaged.

Preventive Measures

(*i*) Afforestation of avalanche prone area.

(*ii*) Trapping the avalanche by control measures.

(*iii*) Disposing the avalanche potential snow packs by artificial triggering

(*iv*) Predicting the occurrence of avalanches through stability analysis and issuing warning about impending avalanche.

(*v*) Guiding the residents about the emergency evacuation shelters.

Avalanche Prone Areas in India

The higher reaches of the Himalayan region are prone to attack by avalanches. The snowy region of the Western Himalayas is particularly prone to avalanches. It includes higher areas in Jammu and Kashmir, Himachal Pradesh and Uttarakhand. The details are as under :

1. Jammu and Kashmir – Higher reaches of Kashmir and Gurez valleys, Kargil and Ladakh and some of the major roads.
2. Himachal Pradesh – Chamba, Kullu-Spiti and Kinnaur are vulnerable areas.
3. Uttarakhand – Parts of Tehri Garhwal and Chamoli districts are vulnerable areas.

Snow Avalanche Zones

There are three types of snow avalanche zones :

1. **Red Zone.** The most dangerous zone where snow avalanches are most frequent and have an impact pressure of more than 3 tonnes per square metre.
2. **Blue Zone.** Where the avalanche force is less than 3 tonnes per square metre and where living and other activities may be permitted with connection of safe designs but such areas may have to be vacated on warning.
3. **Yellow Zone.** Where snow avalanches occur only occasionally.

Avalanche Disaster in India

As mentioned earlier, most avalanche disasters in India take place in the west Himalayan region particularly in Jammu and Kashmir and Himachal Pradesh (see **Table 8.11**).

Avalanche Control Measures

Types of Control Measures. There are two types of control measures *viz.* (*i*) hardware, and (*ii*) software.

(*i*) ***Hardware measures*** are meant for preventing avalanches or for blocking or deflecting avalanches with protective structures.

(*ii*) ***Software measures*** provide safety by eliminating the probability of avalanches by removing

TABLE 8.11. Avalanche Disaster in India

Location	Year	Damage
Himachal Pradesh	March, 1978	30 people killed, road and property damaged.
Lahul & Spiti	March, 1979	237 people killed. Communication lines disrupted.
Jammu & Kashmir	Dec. 1982	100 people killed. Communication lines disrupted
Ladakh	Dec. 1984	27 soldiers killed under avalanches generated by artillery fire.
Jammu & Kashmir	March, 1988	70 people killed. Communication lines disrupted
Himachal Pradesh	March, 1991	Tinku avalanche takes place every year 4-5 times Jan-March, road was blocked for 40 days in 1991.
Himachal Pradesh	Sept. 1995	Due to avalanche, huge chunk of debris came down which later melted into a flood.

Source : Manual on Natural Disaster Management in India. National Centre for Disaster Management (2001), p. 75.

snow deposits on slope with blasting and by predicting the occurrence of avalanches and recommending evacuation from hazardous areas.

Avalanche Control Structures

Two major types of avalanche control structures are (*a*) Prevention Structures and (*b*) Prediction structures.

(*a*) **Prevention Structures.** These structures are meant for preventing the occurrence of avalanches. Following are the major preventive structures.

(i) Avalanches Prevention Forest. These prevent the movement of avalanches by the resistance of tree trunks and branches, increase the stability of snow cover by uniformly distributing it and control quick changes in snow cover.

(ii) Stepped Terraces. Theses help in stabilising the snow cover. Stepped terraces are easy to construct but are not effective in controlling surface layer avalanches.

(iii) Avalanche Control Piles. Avalanche Control Piles are assemblies of single piles driven into slopes in avalanche zones to control surface layer avalanches. Spacing of piles depends upon the type of snow or topographical features. The average spacing is about 5 metres.

(iv) Avalanche Control Fence. Avalanche Control Fence is installed on slopes of avalanche zones to prevent full depth or surface layer avalanches.

(v) Suspended Fences. Suspended fences are used in steep slopes or in areas where foundations cannot be properly installed because of poor ground conditions. These are useful in small area.

(vi) Snow Cornice Control Structures. These structures are installed at tops of mountain areas to prevent the development of snow cornices that can cause avalanches.

(*b*) **Protection Structures.** These structures are installed in the path of the avalanche or in snow deposit areas to change direction of flow of avalanches, to reduce their energy to block their flow or to allow their passage. Following are the main protective structures.

(i) Protective Fences. These are installed to block the avalanches and their action is similar to that of retaining walls. They are normally constructed of steel and are used mainly for blocking small avalanches.

(ii) Retaining Walls. Retaining walls are normally installed in snow deposit areas to block the flow of avalanches before they reach the roadside. These walls need a pocket large enough to store snow deposited by avalanches and are not very effective unless they are installed on gentle slopes of 20 degrees or less.

(iii) Deflecting Structure. As the name indicates, these structures are installed to deflect the flow of an avalanche. This is done particularly to avoid interference of the avalanche in road traffic.

(iv) Snow sheds. Snow shed is a roofed structure installed over a road to allow the flow of an avalanche over the roof. This is most reliable of the various avalanche protection structures.

(v) Retarding Structure. These are structures to reduce the flow velocity or the scale of the avalanches. There are various types such as earth mounds, retarding piles, grating crib work and retarding fences.

Other Control Measures. Apart from the above mentioned measures, there are other control measures which are briefly described as under.

(i) Prediction and Forecasting. Prediction and forecasting is a very effective method of reducing the risk from avalanches can not only prevent avalanche disasters but can also make it efficiently dispose off dangerous snow deposits and cornices.

(ii) Disposal of Avalanches Potential Snow Packs. Methods that dispose of snow packs on hazardous slopes include hard labour, mechanical methods that use blasting powder. In general, small avalanches are usually disposed of by blasting.

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Environment

INTRODUCTION

The word environment has been derived from the French word *Environir* which means '*to surround*'. Thus environment refers to the sum total of conditions which surround man at a given point of space and time. It is a composite term for the conditions in which organisms live. It includes both biotic and abiotic substances. In other words, environment is the totality of all physical, social, and biological factors, individually as well as collectively, that comprise the natural and man made surroundings.

Considering its basic structure, environment may be divided into two broad types *viz*. physical environment and biotic environment. Physical environment is subdivided into three broad categories *viz*., (*i*) solid, (*ii*) liquid and (*iii*) gas which represent three basic realms of the earth known as the ***lithosphere***, the ***hydrosphere*** and the ***atmosphere***. The biotic component of environment consists of plants and animals including man as an important factor. Of all the organisms, man is the most intelligent, skilled and civilized creature. He is both the creator and the moulder of his environment. With his tremendous scientific and technological advancement, man has to a large extent, succeeded in controlling and dominating nature. In this process, he has interfered with nature and disrupted his biotic and abiotic environments.

Pollution. The word pollution has been taken from the Latin word *Pollutionem*, meaning defilement from polluere, to soil or defile (make dirty). Later on Oxford English Dictionary used the word *pollute* with reference to physical contamination of terrestrial or aquatic environments in the nineteenth century. In the twentieth century the word pollution was used with reference to contamination of water, soil and air. According to the report of the Environment Pollution Panel of the **U.S. President's Science Advisory Committee** (1965), environmental pollution may be defined as the unfavourable alteration of our surroundings, wholly or largely as a byproduct of man's actions, through direct or indirect effects, of changes in energy patterns, radiation levels, chemical and physical constitution and abundance of organisms. **R.F. Dasmann** (1975) has defined pollution as "*the accummulation of substances, or forms of energy, in the environment in the quantities, or at rates of flow, which exceed*

capacity of ecosystems to either neutralize or desperse them to harmless levels". In simple words, pollution is an undesirable change in the physical, chemical or biological characteristics of our air, land and water that may or will harmfully affect human life or that of desirable species, our industrial processes, living conditions and cultural assets or deteriorate our raw material resources.

Pollutant. According to **Sir Fedrick Warner**, "A substance is normally considered to be a pollutant if it adversely alters the environment by changing the growth rate of species, interferes with the food chain, is toxic or interferes with the health, comfort, amenities or property values of people." Pollutants may be solids, liquids as well as gases. The solid particulate pollutants include aerosols, industrial wastes, such as lead, mercury, asbestos, etc. The liquid pollutants are dissolved solids, ammonia, urea, nitrates, chlorides, fluorides, carbonates, insecticides and pesticides—all in dissolved form, oil and greases, etc. The major gaseous pollutants are carbon dioxide, sulphur dioxide, nitrogen oxide, etc.

ENVIRONMENTAL POLLUTION IN INDIA

There has been large scale pollution of the natural environment in India, especially after Independence, as a result of unprecedented urbanization and industrialization. The most important source of pollution in India is its fast growing population. Most parts of India are now crowded with people resulting in large scale consumption of resources and creation of wastes. Pollution problems increase almost in proportion to the increase in population because the pollutants and wastes also increase proportionately. In India, the problem of environmental pollution is further complicated by widespread poverty of the masses. A large proportion of Indian population lives below the poverty line in slum areas without basic civic amenities. In fact, *poverty and underdevelopment are India's prime pollution problems which are roots of the major ecological imbalances and poor quality of human environment in the country.*

AIR POLLUTION

Air is a mixture of several gases. The main gases are nitrogen (78.09%) for forming products such as, fertilizers for plants and for making the air inert, oxygen (20.95%) for breathing and carbon dioxide (0.03%) for photosynthesis. Some other gases like argon, neon, helium, krypton, hydrogen, ozone, zenon and methane are also present. Besides, water vapour and dust particles make their presence felt in one way or the other.

Air is most essential for all types of life in the biosphere because it helps in breathing. *Man can live without food for a few weeks, without water for a few days but he cannot live without air even for a few minutes*. A person breathes 22,000 times a day inhaling about 16 kg of air. It is mostly the oxygen which is consumed while carbon dioxide is released during the breathing process. **Table 9.1** gives the composition of respiratory act.

TABLE 9.1. Composition of Respiratory Air

Name of the gas	Volume %of	
	Inhaled air	Exhaled air
Oxygen	20.95	16.4
Nitrogen	79.01	79.5
Carbon dioxide	0.04	4.1

The atmospheric air is recognised as clean when there are no drastic variations in its natural composition and it is devoid of any solid particulate matter. It must be borne in mind that we cannot find clean or pure air in any part of the world because it is constantly being polluted both by nature and man. When we breath, not only oxygen but some other gases such as sulphur dioxide, hydrogen sulphide, carbon monoxide, dust particles, emissions from volcanoes, etc. also enter our respiratory system. Thus air becomes polluted when its normal composition is disturbed either by nature or by man or by both. **World Health Organisation** (WHO) has defined air pollution as limited to situation in which the outdoor ambient atmosphere contains materials in concentration which are harmful to man and his surrounding environment. In simple words air pollution refers to the injection into the atmosphere of gases, liquids and solid particles detrimental to human health. Air pollution knows no political boundaries, it is a global phenomena.

Air Pollutants

Air pollutants are classified as primary or secondary based on their characteristics while they are emitted and physical/chemical changes they undergo while in the atmosphere. The pollutants emitted into the atmospheric directly from the identifiable sources that remain scattered in the atmosphere in the same chemical form as at the time of emission from source are known as ***primary pollutants***. The pollutants which undergo chemical changes in the atmosphere as a result of reactions among two or more pollutants are called ***secondary pollutants***. The pollutants like sulphur dioxide, nitrogen dioxide and particulates are recognised as primary pollutants while several other air pollutants are categorised as secondary pollutants.

Normally speaking, urban air is more polluted than rural air. The routine pollutants in urban air include sulphur dioxide, nitrogen oxides and suspended particulate matter. Besides, there is a severe threat from a range of other air toxins such as carbon monoxide, small particulate emissions, lead, benzene, polycyclic aromatic hydrocarbons (PAH) and ozone. A brief description of various air pollutants commonly found in the urban atmosphere is given below :

1. Sulphur dioxide (SO_2) : Critical Pollutant. Sulphur dioxide is generated from natural resources such as the bacterial decomposition of sulphurs in the soil from the oxidation of hydrogen sulphide produced by the decay of organic matter, from volcanoes, etc. The anthropogenic sources of sulphur dioxide emission arise mainly from combustion of fuels because of trace amount of inorganic and organic sulphur contained in the fossil fuels and ores. It has been estimated that about one-third of the sulphur dioxide emission in the atmosphere arises from the activities of man, chiefly the combustion of fossil fuels. Significant quantities of sulphur dioxide are emitted by oil refineries, automobiles, thermal power plants, acid plants, smelters, incinerators, etc.

Studies conducted by Central Pollution Control Board, indicate that Sulphur Dioxide concentrations in percentage of locations are limited to low and moderate category though fluctuating over the years from 2001 to 2010 (**Fig. 9.1**).

2. Nitrogen Oxide (NO_2) : Killer Gas. Generally recognised as sum of nitric oxide (NO) and nitrogen dioxide (NO_2), it is a reddish brown corrosive gas. The automobile exhaust is one of the largest sources of NO_2 emission in the ambient air, as these are formed during combustion as a result of oxidation of atmospheric nitrogen and organic nitrogen. The significant concentration of nitrogen oxides in gaseous emissions occurs from the industrial emissions where nitric acid is produced or is used in chemical reactions. The residence time of NO_2 in the atmosphere is about a few days and is scavenged from the atmosphere through formation of nitric acid, nitrites or nitrates and through their dry dissociation.

Figure 9.2 shows that NO_2 concentrations showed a reduction in low category and increase in moderate, high and critical categories. These trends are clear indicators of an increase in pollution levels with respect to NO_2. High concentration of NO_2 is a major concern of air pollution. In addition to being a pollutant by itself it also aids formation of yet another deadly gas—ozone. Studies show that NO_2 peaks coincide with traffic peaks.

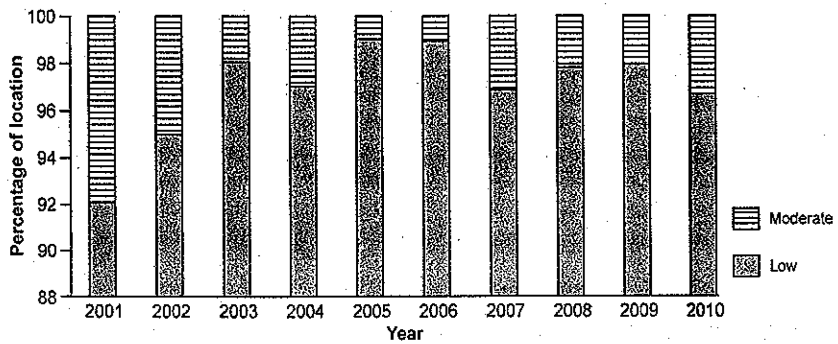

FIG. 9.1. Yearly trends of Sulphur Dioxide in locations (Residential/industrial/rural/other areas)

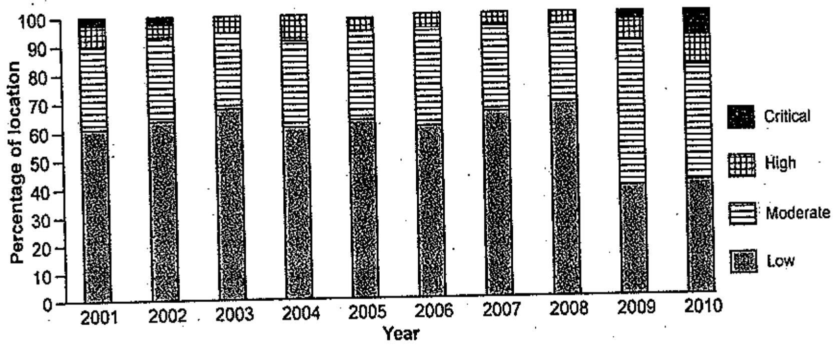

FIG. 9.2. Yearly trends of NO_2 concentration in the air from 2001 to 2010

The steady upward trend of annual NO_2 levels in Mumbai, Delhi and Chennai indicates that the problem is going to take serious turn in the near future.

Though annual mean concentrations of NO_2 in most cities are still within the limits of tolerance, maximum levels in several cities are well above the permissible limits. Gajrala in Uttar Pradesh, Ludhiana, Jalandhar and Patiala in Punjab, Parwanoo in Himachal, Kottayam in Kerala, Pondicherry, Mysore in Karnataka, Haora in West Bengal, Dhanbad, Sindri and Jharia in Jharkhand, Ahmedabad, Surat, Vapi, Rajkot and Ankleshwer in Gujarat, Nagda and Jabalpur in Madhya Pradesh, Jaipur, Alwar and Kota in Rajasthan are some of the towns and cities where NO_2 concentration is already well beyond the standard or it is increasing rapidly.

3. Particulate Matter (P.M.). The particulate matter refers to the solid or liquid particles in its form of dust fumes, mist or smoke and originated either by dispersion of particles from breakdown of solid bulk material or condensation originated, built up from molecular dimension after heating or cooling. The particles have several physico-chemical properties such as size, mass, volume, settling velocity, chemical aerodynamics and optical properties. These properties of the particles play a vital role in atmospheric processes. The size, density and shape of the particles are of prime importance because these factors not only influence their cleansing rate from the environment, but also their effects. The particle size is one of the most important physical characteristics of air borne particulate matter because it controls the residence time of particles in the ambient air. The size of particles may vary from 0.002 μm, (micron) to 500 μm (one micron is equal to one millionth of a metre). Particles larger than 50 μm can be seen with naked eye. Following two types of particulates are recognised depending upon their size.

(*i*) ***Suspended Particle Matter (SPM).*** Particles with size less than 100 μm are very small particles and tend to remain suspended in the atmosphere for a long period of time. Hence, they are known as ***suspended particulate matter (SPM)***. In other words, SPM can be defined as solid and liquid particles in the air that are small enough not to settle down onto the earth's surface under the influence of gravity. The main contributors of SPM in ambient air are dust from different sources like conduction activities, open fields, mining, stone crushers etc. and from industrial sources such as thermal power plants and smelters.

(*ii*) ***Respirable Suspended Particulate Matter (RSPM).*** Respirable Suspended Particulate Matter (RSPM or PM_{10}) are the particulates having diameter less than 10 μm. These are very small particles. As such they can be inhaled and may enter deep into the respiratory tract and pulmonary system of human beings. The sources of RSPM include road dust, wind blown dust and the dust from agriculture, construction and combustion processes. **Figure 9.3** shows that more than half the locations in India are critical with respect to PM_{10} concentration in the air. The number of locations with high and moderate concentrations has also risen and locations with low concentrations are negligibly small.

4. Carbon Monoxide (CO). Incomplete combustion of carbon results in the production of carbon monoxide (CO). The anthropogenic sources of

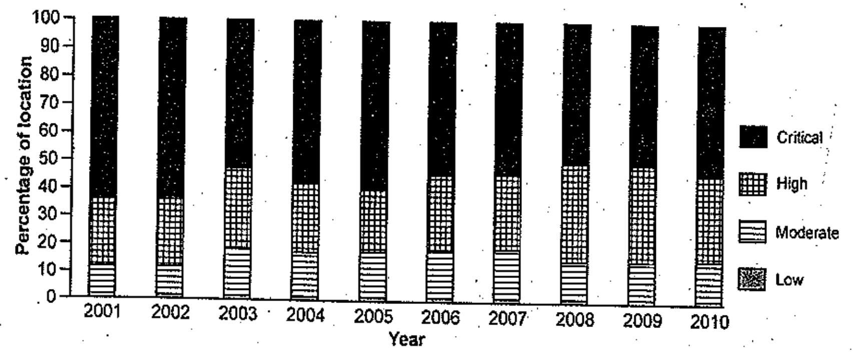

FIG. 9.3. Percentage of locations with low, moderate high and critical concentration of PM_{10} from 2001 to 2010.

CO are motor vehicles, coal combustion, fuel oil combustion, industrial processes, solid waste disposal and refuse burning. In motor vehicles air-to-fuel ratio has a direct impact on carbon monoxide emissions. At lower air-to-fuel ratio, carbon monoxide emissions are increased due to incomplete combustion in low presence of oxygen.

In urban areas, carbon monoxide concentration follows a diurnal pattern, which depends on traffic volume and speed. Generally CO concentrations reach to a maximum in the early morning hours due to peak early morning traffic and then fall to low level during the day. A second peak of CO concentration is usually observed corresponding to the late afternoon traffic period, and decrease to low levels during the night.

The residence time of CO in the atmosphere is about three years, The anthropogenic sources of carbon monoxide have been continuously increasing during the last few years in most of the urban areas.

5. Photochemical Oxidants. These are mainly the result of secondary reactions in the atmosphere and are not directly attributed to nature. *Ozone* is the main photochemical oxidant and its formation is normally attributed to nitrogen dioxide photolytic cycle. Ozone is formed through dissociation of nitrogen oxides (NO_2) by sunlight to yield the oxygen atoms, which then react with molecular oxygen to produce ozone molecule. The presence of reactive hydrocarbon allows ozone to accumulate at higher than steady levels.

The meteorological factor important in formation and transport of ozone in the lower troposphere are degree of atmospheric stability, wind speed and direction, intensity and wave length of sunlight and synoptic weather condition. Ozone produced near pollutant sources/areas can be transported over long distances. A result of such reactions produce photochemical smog which is characterised by grayish haze during period of excessively high ground level pollution.

Peroxyacyl nitrate (PAN) is phytotoxic pollutant obstructing visibility. PAN is relatively stable in upper troposphere and can travel over long distances. Upon mixing with lower tropospheric air, PAN can thermally dissociate and release NO_2.

6. Organics in Ambient Air. Hydrocarbons and Polynuclear aromatic hydrocarbons, Benzene and volatile organic compounds are the chief organics in ambient air.

(i) Hydrocarbons and Polynuclear- aromatic hydrocarbons (PAH). The ambient hydrocarbon composition includes the unburned hydrocarbon from fuels such as gasoline, species formed during combustion and natural hydrocarbons emitted by vegetation. The major anthropogenic sources of hydrocarbons are partially burned gasoline from vehicular sources and interior emissions. Gasoline evaporation and solvent evaporation also account for emission of hydrocarbons. Industrial sources of hydrocarbons include chemical manufacturing facilities, petroleum refineries and metallurgical operations.

Polynuclear aromatic hydrocarbons (PAHs) are homologs of benzene. The sources of PAHs are heat generation using coal, refuse burning, motor vehicles,

industries such as steel and coke manufacturing and carbon-black manufacturing.

The residence time of hydrocarbons in the atmosphere is about three years. Many of the hydrocarbons are oxidised and several are converted to other organic compounds in the presence of nitrogen oxides. Ultimately the hydrocarbons may be converted to particulates and scavenged from the atmosphere.

(ii) Benzene. Benzene is produced during the distillation of crude petroleum and forms a significant component of gasoline. Transport vehicles comprise the major source of benzene emissions. Other sources of benzene emission are chemical manufacturing, coke ovens, petroleum refineries, etc. It is estimated that emissions of benzene from motor vehicle operation are substantial and benzene comprises about 4% of automobile exhaust emission and approximately 1% of fuel evaporative emissions. The urban areas have higher concentration of benzene.

(iii) Volatile Organic Compounds (VOC). The organic compounds which evaporate easily are recognised together as volatile organic compounds. Technically such compounds are defined as organic compounds with a vapour pressure of 1300 pascals (about 1% atmospheric pressure at sea level). These compounds may include several aromatic hydrocarbons and are included into the common category because of their similar physical behaviour in the atmosphere. Volatile organic compounds emerge as evaporative emissions during handling, storage and use as part of unburnt or partially burnt hydrocarbon mostly along with exhaust gases from vehicles. The volatile organic compounds (VOC) are emitted to the atmosphere from transport, use of industrial solvents and for domestic purposes. These compounds are scavenged with condensation along with water vapcurs, absorption on surfaces or on particles. Some outstanding examples of volatile organic compounds are aldehydes, ketones, organic acids, alcohols, furans, etc.

TABLE 9.2. Typical Sources of some Air Pollutants in Ambient Air

Sl. No.	Air Pollutants	Major Sources
1.	Sulphur Dioxide (SO_2)	Fuel combustion, power station, industrial processes, chemical processes, diesel vehicles, solid waste disposal, smelters.
2.	Nitrogen Oxide (NO_x)	Transport (road, rail, passenger and commercial), fuel combustion, power stations, industrial boilers, chemical processes, waste incinerators, smelters.
3.	Particulate Matter (SPM, RSPM-PM_{10}, RSPM-$PM_{2.5}$)	Fuel combustion, power stations, construction activities, industrial processes, diesel vehicle exhaust, re-suspended road dust, domestic refuse burning, domestic wood.
4.	Carbon Monoxide (CO)	Transport, combustion, industrial processes, solid waste disposal, refuse burning.
5.	Ozone (O_3)	Secondary pollutants formed during photochemical reaction.
6.	Organic compounds	Transport, oil based fuel combustion sources, chemical processes, solvent use, waste incinerators, vaporization of fuel.
	Benzene	Petrol combustion products, petrol filling stations, chemical process.
	Polynuclear aromatic hydrocarbons (PAH)	Fuel combustion, industrial emission.
	Volatile organic compounds (VOC)	Transport, solvents (especially used in industrial and domestic sector).
7.	Trace metals	Fuel combustion, chemical process, transport, metal production and finishing operation, product manufacture.
	Lead (Pb)	Lead additives in gasoline, soil originated particles.
	Cadmium (Cd)	Fuel combustion, metal production process, transport.

Source : Air Quality Status and Trends in India (2000), Central Pollution Control Board, pp. 17-18.

7. *Trace Metals in Ambient Air.* Various metals are found in the ambient air in trace and ultra trace concentrations. These include lead, cadmium, zinc, nickel, iron, chromium, etc. They are briefly described as under :

Lead. The airborne soil is the primary source of atmospheric lead. Smelter and refinery processes, as well as incineration of lead containing waste are major point sources of lead. *One of the most important source of lead is release of lead compounds from motor transport using* lead gasoline containing tetra-ethyl or tetra methyl lead. It is estimated that about 75% of lead is emitted into the atmosphere in the form of particles less than 1 μm in size which can stay in atmosphere for long time. Approximately 70-80% lead which is added to the leaded gasoline for increasing its octane number is discharged into the atmosphere. Other major sources of lead emission are burning of lead containing products like paints, batteries, plastics, combustion of coal and oil.

Sources of ***chromium*** include metallurgical and chemical industries, products employing chromate compound, cement and asbestos. Sources of ***zinc*** include zinc refineries, manufacturing of brass, zinc and galvanising process. Sources of ***cadmium*** include metal industries engaged in extraction, refining, electroplating and welding of cadmium material. It is also emitted as byproduct of refining laced zinc and copper. It is estimated that about 76% of all anthropogenic cadmium emissions come from non-ferrous metal industries, Sources of ***nickel*** include metallurgical plants using nickel, engines burning fuels containing nickel additives, burning of coal and oil, nickel plating facilities and incineration of nickel products. Sources of ***iron*** in ambient air include iron and steel plants, fly ash from combustion of coal and fuel oil, municipal waste incineration and use of welding rods.

Different pollutants in ambient air originate from different sources. Most sources of pollutants are associated with transport or industries and have different effects in different parts of the country. **Table 9.2** gives a brief summary of typical sources of some air pollutants in ambient air.

The areal distribution of three major pollutants (SO_2, NO_2 and PM_{10} is given in **table 9.3**. This table shows that Jharkhand had the maximum concentration of SO_2 (23 μg/m^3) followed by Maharashtra (17 μg/m^3). With respect to NO_2, West Bengal had the maximum annual concentration (64 μg/m^3) followed by Delhi (55 μg/m^3). With respect to PM_{10}, Delhi had the maximum annual average concentration (261 μg/m^3) followed by Jharkhand (193 μg/m^3).

Effects of Air Pollutants

Air pollutants have varied effects on human life, the most important being their effects on human health. Their other effects are on materials, and vegetation. A brief description of effects of various air pollutants on health is given as under :

1. Health Effects Associated with Air Pollutants

Air pollutants have serious adverse effect on human health. People living in urban and industrial areas are particularly prone to varied types of diseases due to air pollution.

I. *Health Effects of Sulphur Dioxide (SO_2).* Human beings chronically exposed to SO_2 have higher incidence of cough, shortness of breath, bronchitis, colds of long duration and fatigue. Most of the SO_2 in the atmosphere is converted to sulphate salts, which are removed by sedimentation or by washout alongwith precipitation thereby making rain water acidic due to sulphuric acid formation. The most common acute exposure to SO_2 at concentration $>= 0.4$ ppm (parts per million) is induction of asthmatics after exposure lasting only 5 minutes. Increased prevalence of cough in children with intermittent exposure to SO_2 levels of 1.0 ppm is observed.

II. *Health Effects of Nitrogen Dioxide (NO_2).* The oxides of nitrogen are toxic gases which enter the human body during breathing. High concentration of NO_2 may increase susceptibility to respiratory pathogens and also increases risk of acute respiratory diseases like bronchitis, chronic fibrosis, emphysema and bronchopneumonia. NO_2 exposure can cause decrement in lung functions. It has been established that continuous exposure with as little as 0.1 ppm NO_2 in air over a period of one to three years increases incidence of bronchitis, sedema, emphysema, oedema and adversely affects the performance of lungs. US study by Hasselblad *et al.* (1992) indicate that repeated NO_2 exposure increases respiratory illness in children. The epidemiological studies suggest that an increase of 30 μg/m^3 in NO_2 levels results in about 20 per cent increase in

TABLE 9.3. Annual Average Concentration of Criteria Pollutants in States
(residential/industrial/rural/other and sensitive areas)

States & Union Territories	SO_2		NO_2		PM_{10}	
	Annual average (μg/m^3)	Standard deviation	Annual average (μg/m^3)	Standard deviation	Annual average (μg/m^3)	Standard deviation
Andhra Pradesh	5	2	17	4	73	24
Assam	7	1	15	2	76	51
Bihar	5	2	26	9	118	80*
Chandigarh	2	0	16	7	92	56
Chhattisgarh	11	1	22	2	107	14
Dadra & Nagar Haveli	7	0	18	1	39	27
Daman & Diu	7	0	18	1	35	21
Delhi	5	2	55	13	261	130*
Goa	14	15	18	10	68	36
Gujarat	15	3	23	3	89	15
Haryana	14	4	23	6	171	73*
Himachal Pradesh	3	1	15	4	88	39
Jammu & Kashmir	5	2	13	4	105	41
Jharkhand	23	3	39	4	193	67*
Karnataka	10	6	22	5	70	35
Kerala	4	1	13	3	42	16
Madhya Pradesh	11	6	17	6	137	57
Maharashtra	17	7	31	11	101	40
Meghalaya	2	1	10	4	101	15
Mizoram	2	0	6	1	42	10
Nagaland	2	0	6	2	68	42
Odisha	5	1	18	3	86	25
Punjab	11	2	27	5	187	37
Puducherry	6	2	13	3	38	12
Rajasthan	7	2	29	6	168	99*
Tamil Nadu	9	3	20	8	70	39
Uttar Pradesh	12	6	30	11	181	111*
Uttarakhand	—	—	—	—	169	36
West Bengal	10	4	64*	19	110	70

N.B. '—' inadequate data, *-exceeding NAAQS. Data of monitoring stations with monitoring days greater than or equal to 50 has been considered.

Source : National Ambient Air Quality Status and Trends in India 2010, Central Pollution Control Board, p. 24.

respiratory illness and diseases. Continuous exposure with more than 2.0 ppm NO_2 may cause extensive morphological alteration, lung dispensability and permanent changes in the lung (bronchiolitis).

III. ***Health Effects of Particulate Matter.*** The particles may influence the human body on setting and cause external effects *e.g.*, effects on skin. However, certain groups of particles pass into the blood stream on being inhaled and act as systematic poison. The effect of irritant particles in respiratory tract depends upon the size of the particles, their solubility, penetration deposition and clearance mechanism in human respiratory tract. Fine particles may cause irritation of broncospasm, pulmonary oedema and allergic alveolitis, while certain moulds of larger particle size cause obstructive lung disease. As the presence of finer particle size increases, the percentage of particles deposited in upper part of respiratory tract decreases, thus particles are inhaled deeper. The soluble nature of particles of chemical origin may cause systematic intoxication in the body. Increased particle presence in ambient air increases the frequency of cough and phlegm. The susceptibility of infection in pulmonary system increases in case the inhaled particles are active particles constituting bacterial, fungal spores or viral strains. The acute effect of particulate air pollution results in changes in respiratory health status and depict several respiratory symptoms. The symptoms are often recorded into upper respiratory symptoms such as stuffy or running nose, sinusitis, sore throat, wet cough, head cold, hay fever and burning or red eyes. The lower respiratory symptoms include wheezing, dry cough, phlegm, shortness of breath, chest discomfort and pain. The cough is the most frequently reported symptom due to continued exposure to high particulate laden ambient air.

Asthma and allergic alveolitis are two main respiratory diseases related to chronic exposure to particles. Studies reveal a direct relationship in asthmatic attack with exposure to particles. Particles containing fungi, viral or bacterial pathogens loading in ambient air may play their role in transmission of infectious diseases. Increased particulate exposure increases the incidence of bronchitis. The bronchitis or pneumonia induced by air pollution in the presence of pre-existing heart problems might precipitate congestive heart failure and cardiovascular mortality.

IV. ***Health Effects of Carbon Monoxide (CO).*** Carbon monoxide is absorbed from the lung tissue in blood stream. Toxic effects of CO are mainly due to its high affinity for Hb which is 240 times greater than oxygen affinity. The COHb in blood of exposed population may be between 3.0 and 5.3 per cent whereas the safe limit is less than 2 per cent.

High dose exposure of CO may affect lung tissue and may lead to acute decrement in lung functions. CO level to about 5 per cent may cause cardiovascular effect in young healthy, non-smoking individuals leading to fatigue and reduced ability to work. The recurrent episode of exertial angina increase risk of precipitating heart attack, fatal arrhythmia or myocardial damage, increased risk of sudden death with coronary artery disease. Increased concentration of carbon monoxide also leads to stroke, head injury, artherosclerosis, hypertension, etc. High CO concentration has special effect on children and infants. There are strong evidences of reduction in birth weight, cardio megaley, delay in behavioural development and disruption of cognitive function and sometimes even infant death syndrome. The other systematic influence of CO poisoning include effects on lever, kidney, bone, immune capacity and spleen.

V. ***Health Effects of Ozone.*** Variations in ozone levels in urban environment are the main cause of concern, both with regard to health risk associated with concentration exceeding the standard and possible health effect associated with human exposure to somewhat lower ozone concentration over long period of many days. High elevation of ozone causes major problem of human health which includes eye, nose and throat irritation, chest discomfort, cough and headache. Ozone is a respiratory irritant, reacts rapidly with tissues and airways lining of lungs. The acute reversible decrement in lung functions and increased respiratory symptoms occur in individual exposed for 1 to 3 hours with ozone concentration ranging between 235 to 314 $\mu g/m^3$. Acute exposure to ozone may cause lung inflammation within a few hours. Long term ozone exposure has been associated with inflammation of lungs which may be involed in progression from chronic health effects. Ozone also increases susceptibility to pulmonary bacterial infections and it can exacerbate its severity of influenza infection. Acute exposure to low ozone levels decreases activity pattern, may affect immune system leading to potential health risk.

VI. ***Health Effects of Benzene.*** Benzene is a hazardous air pollutant which accelerates carcinogenicity and human health risk from ambient air. Various studies have provided evidence regarding effect of benzene linked to genetic change, chromosomal aberration, etc. International Agency for Research on Cancer (IARC) has classified benzene as carcinogenic to humans which increases the frequency of cancer in human beings. Exposure to excessively high level of benzene may cause cancer in kidney, testes, brain, pancreas, stomach, lung, respiratory tract, bladder and uterus. Benzene acts as Leukaemogen in human beings, acting as etiologic agent of aplastic anaemia leading to acute myclogenous leukaemia. World Health Organisation (WHO) estimate a four in one million risk of leukaemia on exposure to benzene to a concentration of 1 mg/m^3. Benzene has also been recognised as causing DNA damage in mammalian cells. Prolonged exposure to even mild form of benzene may cause euphoria followed by giddiness, irregular heart beat, headache, dizziness, nausea and unconsciousness. Breathlessness, nervous irritability and unsteadiness in walking may persist for a long time. Acute benzene poisoning includes extensive petechial haemorrhage in the brain pleurae, pericardium, urinary tract, mucous membrane and skin. Pneumonitis and bronchitis can also be caused by direct action of benzene. The other effects of benzene are disorders of blood, harmful effect on bone marrow, anaemia and reduced ability of blood to clot, damage to immune system and reproductive and development toxicant.

It has been found that women are more susceptible than men to benzene. Benzene exposure may cause menstrual disorder and retard foetal development.

VII. ***Health Effects of Volatile Organic Compounds (VOC).*** The volatile compounds have potential carcinogenic effects on human beings and are termed as air toxins. These compounds react with oxides of nitrogen in the presence of sun light and give rise to photochemical smog. This smog is a dense haze which restricts visibility. Hazy fumes cause irritation to eyes and lungs and damage plant life.

VIII. ***Health Effects of Lead.*** Lead particles from the ambient air can be inhaled, can settle down as dust in neighbouring area, on vegetation and water bodies and may be partly ingested. Out of the total estimated release of lead from the vehicular emission, about 50-70% is released as emission into the environment and the remaining part gets deposited. *Lead is pervasive environmental poison which affects virtually every system in the body.* It can damage the kidneys, the nervous system, the reproductive system and cause high blood pressure.

Children are more prone to lead pollution because they absorb lead more readily than adults. It affects the development of brain of foetuses and young children. Children exposed to lead show lack of intelligence, behavioural problems and decreased ability to concentrate. Blood lead levels as low as 10 μg/decilitre are associated with harmful effects on the learning process of the children. Elevated blood lead level can be more harmful. At extremely high level (70 μg/decilitre or higher), seizure, coma and even death can occur.

Lead is specially harmful to pregnant women and infants. Lead can get accumulated and stored in bones for decades and can be released whenever there is demand for calcium such as during pregnancy and lactation. During lactation, lead crosses placenta and is detected in breast milk. This is the major source of lead to infants which causes neurological problems in the developing child.

Not to speak of women, infants and childrens, even adult males are not spared by lead pollution in the air. Chronic exposure with elevated blood lead levels are associated with hypertension, headache, confusion, irritability and insomnia. Further higher level cause drowsiness, loss of muscular coordination, kidney damage, fatigue, apathy and susceptibility to infection and anaemia. Higher blood lead level (80 μg/decilitre or more) also leads to gastro-intestinal problems and liver damage.

2. Effects of Air Pollutants on Materials

Air pollutants produce physical and chemical change in materials which results in their damage and destruction. The natural effects of corrosion and weathering are aggravated when the air is polluted. The most destructive air pollutants to materials are

TABLE 9.4. Air Pollutants and their Effects on Materials

Sl. No.	Air Pollutants	Effects
1.	Particulate Matter (PM)	— Physical erosion with abrasive action. — Particulate deposits cause streaky appearance. — Corrosion of metallic substances. — Deposition on electric contacts interfere with function, accelerate corrosion. — Soiling to textile, reduced wear life and abrasive effect.
2.	Sulphur dioxide (SO_2) and sulphur trioxide (SO_3)	— Flaking of surfaces due to formation of sulphuric acid from SO_x. — Acceleration of corrosion of steel and other metals. — Embrittlement of paper and leather. — Reduced strength of fibres in textiles.
3.	Oxides of nitrogen (NO_x)	— Corrosion effect on surface and metals. — Fabric discoloration and fading.

Source : Air Quality Status and Trends in India (2000), Central Pollution Control Board, p. 44.

smoke, grit, dust and oxides of sulphur. Sulphur dioxide is the most dangerous air pollutant. It changes to sulfurous and sulphuric acid with moisture and accelerates the rate of corrosion. Amount of moisture in the air determines the rate of corrosion—more the moisture, more the corrosion.

Different types of metals and metallic structures such as iron and steel, aluminium and aluminium alloys, copper and copper alloys are corroded when exposed to polluted air. Building materials are also corroded and disfigured with increasing pollution of air. Smoke, grit and soot deposits disfigure the buildings. During high winds, larger particulates can result in surface erosion. The oxides of sulphur react with limestone to form calcium sulphate. Slow loss of substances from surface occurs during rains which leads to blistering. Effects of various air pollutants on materials are shown in **Table 9.4.**

3. Effect of Air Pollution on Vegetation

In addition to its effects on health and materials, air pollution has damaging effect on vegetation also. The effects of air pollutants on vegetation depends upon their chemical nature, level of concentration and duration of exposure.

The principal air pollutants of prime concern to agriculture and vegetation are sulphur dioxide, SPM and photochemical oxidants. The air pollutants effects on vegetation are demonstrated by plants through following characteristics :

- Qualitative and quantitative changes in solar radiations input on leaf surface and alteration in energy exchange process.
- Decrease in chlorophyll and chloroplast injury.
- Increase in gaseous exchange process.
- Dust induced alteration in physico-chemical parameters.

Table 9.5 shows the impact of major air pollutants *viz.* sulphur dioxide, ozone and suspended particulate matter on vegetation.

Ambient Air Quality Standards. In order to arrest the deterioration in air quality and to provide for prevention and control of air pollution, the Government of India enacted the Air (Prevention and Control of Pollution) Act in 1981. The responsibility has been further emphasised under Environment (Protection) Act, 1986. It is necessary to assess the present and anticipated air pollution through continuous air quality survey/monitoring programmes. The Central Pollution Control Board had formulated and notified the National Ambient Air Quality Standards (NAAQS) for industrial, residential and sensitive areas. The notified ambient air quality standards are presented in **Table 9.6.**

TABLE 9.5. Effects of Air Pollutants on Vegetation

Sl. No.	Air Pollutants	Effects on Vegetation
1.	Sulphur dioxide	— Enters into leaf through stomata. — Excessive exposure causes injury on blade with ivory colour, brown to reddish brown spots, depending on plant and environmental conditions.
2.	Ozone	— High concentration causes dark brown to black lesions on upper surface of leaves.
3.	Suspended Particulate Matter	— Block the stomata through deposition on leaf surface. — Excessive dust deposition retards the growth of plant. — Automobile exhaust smoke damage lower surface of leaves, bronzing and silvering, upper surface shows fleck like marking.

Source : Air Quality Status and Trends in India (2000), Central Pollution Control Board, p. 47.

TABLE 9.6. National Ambient Air Quality Standards (NAAQS)

Pollutant	Averaging time	Indian air quality standards[1]			WHO[2] recommen-dations
		Sensitive areas	Residential, rural and other areas	Industrial areas	
Sulphur dioxide (μg/cum)	10 minutes 1 hour 24 hours (2) Annual (1)	— — 30 15	— — 80 60	— — 120 80	500 350 100–150 40–60
Nitrogen oxides (μg/cum)	1 hour 24 hours (2) Annual (1)	— 30 15	— 80 60	— 120 80	400 150 —
Ozone (μg/cum)	1 hour 8 hours (2)	— —	— —	— —	150–200 100–120
Suspended particulate matter (μg/cum)	24 hours (2) Annual (1)	100 70	200 140	500 360	150–230 60–90
Respirable particulate matter (μg/cum) (Particulate less than 10 microns)	24 hours (2) Annual (1)	75 50	100 60	150 120	70 —
Lead (μg/cum)	24 hours (2) Annual (1)	0.75 0.50	1.00 0.75	1.5 1.0	— —
Carbon monoxide (mg/cum)	1 hour 8 hours (2)	2.0 1.0	4.0 2.0	10.0 5.0	30 10

Note : μg/cum : Microgramme per cubic meter, mg/cum : milligramme per cubic meter WHO: World Health Organisation.

1. Annual arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly, at uniform interval.
2. 24 hourly/8 hourly values should meet 98 per cent of the time in a year. However, 2 per cent of the time it may exceed, but not on two consecutive days.

Source : The Citizen's Fifth Report (2002), Centre for Science and Environment, p. 170.

As mentioned above, the Central Pollution Control Board (CPCB) is responsible for setting air quality standards. However, though World Health Organization (WHO) has applied guidelines for 1 hour, 8 hour and 24 hour averages, in India only annual mean and 24 hour average standards have been presented, except for carbon dioxide (CO) for which 8 hour and 1 hour standards have been notified.

Separate standards have been notified for industrial, residential and sensitive areas. This has drawn a lot of flak as this classification does not explain how the standards can satisfy the primary objective of protecting public health. It allows more lax limits for industrial areas. This issue had emerged at the World Bank-sponsored workshop on integrated approaches to vehicular pollution control in Delhi in April, 1998.

As a result of this classification, separate standards operate in Indian cities whereas WHO guidelines are common for all land-use areas. The national standards for annual sulphur dioxide emissions and SPM 10 levels in industrial areas is 1.6 times and 2.1 times higher than WHO norms. National annual suspended particulate matter standards for residential areas is 2.3 times higher than the 60 microgrammes per cubic metre (μg/cum) norm set by WHO (*See Table 9.5*). Significantly, Indian NO_X standards are stricter than WHO norms. While WHO allows 150 μg/cum over 24 hours, Indian residential standards are 80 μg/cum over 24 hours.

Air quality standards need to be made stricter if a lower level of pollutant affects health more than previously thought. However in India, the standards were revised only once in 1994 to create a new category called respirable suspended particulate matter (RSPM) to account for small particulate emissions.

Medical experts say that as standards are set for individual pollutants, they fail to show the combined effect. "All pollutants together can have an aggregate effect on health that is much greater than the individual effect. This needs to be kept in mind while setting air pollution standards."

National Air Monitoring Programme (NAMP)

Central Pollution Control Board initiated National Ambient Air Quality Monitoring (NAAQM) programme in the year 1984 with seven stations. Subsequently, the programme was renamed as National Air Monitoring Programme (NAMP). The number of monitoring stations under NAMP increased steeply from 28 in 1985 to 290 in 1992 and their number remained at the same level until 1999. Thereafter the number of monitoring stations increased and stood at 456 in 2010-11 covering 190 cities/towns in 26 states and 5 union territories as on 31st March, 2011.

SOME RECENT FINDINGS REGARDING AIR POLLUTION

The International Agency for Research on Cancer (ARC) announced, for the first time, that air pollution causes lung cancer. It also said that poisoned air's major component, particulate matter—smoke, dust and other dirty byproducts of road traffic, factories and construction—must now be classified a carcinogen, a cancer causing substance, alongside tobacco, asbestos and ultraviolet radiation.

- According to World Bank Report (2013), air pollution costs India about $ 30 billion or 3% of GDP.
- Of 400 locations monitored by the Central Pollution Control Board, 99% reported unsafe levels of PM 10 according to a 2013 analysis of national air quality data by Centre of Science and Environment. Ninety cities and towns reported critical air pollution levels and 23 are most critical which means they exceed safety limits by 300% or even more.
- In a World Bank report released in July, 2013, India ranked 126 out of 132 countries graded for environmental performance, behind China, Pakistan and Bangladesh. For effects of air pollution on its citizens, India ranked last *i.e.* 12 of 132.
- Every year, outdoor air pollution claims 109,000 lives of adults, and 7,513 lives of children below five years in India.
- Annually, over 37 lakh hospital admissions are reported due to outdoor air pollution in urban areas.

The number of critically polluted cities has increased from 49 in 2000 to 89 in 2013.

Objectives

The objectives of the NAMP are as follows :

- To determine status and trends of ambient air quality.
- To ascertain whether the prescribed ambient air quality standards are violated, and to assess health hazard and damage to materials.
- To continue ongoing process of producing periodic evaluation of air pollution situation in urban and industrial areas of the country.
- To identify non-attainment cities.
- To obtain the knowledge and understanding necessary for developing preventive and corrective measures.
- To understand the natural cleansing process undergoing in the environment through dilution, dispersion, wind based movement, dry deposition, precipitation and chemical transformation of pollutants generated.

According to Central Pollution Control Board Report 2012, India has ten most polluted cities where the average annual particulate matter is very high. Particulate matter is expressed in terms of $\mu g/m^3$ (micrograms per cubic metre of air). These cities are Delhi (261 $\mu g/m^3$). Amritsar (219 $\mu g/m^3$), Ludhiana (214 $\mu g/m^3$), Lucknow (204 $\mu g/m^3$), Nashik (113 $\mu g/m^3$), Kolkata (100 $\mu g/m^3$) Mumbai (97 $\mu g/m^3$), Hyderabad (79 $\mu g/m^3$), Bengaluru (60 $\mu g/m^3$) and Chennai (50 $\mu g/m^3$). Global Burden of Disease records deaths and illness from all causes every 10 years and in its report of 2013, it has been mentioned that outdoor air pollution caused 6.2 lakh deaths in 2010, which is a six fold jump from the one lakh deaths in 2000. This makes polluted out door air the fifth largest killer in India after high blood pressure, indoor air pollution, tobacco use and poor nutrition.

The Central Pollution Control Board 2012 Report also says that one in three people in India live in critically-polluted areas that have noxious levels of nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and lung-clogging particulate matter larger than 10 microns (PM10) in size. Of the 180 cities monitored by the board in 2012, only two—Malapuram and Pathanamthitta in Kerala—meet the criteria of low air pollution (50% below the standard of 60 $\mu g/m^3$).

Vehicular Pollution

Vehicular pollution has grown at an alarming rate due to growing urbanisation in India. The air pollution from vehicles in urban areas, particularly in big cities, has become a serious problem. The pollution from vehicles has begun to tell through symptoms like cough, headache, nausea, irritation of eyes, various bronchial and visibility problems.

The main pollutants emitted from the automobiles are hydrocarbons, lead/benzene, carbon monoxide, sulphur dioxide, nitrogen dioxide and particulate matter. The main cause of vehicular pollution is the rapidly growing number of vehicles. The other factors of vehicular pollution in the urban areas are 2-stroke engines, poor fuel quality, old vehicles, inadequate maintenance, congested traffic, poor road condition and old automotive technologies and traffic management system. In India, the number of vehicles increased from 0.3 million in 1951 to 58.3 million in 2001-02. About half the vehicles are concentrated in 39 metropolitan cities (cities with population of over one million). The two wheelers are the major contributors of vehicular air pollution followed by four-wheelers (*e.g.*, car, jeep, taxi etc.), trucks and buses in decreasing order of magnitude.

Delhi is a typical example of air pollution by vehicles. Delhi's vehicular population increased from an insignificant of 2.17 lakh in 1971 to 82 lakh in 2014. Over 1,400 vehicles are registered each day in Delhi. Delhi has more vehicles than Mumbai, Kolkata and Chennai put together. Unfortunately, number of vehicles in Delhi outpaces the road length.

Share of vehicular pollution in Delhi has increased from 23% in 1970-71 to 71% in 2013-14. In contrast share of industrial pollution decreased from 56% in 1970-71 to less than 20% in 2013-14.

Much of the vehicular air pollution can be avoided by maintaining proper speed of the vehicles. Vehicles standing on the road crossing or in traffic jams cause more pollution. The quantity of harmful emissions decreases with increasing speed (*See* **Table 9.7**).

TABLE 9.7. Emissions from Vehicles at Varied Speeds (gm/km)

Speed (km/hour)	Auto		Bus	
	Carbon monoxide	Hydrocarbons	Carbon monoxide	Hydrocarbons
10	33.02	4.47	22.6	5.7
25	21.20	2.60	14.6	2.3
50	9.80	1.30	8.2	0.0

Source : Centre for Science and Environment.

Delhi is a major point of intersection in north India, for both passenger and freight traffic. Delhi is connected to five national highways directly (NH 1—GT Karnal road, NH 2—Mathura road, NH 8—Gurgaon road, NH 10—Rohtak road, NH—24 Hapur road) and indirectly to two (NH 24 carries load of NH 58 and NH 91). Moreover, the city has 86 entry points out of which 17 are key points for commercial traffic. In order to divert the interstate traffic the 'Peripheral Expressway' has been proposed for the city. In fact two expressways are proposed to be constructed. The Eastern Expressway has two corridors—the Faridabad-NOIDA. Ghaziabad route (56 km) and the Ghaziabad-Kundli route (49 km). The western Expressway (88 km) will connect Faridabad with Kundli. A survey conducted at the Rana Pratap Inter State Bus Terminal at Kashmiri Gate in Delhi has revealed that 65 per cent buses from Uttar Pradesh, 50 per cent from Haryana and 25 per cent from Punjab emit more pollutants than the permitted limit. A World Bank study in Delhi showed that diesel vehicles were responsible for as much as 62.5 per cent of the total particulate load coming from all vehicles. Even after the implementation of the CNG programme, a recent World Bank study of 2004 confirms, based on actual measurements and characterisation of PM2.5 (a tiny fraction of the particulate), that diesel fuel's contribution could still rise as high as 23 per cent. Besides, air traffic also adds to the air pollution. More than 950 tonnes of pollutants are released by air traffic every day. With the increase in Air Traffic this pollution is bound to increase in future. Even smog (mixture of smoke and fog) is becoming a real threat to Delhi's air environment.

DELHI IS THE MOST POLLUTED CITY OF THE WORLD

According to a study released by the World Health Organisation (WHO) on May 7, 2014, Delhi, the capital city of India, has earned the dubious tag of being the world's most polluted city. The study described India's air pollution as the worst in the world. Delhi has surpassed Beijing with respect to air pollution. Beijing was treated as the world's most polluted city before the release of this study. Delhi is being followed by Beijing (China), Cairo (Egypt), Santiago (Chile) and Mexico City (Mexico). This study was based on data collected from 1,600 cities in 90 countries. Delhi's vehicle population has been estimated at 82 lakh in 2014 and the benefits of CNG introduced in 2000 have been lost. Thirteen out of dirtiest 20 cities were in India. After Delhi, Patna, Gwalior, and Raipur are in the top four spots.

In Mumbai about 52 per cent of the total pollution load is contributed by vehicles. Vehicles contribute about 54 per cent of SPM and 52 per cent of nitrogen dioxide in Mumbai. About 30 per cent of the total pollution load in Kolkata comes from vehicles. Among the metropolitan cities of India. Chennai seems to have clearer air. However, experts warn that SPM in many locations in Chennai is the cause of concern. According to latest studies, high SPM levels in some of the residential and other non-industrial localities is largely due to emissions by vehicles. Studies in Hyderabad show that between 1993-2013, the pollution level in the city had gone up by 270 tonnes per day largely because of increase in the number of vehicles. According to Andhra Pradesh State Pollution Control Board vehicles contribute more than 1600 tonnes of pollutants every day. About 68% of the pollutants are emitted by two-wheelers. The sad story of air pollution by vehicles is almost the same in most of the big cities of India.

Even in small towns such as Parwanoo in Himachal Pradesh, Agartala in Tripura, Dehra Dun in Uttarakhand, Alwar in Rajasthan and Puducherry, air is polluted mainly by vehicles and partly by industries and mining. Experts say that traditional non-motorized transport is fast giving way to polluting two and three wheelers. Jammu had only 24,000 vehicles just a decade ago. Today Jammu has 2 lakh vehicles out of which 80 per cent are two wheelers. In Guwahati and Jorhat there is unprecedented increase in air pollution due to rapid increase in the number of vehicles.

Industrial Pollution

There has been phenomenal growth of industries in India, particularly after independence. Industries emit all sorts of pollutants in the air and result in air pollution to great extent. The major industrial air pollutants are suspended particulates, carbon monoxide, sulphur dioxide, nitrogen oxides and many more.

In Delhi, besides big units there are 70,000 uncontrolled small scale industries, discharging into atmosphere gases, liquids and solid wastes producing health hazards. A recent study conducted by Central Pollution Control Board has revealed that Najafgarh Road, Lawrence Road, Wazirpur, Kirti Nagar, DLF industrial area and Moti Nagar are the most polluted areas which suffer at the hands of polluting industries. In Mumbai, belt between Chembur and Trombay is highly industrialised and has 3 to 6 times more pollution than the remaining parts of the city. Tarapur Atomic Power Plant continues to spew out dangerous radiation doses. Kolkata's industrial units have led to precarious situation with regard air pollution. According to a report submitted by National Environmental Engineering Research Institute (NEERI), Nagpur, the total daily emission from all sources amounts 1,305 tonnes in Kolkata Metropolitan District, wherein 900 tonnes of pollutants are produced in the industrial belt of Kolkata and the rest in Haora industrial belt. The major pollutants are suspended particulates (560 tonnes), carbon monoxide (450 tonnes), sulphur dioxide (125 tonnes), hydrocarbons (102 tonnes) and nitrogen oxides (70 tonnes). Surat is another example of air pollution. This industrial city has a very high average of suspended particulate matter (SPM) amounting to about 267 microgram per cubic metre of air per day. The discharges of sulphur dioxide, nitrogen oxide and hydrogen sulphide are 20.4, 24.6 and 0.5 microgram per cubic metre of the air respectively. Ahmedabad has a large number of textile mills as well as other industries which are contributing to air pollution.

The Bhopal Gas Tragedy

Air pollution is also caused by sudden gas leakage in industries. The Bhopal Gas Tragedy, which occurred on the night of December 2-3, 1984 from the Union Carbide Factory, is a living example of one of the deadliest disasters caused by human negligence. This is considered to be the biggest tragedy so far in the industrial history of the world. According to official sources, 2,500 human lives were lost due to leakage of deadly Methyl Iso-Cynate (MIC) gas but the non-governmental sources put the death toll at 5,000 persons. More than 3,000 persons fell seriously ill. About 200 women delivered dead babies and about 400 babies died within a few hours of their birth. Those who could survive, developed blue spots in their levers, suffered from coughs and asthma and most of them lost their eye sight. About 47 per cent of the pregnant women suffered from instantaneous abortion, whereas some pregnant women opted for voluntary abortion. According to official figures, 10,000 people have been rendered permanently disabled and another 30,000 partially handicapped. About 1.5 lakh persons have suffered minor disability. It is, therefore, righty said that *whereas industries, bring us economic prosperity, they cause ill health and death also.*

Thermal Power Plants

Thermal power plants comprise the second most dangerous source of air pollution, next only to vehicles. Most of the thermal power plants used large quantities of coal which produce huge amount of smoke, ash and other pollutants. The impact of thermal power plants on environment is of growing concern given the anticipated growth of this sector. The coal used in thermal power plants in India is rarely of good quality. The ash content of the inferior grade coal is 38 per cent and in future may rise to 42 per cent. As a result, emissions of SPM, SO_2 and fly ash are of very high order. It has been reported that more than half of the thermal power plants in the country are not complying with the standards and are spewing out as much as 40 million tonnes of flyash every year.

Supply of the beneficated coal—coal washed to lower ash content—has emerged as a serious policy issue in the last decade. Pollution control equipment can also function more efficiently if ash load is reduced by using washed coal.

Critically Polluted Areas

Industrial pollution has left several critically polluted areas in India. As many as 24 critically polluted areas have been identified. The critically polluted areas and the industries responsible for their pollution are detailed in **Table 9.8.**

The areal distribution of critically polluted areas is given in **Fig. 9.4**.

Reasons for High Air Pollution in India. Following are the main reasons for high air are pollution in India :

(i) *Poor Quality of Fuel.* Fuel used for industries and transport is by and large of poor quality.

Although various measures have been taken to improve the quality of fuel during the last few years, poor quality of coal and fuel oil is a matter of great concern.

(ii) Uncontrolled Growth of Vehicle Population. There had been uncontrolled growth of vehicle population in almost all the big and small cities of India. This has resulted in high level of air pollution.

(iii) Poor Vehicle Design. Poor vehicle design especially 2-stroke two wheelers results in high emission of air pollutants.

(iv) Haphazard Growth of Industries. The haphazard growth of industries, particularly after independence, has lead to large real air pollution in India.

(v) Wrong Siting of Industries. Wrong siting of industries especially close to residential areas results in people getting affected due to air pollution.

(vi) Old Process Technology. Old process technology is employed in many industries especially in small scale industries resulting in high emission of air pollutants.

TABLE 9.8. Critically Polluted Areas

Sl. No.	Problem Area	Type of Industry
1.	Singrauli	Power Plants, Mining, Aluminium Industry.
2.	Korba	Power Plants, Aluminium Industry, Mining.
3.	Vapi	Chemical Industries.
4.	Ankaleshwar	Chemical Industries.
5.	Greater Kochi	Oil Refineries, Chemical, Metallurgical Industries.
6.	Vishakhapatnam	Oil Refinery, Chemical, Steel Plants.
7.	Haora	Foundry, Rerolling Mills.
8.	Durgapur	Chemical Industries, Power Plants, Steel Plants.
9.	Manali (Tamil Nadu)	Oil Refineries, Chemical Industry, Fertilizer Industry.
10.	Chembur	Refineries, Power Plant, Fertilizer Industry.
11.	Mandi Gobindgarh	Secondary Steel Industry.
12.	Dhanbad	Mining, Coke Oven.
13.	Pali	Cotton Textile, Dyeing.
14.	Nagafgarh Drain Basin	Power Plants, Vehicles.
15.	Angul-Talcher	Mining, Aluminium Plants, Thermal Power Plants.
16.	Bhadravati	Iron & Steel, Paper Industry.
17.	Digboi	Oil Refinery.
18.	Jodhpur	Cotton Textile, Dye.
19.	Kala-Amb	Paper, Electroplating.
20.	Nagda-Ratlam	Viscose Rayon, Caustic, Dyes, Distillery.
21.	North Arcot	Tanneries.
22.	Parwanoo	Food Processing Unit, Electroplating.
23.	Patancheru-Bollaram	Organic Chemical, Paints, Petrochemical Industry.
24.	Tarapur	Chemical Industry.

***Source*:** National Ambient Air Quality Status (June, 2004), Central Pollution Control Board, Delhi, pp. 2 and 3.

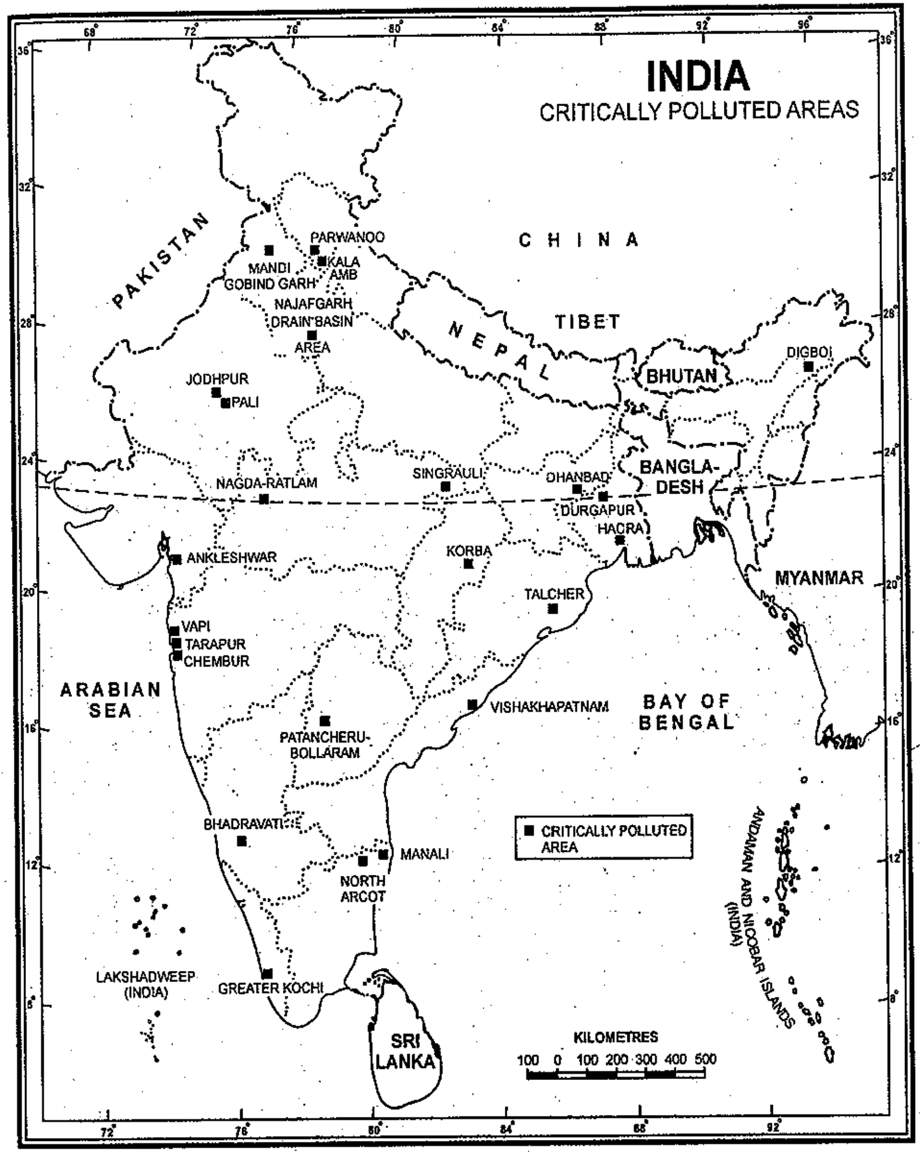

FIG. 9.4. India : Critically Polluted Areas

(vii) No Pollution Control Step in Early Stage of Industrialization. No pollution control steps were taken in early stages of industrialization which has resulted in high levels of air pollutants in many areas.

(viii) No Pollution Prevention and Control System in Small/Medium Scale Industry. Lack of pollution prevention and control system in small/medium scale industry results in high levels of air pollution.

(ix) Poor Compliance of Standards in Small/Medium Scale Industries. Poor compliance of standard in small/medium scale industries also results in high levels of air pollution.

Other Causes of Air Pollution

Large amount of garbage, lack of sanitary facilities and sewer wastage are also responsible for air pollution. Cigarette, *biri*, cigar, and *hooka* smoking have become a great pollutant of air both in urban as well as rural areas. The worst affected are the closed areas such as cinema houses, buses and railway compartments, etc. Smoking leads to some of the serious ailments like heart disease and cancer. The smoker not only spoils his own health but affects adversely the health of the silent smoker who is sitting by his side. A total ban on smoking will go a long way in reducing the pollution levels of air.

Large scale use of pesticides and insecticides, in the agricultural field during the last five decades, has resulted in air pollution in rural India. The life style of the Indian rural masses is closely related to air pollution. Most people in rural India burn wood, cowdung cakes, coal and kerosene oil to cook food. The kitchens are generally housed in unventilated rooms, where unscientific or conventional *chulhas* (ovens) are used. The fuels used in these kitchens emit large quantities of smoke, consisting of carbon monoxide, carbon dioxide, sulphur, etc. thereby polluting the air to a great extent. On an average, about 100 million tonnes of fire wood is burnt in India annually which produces about 3.14 million tonnes of particulate matter, 2.35 million tonnes of hydrocarbons, 1.96 million tonnes of sulphur dioxide, 0.16 million tonnes of carbon monoxide and 0.39 million tonnes of nitric oxides. The world's worst air pollution problem could be the wood smoke inhaled by poor Indian women, especially in rural areas, while cooking. A tonne of particulate from household wood stoves may actually lead to more than 500 times the human exposure than a tonne of particulate from coal fired power station. About 55 million tonnes of cowdung cakes are burnt in India emitting 7.2 lakh tonnes of particulate matter, 5.4 lakh tonnes of hydrocarbons, 4.5 lakh tonnes of sulphur dioxide, 90 thousand tonnes of nitric oxides and 38 thousand tonnes of carbon monoxide.

INITIATIVES FOR CONTROL OF AIR POLLUTION

Various measures have been taken to control air pollution from vehicles and industries. These measures are described as under :

Measures taken for Control of Air Pollution from Vehicles

1. Vehicular Emission Norms

The vehicular emission norms in India are detailed below :

Strict emission norms, particularly in metropolitan areas like Delhi, Mumbai, Kolkata, Chennai, etc., have been introduced and enforced from time to time so that air pollution level is controlled to the tolerable limits. Different phases of Euro and Bharat are worth mentioning in this context. However, rapidly increasing number of vehicles in our cities and towns has more or less multiplied the impact of vehicular emission norms with respect to air pollution.

Barely 20 Indian cities follow Euro IV emission standards for new vehicles, most follow Euro III. Euro IV is seven years behind. European standards and Euro III is behind by 12 years, as per report by Centre for Science and Environment (CSE), Delhi.

2. Fuel Quality Specifications

Diesel and Gasoline fuel quality with respect to environment related parameters had been notified under Environment (Protection) Act during April 1996. The specifications include low leaded gasoline, unleaded gasoline and low sulphur diesel.

(i) **Unleaded Gasoline.** With the progressive reduction of lead content in petrol (from 0.56 gm/l to 0.15 gm/l and then to 0.013 g/l in unleaded petrol) introduction of unleaded petrol for new passenger cars from April, 1995 and supply of only unleaded petrol for all vehicles from September, 1998, in NCT—Delhi a lethal pollutant from vehicular exhaust has been removed. The lead content in the atmosphere near traffic intersections of Delhi has reduced by more than 60% with the introduction of unleaded petrol.

(ii) **Benzene Reduction.** The fear of increased emission of benzene and reduced performance of engines by the use of unleaded petrol has also been falsified. The oil refineries were told to combine the benzene content in the unleaded petrol upto 5% (v/v) in 1996 and 3% (v/v) from the year 2000. In addition to phasing out of lead, it is considered necessary to reduce the benzene (to 1% or lower) and aromatics in petrol not only for Delhi but also for other parts of the country.

(iii) **Sulphur in Diesel.** Sulphur content in diesel supplied in Delhi was reduced to 0.5% in 1996 and it was further reduced to 0.25% from April 1996 onward. The diesel with 0.25% sulphur has been made available throughout the country by September, 1999. Considering the fact that several countries have introduced diesel with much lower sulphur content it is necessary to have low sulphur diesel for meeting the emission norms.

3. Quality Lubricants

Specifications of 2T oil for two stroke engines with respect to smoke emission has been notified under EPA during September 1998 for implementation from 1.4.1999 throughout the country. Pre-mix 2T oil dispenser has been installed at all petrol filling stations in big cities so that excessive oil is not being used by the vehicle owners. Sale of loose 2T oil has been banned from December 1998 in Delhi.

4. Alternate Fuels

A very important factor in reducing vehicular pollution is the introduction of alternative fuels such as CNG and LPG.

(i) Bio-fuels mainly Ethanol and Biodiesel (in B20 form) from Jatropa feedstock are the prospective options.

(ii) CNG (Compressed Natural Gas). CNG is a better and clean fuel providing limited emissions of various toxic gases. All Government vehicles were required to compulsorily fit CNG kit or catalytic converter by December 1996. New CNG taxies are being registered in Delhi as well as there is no restriction or registration of CNG vehicles in National Capital Territory (NCT) as they already comply EURO-II norms. CNG kits has been exempted from customs duty for promotion of installation of CNG kits in vehicles. Emission norms for CNG vehicles have been notified under Motor Vehicles Rules dated 24.4.2001. Besides Delhi and Mumbai the supply of CNG has been extended to the cities of Ankleshwar, Vadodara, and Surat in Gujarat and Kanpur, Bareilly, Agra and Lucknow in Uttar Pradesh. The total CNG vehicles in the country touched 3.54 lakhs in 2012.

(iii) LPG. The use of LPG as an alternate fuel in automobiles has been made applicable for which amendment has been made in Motor Vehicles Act to legally permit the use of LPG as automobile fuel Hon'ble Supreme Court permitted dual mode facility (CNG + Petrol) for the vehicles in its order dated 10th May 2000. Emission norms for LPG vehicles were modified on 24.4.2001. In Kolkata, three wheelers have been ordered to switch over to LPG mode from September, 2005.

(iv) ***Battery driven vehicles :*** Battery driven vehicles have been introduced in few corridors in Delhi and in some other big cities.

5. Phase out of Grossly Polluting Vehicles

(i) Registration of new auto rickshaws with conventional engine has been banned from May 1996 and registration of Defence Service and Govt. auctioned vehicles has been banned from April 1998 in Delhi.

(ii) Commercial vehicles more than 10 years old have been prohibited from plying in Delhi and other major cities of the country.

(iii) Registration on alternation of vehicles by replacing petrol engine with diesel has been banned from 1.4.1998 in Delhi.

6. Promotion of Comprehensive inspection and Certification

It has been possible to reduce 30-40% pollution loads generated by vehicles through proper periodical inspection and maintenance of vehicles. Such inspection and maintenance of vehicles is being carried on by State Pollution Control Boards, Pollution Control Committees and Transport Directorates in different parts of the country.

7. Traffic Management

(i) Restriction has been imposed on goods vehicles during day time in several big cities.

(*ii*) Time clocks have been installed in important red lights to enable the drivers to switch off their vehicles depending on the time left in the time clocks.

(*iii*) More fly-overs and subways have been constructed and T-Junctions have been closed for better traffic flow.

(*iv*) Almost all big cities are plagued with traffic jams on important roads. Standing vehicles cause much air pollution. Steps should be taken to avoid traffic jams as far as possible.

8. Public Transport System

(*i*) To discourage the use of individual motor vehicles by people, public transport system is augmented from time to time in various urban areas of the country. The number of buses has been increased in big cities like Delhi.

(*ii*) Private sector has been allowed to operate public transport buses to increase mobility.

(*iii*) Mass Rapid Transport System (MRTS) has been launched. Metro Rail Transport System is making rapid progress in a large number of cities and is likely to reduce pressure on transport system of these cities.

9. Technology

(*i*) Fitment of catalytic converter for new petrol passenger cars has been made compulsory.

(*ii*) Two wheeler scooters with four stroke engines have been introduced in the market from October 1998.

(*iii*) Registration of only rear engine auto rickshaws is being allowed from May 1996 onwards.

(*iv*) Only four stroke two wheelers are being registered.

10. Information Dissemination/Mass Awareness

(*i*) Messages/articles related to vehicular emissions are disseminated through newsletters, pamphlets, newspapers, magazines, Television, Radio, Internet and through Workshops, Summer Courses, Exhibitions, display, Pollution Control Camps etc.

(*ii*) Display of ambient air quality data through Electronic Display System as well as dissemination through newspapers, daily news and Internet.

(*iii*) Publishing reports related to vehicular pollution control and dissemination to various organisations.

(*iv*) Regular publication of air quality statistics regarding ambient air quality status in the country.

(*v*) Non-Government Organisations (NGOs) working in the area of Vehicular Pollution Control in different parts of the country are being encouraged for creating mass awareness.

Measures Taken for Controlling Air Pollution from Industries

The measures taken for controlling air pollution from industries are as follows :

1. Emission standards have been notified under the Environment (Protection) Act, 1986 to check pollution.
2. Industries have been directed to install necessary pollution control equipment in a time bound manner and legal action has been initiated against the defaulting units.
3. As many as 24 critically polluted areas have been identified. These areas are Singrauli, Korba, Vapi, Ankleshwar, Greater Kochi, Vishakhapatnam, Haora, Durgapur, Manali, Chembur, Mandi Gobindgarh, Dhanbad, Pali, Najafgarh Drain Basin, Angul-Talcher, Bhadravati, Digboi, Jodhpur, Kala Amb, Nagda-Ratlam North Arcot, Parwanoo, Patancheru, Bollaram and Tarapur, Action plans have been formulated for restoration of environmental quality in these areas.
4. Environmental guidelines have evolved for siting industries.
5. Environmental clearance has been made compulsory for 29 categories of development projects involving public hearing/NGO participation as an important component of Environmental Impact Assessment process.
6. The process of Environment Auditing has been initiated in highly polluting industries. The methodology has been standardised and finalised for respective group of industries. Submission of Environmental Statement has been made mandatory.
7. Under Indo-German Bilateral Programme, methodology for zoning, mapping and siting of industries has been developed in various states in collaboration with State Pollution Control Boards in order to identify the existing characteristics of the district, unsuitable zones for the industries, air quality mapping assessment of risk due to siting of air polluting industries and industrial suitability mapping. Based on zoning/siting programme, the site clearance procedure has been streamlined.
8. Minimal National Standards (MINAS) have been presented for highly polluting industries under The Air (Prevention and Control of Pollution) Act, 1981 and Environment (Protection) Act 1986.
9. Power plants (coal based) located beyond 1000 kms from the pit-head are required to use low ash content coal (not exceeding 34%) with effect from 1.6.2002. Power plants located in the sensitive areas are also required to use low ash coal irrespective of their distance from the pit head.

   It is estimated that about 40 million tonnes of fly ash is generated per annum from thermal power plants and contribute to particulate matter loading to environment. Fly ash possesses good pozzolinic properties due to presence of active and finely divided silica, alumina and calcium oxide, which provide it with cement like qualities in combination with lime rich material. Thus fly ash emitted by thermal power plants can be used for manufacturing bricks, blocks, aggregates and cement.
10. Use of cleaner technologies is a new dimension emerging rapidly for cleaner production and to increase production efficiency, and at the same time eliminate or atleast minimise emission and waste at their source rather than to treat them at the end of the production chain after they are generated.
11. Industrial wastes like slags, red mud, etc. are generated from iron and steel and during extraction of non-ferrous metals such as aluminium and copper. The slags are dumped in the vicinity of plant while red mud is disposed as slurry. This slurry becomes air borne after getting dried. In phosphoric fertilizer plants about 4.5 million tonnes of phospho-gypsum (with floride contents 0.7 to 1.5 %) are produced. This can be used for cement, gypsum board, partition panel, ceiling tiles, artificial marble and fibre boards. The thrust will have to be made for proper disposal and reutilisation of these waste materials.

WATER POLLUTION

Water is the most important element in the biosphere because it sustains all sorts of life on the planet earth. The purity and quality of water is of basic concern to mankind since it is directly related to human beings. Nature has given us plenty of water and even then we are feeling the shortage of water for drinking, washing, irrigation and industrial purposes because we have misused and polluted our water resources to a great extent. Water pollution may be defined as *alteration in the physical, chemical and biological characteristics of water, which may cause harmful effects on human and aquatic life*. Water pollution is now-a-days considered not only in terms of public health but also in terms of conservation, aesthetics and preservation of natural beauty and resources.

For the sake of simplicity, the water resources are divided into two categories *viz. surface water* and *ground water*. Surface water is found in the form of rivers, canals, lakes and ponds, etc. Some of the rain water percolates in the rocks under the surface and is available as underground water. This is used through hand pumps, wells, tube wells and springs.

In India, water pollution has been taking place on a large scale and for a long time. Both surface and ground water bodies are polluted to a great extent.

Surface Water Pollution

According to a report of NEERI, a staggering 70 per cent of the available water in India is polluted. From Dal Lake in the north to Periyar and Chalyar rivers in the south and from Damodar and Hugli in the east to Thane Creek in the west, the picture of water pollution is uniformly gloomy. Most of the rivers are carrying polluted water. We have been dumping all sorts of waste matter into our rivers—industrial waste, municipal sewage, residues of chemical fertilizers and what not. These wastes are both, solids as well as in dissolved form. Apart from polluting the river, they decrease the depth of the river and raise the level of river beds. Thus the river becomes a garbage can, without depth and flow. Most of the sewage of towns and cities is dumped into water courses without any treatment rendering the natural water course down stream unfit for drinking and even for bathing. About 14 river basins have been affected by untreated city sewage. Large scale pollution of rivers is turning them into septic drains posing serious threat to the health of millions of people.

Main Causes of Water Quality Degradation

There are several causes of water pollution in India. The main causes are briefly described as under :

1. Urbanisation

Rapid urbanisation in India during the recent decades has given rise to a number of environmental problems such as water supply, wastewater generation and its collection, treatment and disposal. Many towns and cities which come up on the banks of rivers have not given a proper thought to problem of wastewater, sewage, etc. In urban areas, water is tapped for domestic and industrial use from rivers, streams, lakes, ponds, wells, etc. Nearly 80% of the water supplied for domestic use passes out as wastewater. In most cases, this wastewater is let out untreated and causes large scale pollution of the surface water. A part of it percolates into the ground and contaminates the ground water. About 70% of the population of class I cities is provided with sewerage facility. The Ganga river basin contributes about one-third of the total wastewater of India.

As per the latest estimate, only 30 per cent is treated before letting out, the rest is disposed off untreated. The level of treatment available in cities with existing treatment plant varies from 2.5% to 89% of the sewage generated. Treated or partly treated or untreated wastewater is disposed into natural drains joining rivers or lakes or used on land for irrigation/fodder cultivation or to the sea or a combination of them by the municipalities.

Municipal water treatment facilities in India, at present, do not remove traces of heavy metals. Given the fact that heavily polluted rivers are the major sources of municipal water for most towns and cities along their courses, it is believed that every consumer has been, over the years, exposed to unknown quantities of pollutants in water they have consumed. To add to this, Indian towns and cities have grown in an unplanned manner due to rapid population growth.

Facilities for running water have been provided in many towns and even in some villages during the last couples of decades. This has resulted in the use of flush-latrines and much larger use of water in home for bathing, washing of clothes, utensils etc., generating large quantities of wastewater. Use of soaps and detergents and amounts of various food materials going to sink have also grown considerably with improved life standards. But sewerage has lagged far behind water supply. According to estimates made by the Central Pollution Control Board, only 22% of the wastewater from class I cities and 14% from class II cities is being collected through sewerage. A large number of cities/towns either do not have any sewerage system or the sewerage system is overloaded or defunct. All this results in large quantity of wastewater remaining uncollected.

Situation in big cities is worsened by migration of poor people from the surrounding rural areas. These people migrate to the cities in search of livelihood. According to an estimate by CPCB, only about 40-50% of the population of the major cities like Delhi, Mumbai, Kolkata, Chennai and Bengaluru are served by sewer systems. Even where there sewers exist, they often leak or overflow, releasing their contents to storm-water or other surface drains or percolate in to the soil to reach ground water. Very often uncollected and untreated sewerage water reaches the streams thereby polluting their water.

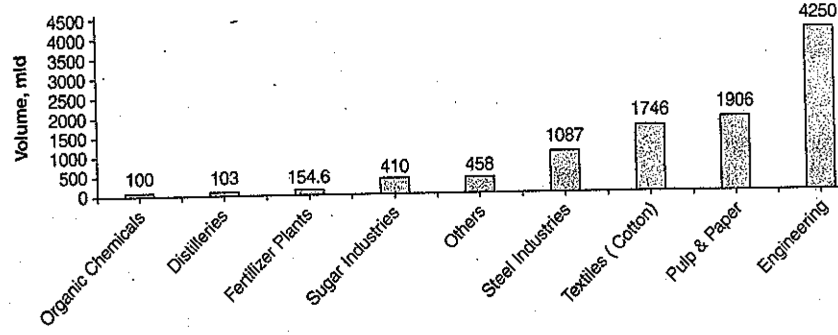

FIG. 9.5. Volume of wastewater generated from different industries in India

2. Industries

Most Indian rivers and other sources of fresh water are polluted by industrial wastes or effluents. All these industrial wastes are toxic to life forms that consume this water. The total wastewater generated from all major industrial sources is 83,048 Mld which includes 66,700 Mld of cooling water generated from thermal power plants. Out of remaining 16,348 Mld of wastewater, thermal power plants generate another 7,275 Mld as boiler blow down water and overflow from ash ponds. Engineering industries comprise the second largest generator of wastewater in terms of volume. Under this category the major polluting industries are electroplating units. Other significant contributors of wastewater are paper mills, steel plants, textile and sugar industries. The major contributors of pollution in terms of organic load are distilleries followed by paper mills. **Figure 9.5** shows the volume of wastewater from different industries in India.

Both large scale industries and small scale industries contribute their share of water pollution. While many large scale industries claim to have installed costly treatment and disposal equipments, these are often not in proper working order. Several examples can be cited, such as oil wastes present in the storm-water channel along Haldia Refinery and ammonia pollution in ground water around a urea factory of Kanpur and a natural spring close to the Zuari Agro Urea plant in Goa.

Small scale and cottage industries cause no less water pollution than the large scale industries. There are about 3 million small scale and cottage industrial units in India. These units neither have, nor can they afford, appropriate sanitation and/or pollutant disposal systems, and yet have not hasistated in adopting highly polluting production technologies such as chrome, tanning of leather, use of azo-dyes in fabrics, use of cadmium in ornaments and silver-ware, electroplating with cyanide baths, production of dye-intermediates and other refractory and toxic chemicals, etc. Their solid wastes and sludges get scattered around or dumped in unlined pits and effluents flow to streams through storm-drains or stagnate in depressions to percolate, leach or get washed-off during the next rainy season. This is the story of many industrial areas and urban centres in the country.

The pollution levels from domestic and industrial sources are quite different from each other. Comparison of pollution load generated from domestic and industrial resources is shown in **Fig. 9.6.**

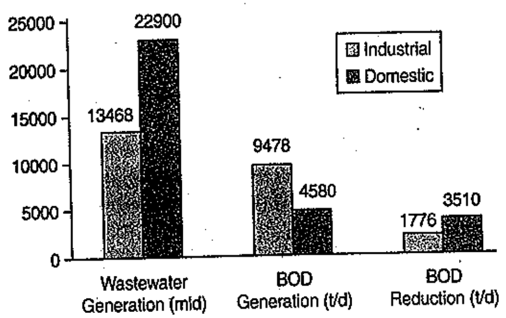

FIG. 9.6. Comparison of pollution load generation from domestic and industrial sources

3. Agricultural runoff and improper agricultural practices

Traces of fertilizers and pesticides are wasted into the nearest waterbodies at the onset of the monsoons or whenever there are heavy showers. As the point of entry of such agricultural inputs is diffused throughout the river basin, they are termed as *non-point* sources of pollution. Although irrigation has increased considerably in the country, precious little has been done to tackle the problem of the high salinity return water. This is the situation in Punjab and Haryana. In Haryana, the 40 km long drain No. 8 pours 250,000 kg/day of chlorides into the Yamuna to raise the chloride concentration in the river from 32 mg per litre just upstream of the drain confluence to 150 mg per litre just downstream of it. And most of these chlorides are from agricultural return flows. According to the findings of the CPCB, some of the seepage into the drain contain over 15,000 mg per litre of chlorides. Intensive and ever increasing usage of chemical fertilizers, pesticides, weedicides and other chemicals is adding a new dimension to such pollution. According to A.K. Dikshit, senior scientist with the Indian Agricultural Research Institute (IARI), New Delhi, farmers often indulge in excess usage of fertilizers and pesticides. When these are used more than the recommended doses, they pollute water, land and air.

Flood-plain cultivation is another significant contributor to water pollution. Fertilizers and pesticides used in these tracts of land are bound to be washed into rivers during the monsoons.

4. Withdrawal of Water

Indian rivers, particularly the Himalayan rivers, have plenty of water in their upper courses. They are, however, starved of water when they enter the plain area. Irrigation canals whisk away clean water soon after the rivers reach the plains, denying water to flow in the river downstream. What flows into the river is water trickling in from small insignificant streams and drains carrying untreated sewage and effluents. The river-turned drains flow downstream with little or no fresh water unless a large river augments the depleted flows.

As the quantity of fresh water in the river is negligibly small, pollution—either from urban and rural areas, industries or even natural forms of pollution—cannot get diluted and its ill effects are not reduced. The Yamuna has almost no water at Tajewala in Haryana where the Eastern Yamuna Canal and the Western Yamuna Canal abstract all the water for irrigation. Similarly, the Upper Ganga Canal and the Lower Ganga Canal have left the Ganga downstream almost dry. When the Yamuna and the Ganga flow past Delhi and Kanpur respectively, they are turned into stinking sewers. Therefore, it is essential that a minimum level of flow of water must be maintained in the river. This is known as ***minimum flow of rivers***. According to a report of the Ministry of Water Resources on the study of minimum flows in the Ganga, impact on river water quality resulting from discharges of treated or untreated wastewater into the river will depend on the dilution offered by the quantum of flows in the river. Minimum flow in the recipient river will be required to maintain the desired water quality. Further, the study has expressed the view that it is not possible to fix the minimum flow of water in the entire course of the river because it depends on the pollution discharged at different points on the river. For example the existing minimum flow in the Ganga at Kanpur in May is hardly 50 cumecs (cubic metres per second) whereas the required minimum in the same month is 350 cumecs. The study further says that since the water is scarce it is not possible to add further fresh water for dilution. The solution lies in less amounts of pollution entering the river. In view of the increased demand of water for irrigation, the minimum flow is likely to fall further in future. In the words of K.C. Sivaramakrishnan, former director of the Ganga Action Plan (GAP), "maintenance of minimum flow is an important point. In simple terms a non-existent river cannot be cleaned. In case of the Ganga between Bijnore and Kanpur, the river is just a small stream. In case of the Yamuna, from Delhi till the point where the Chambal joins, the river is just a trickle. Other rivers like Sabarmati are almost devoid of water."

The Yamuna is dying a slow death in Delhi. In fact it is a dead river as it flows past Delhi. This river is relatively less polluted when it enters Delhi at Wazirabad barrage, but a mere 100 metres downstream the barrage, the river receives untreated sewage and industrial waste. The committee on minimum flows in the Yamuna indicates that if the minimum flows requirement in Delhi is met, that would suffice for the entire course of the river. According to report of the committee, discharge downstream of Tajewala and Okhla is less than 5 cumecs whereas minimum flow of 10 cumecs is required between Tajewala and confluence of the Yamuna with the Chambal. The committee states that this shortfall can be met either by creating storage facilities in the catchment area or from imports from another river basin. Increasing demand from the Yamuna water for irrigation and for meeting the urban requirements would leave very little freshwater in the river to maintain the minimum flow.

The maintenance of minimum flow, to sustain a river ecology through its course as well as its confluences, is a *recent awakening which requires serious thought*. This policy must be pursued vigorously so that river pollution is kept at certain permissible limit.

5. Religious and Social Practices

Religious faith and social practices also add to pollution of our river waters. Carcasses of cattle and other animals are disposed in the rivers. Dead bodies are cremated on the river banks. Partially burnt bodies are also flung into the river. All this is done as a matter of religious faith and in keeping with ancient rituals. These practices pollute the river water and adversely affect the water quality. Mass bathing in a river during religious festivals is another environmentally harmful practice. Studies have revealed that the biochemical oxygen demand (BOD) goes up drastically when thousands of people simultaneously take a 'holy dip'. Religious practices also demand that offerings from a ***puja*** be immersed in a river. It is now common to see people immersing offerings in plastic bags. Plastic bags are very dangerous and further add to the pollution load of the river. In 2013, Allahabad played host to the biggest and the most spectacular gathering of humanity in the world—the Maha Kumbh. A staggering 100 million congregated at the Sangam-up from 70 million in 2001 and the Ganga had to bear the brunt of this massive load of humanity.,

Effects of Water Pollution

Water pollution adversely affects the health and life of man, animals and plants alike. Polluted water is also harmful for agriculture as it adversely affects the crops and the soil fertility. Pollution of sea water damages the oceanic life.

1. Health Aspects of Water Quality. Consumption of polluted water is a major cause of ill health in India. Polluted water causes some of the deadly diseases like cholera, dysentery, diarrhoea, tuberculosis, jaundice, etc. About 80 per cent of stomach diseases in India are caused by polluted water. Water borne diseases are the single most important factor responsible for nearly 80 per cent of human mortality in India. Children are the worst affected, especially in rural areas and urban slums. Typical water borne diseases and their causative factors are summarised in the **Table 9.9**.

2. Effects of Organic Pollution on Water Quality. All organic materials can be broken down or decomposed by microbial and other biological activity (biodegradation). Organic and some of the inorganic compounds exhibit a biochemical oxygen demand (BOD) because oxygen is used in the degradation process. Oxygen is a basic requirement of almost all aquatic life. Aquatic life is adversely affected if sufficient oxygen is not available in the water. Typical sources of organic pollution are sewage from domestic and animal sources, industrial wastes from food processing, paper mills, tanneries, distilleries, sugar and other agro based industries.

3. Effects of Nutrients on Water Quality. Water supports aquatic life because of the presence of nutrients in it. Here the primary focus is on fertilizing chemicals such as nitrates and phosphates. Although these are important for plant growth, too much of nutrients encourage the over-abundance of plant life and can result in environmental damage called ***"entrophication'***. This can occur at both microscopic level in the form of algae or macroscopic level in the form of aquatic weeds. Nitrates and phosphates are contributed by sewage, agricultural run-off and run-off from un-sewered residential areas.

4. Effects of High Dissolved Solids (HDS) in Water Quality. Water is the best solvent and can dissolve a large variety of substances which come in its contact. The amount of dissolved solid is a very important consideration in determining its suitability for drinking, irrigation and industrial uses. In general, waters with a total dissolved solids of less than

500 mg/litre are most suitable for drinking purposes. Higher amount of dissolved solids may lead to impairment of physiological processes in human body. Dissolved solid is a very important criteria for irrigation. This is due to the fact dissolved solid accumulates on the ground resulting in salinization of soil. In this way it renders the agricultural land non-productive. Dissolved solids are harmful for industries also because they form scales, cause foaming in boilers, accelerate corrosion and interfere with the colour and taste of many finished products.

TABLE 9.9. Water Related Diseases and Causative Factors

Name of the disease	Causative organism
1. Water-borne diseases	
Bacterial	
• Typhoid	Salmonella typhi
• Cholera	Vibrio cholerae
• Paratyphoid	Salmonella paratyphi
• Gastroenteritis	Enterotoxigenic Escherichia coli
• Bacterial dysentery	Variety of *Escherichia coli*
Viral	
• Infectious hepatitis	Hepatitis-A virus
• Poliomycetis	Polio-virus
• Diarrhoeal diseases	Rota-virus, Norwalk agent, other virus
• Other symptoms of enteric diseases	Echono-virus, Coxsackie-virus
Protozoan	
• Amoebic dysentery	Entamoeba hystolitica
2. Water-washed diseases	
• Scabies	Various skin fungus species
• Trachoma	Trachoma infecting eyes
• Bacillary dysentery	*E. coli*
3. Water-based diseases	
• Schistosomiasis	Schistosoma sp.
• Guinea worm	Guinea worm
4. Infection through water related insect vectors	
• Sleeping sickness	Trapanosoma through tsetse fly
• Malaria	Plasmodium through Anaphelis
5. Infections primarily due to defective sanitation	
• Hookworm	Hook worm, Ascaris

Source : Water Quality in India, Status and Trends (1990-2001), Central Pollution Control Board (March 2003), pp. 31-32.

5. Effects of Toxic Pollutants on Water Quality. Toxic pollutants mainly consist of heavy metals, pesticides and other individual xenobiotic pollutants. The ability of a water body to support aquatic life, as well as its suitability for other uses depends on many trace elements. Some metals *e.g.*, Mn, Zn and Cu present in trace quantities are important for life as they help and regulate many physiological functions of the body. Some metals, however, cause severe toxicological effects on human health and the aquatic ecosystem.

6. Effects of Thermal Discharges on Water Quality. The discharge of cooling water from industrial and commercial operations generally heats up the aquatic environment. Organisms may become physiologically stressed or may even be killed when exposed to heated water. If water heating is supplemented by the summer heat, the impact on aquatic environment can be disastrous. Thermal pollution also causes a decrease in the driving force or oxygenation which may directly kill aquatic life through asphyxiation. If toxic pollutants are present in the aquatic environment. thermal pollution may increase their toxicity to the aquatic life. Bioavailability of many pollutants may also increase due to thermal pollution, which may ultimately adversely affect the aquatic life.

Water Quality Monitoring

Water quality monitoring is defined by the International Organisation for Standardization (ISO) as : "the programmed process of sampling, measurement and subsequent recording or signalling or both, of various water characteristics, often with the aim of assessing conformity to specific objectives." Water quality monitoring is essential to ensure that the water quality is being maintained or restored at desired level. With the introduction of

Water (Prevention and Control of Pollution) Act, 1974 and its subsequent amendment in 1981, the prime responsibility has been to maintain or restore the wholesomeness of water. It was therefore imperative to establish a water quality monitoring network to update on the existing water quality *vis-a-vis* the derived quality depending on the designated best use. The first water quality (WQ) stations were chosen on the river Yamuna. Central Pollution Control Board (CPCB) initiated water quality monitoring in 1976-77 with 18 stations on the Yamuna river. The number of stations gradually increased based on available resources and water quality problems. CPCB has been identified as the Government of India's agency to serve as a focal point for carrying water quality monitoring under the Global Environment Monitoring System (GEMS) programme of World Health Organisation (WHO) in India.

The number of monitoring network rose to 2,500 stations in 2011-12 in 28 states and 6 union territories. The monitoring network covers 445 rivers, 154 lakes, 12 tanks, 78 ponds, 41 creeks/seawater, 25 canals, 45 drains, 10 water treatment plants and 807 wells.

Water Quality Status

The water quality monitoring results indicate that organic and bacterial pollution are the critical parameters in Indian aquatic resources. This is mainly due to discharge of domestic wastewater, mostly in untreated form, from the fast growing urban centres of the country. By and large the municipal corporations do not have the requisite resources and are not able to treat the increasing load of municipal sewage flowing into the water bodies. Besides the receiving water bodies do not have adequate water for dilution. Therefore, the oxygen demand and bacterial pollution in Indian water bodies is increasing with each possing day. This is the main cause of increasing trend of water borne diseases.

Most of the surface water in India is found in rivers and there are several river basins in India. It will, therefore, be relevant to study the problem of water pollution on the basis of river basins. The pollution status of major river courses is shown in **Fig. 9.7** and is discussed as under :

1. The Ganga Basin

This is the largest river basin of India. It covers over one-fourth of the country's total geographical area and is the home for about half of her population. The Ganga basin accounts for nearly 50 per cent of Class I and Class II towns of the country and the mode of discharge of the municipal waste is mainly into the river system.

TABLE 9.10. Sewage generation and Treatment capacity in Ganga (2012)

Sewage Generated (MLD)	2,723.30
Treatment Capacity (MLD)	1,208.80
Gap	1,514.50
% gap : treated vs. untreated	55

Source : State of India's Environment 2014, Centre for Science and Environment, p. 23.

The polluted stretches include large stretches of the Ganga itself, the Yamuna (Delhi to Etawah), the Chambal (downstream of Nagda to downstream of Kota), the whole of the Kali river, the Hindon (Saharanpur to Confluence with the Yamuna), Kshipra (around Ujjain and downstream), Damodar (downstream of Dhanbad to Haldia), Gomati (Lucknow to confluence with Ganga), Betwa (along Mandideep and Vidisha), Son etc.

Pollution of water in some of the major rivers of the Ganga basin is described as under :

GANGA. The Ganga is the most sacred and at the same time one of the most polluted rivers of India. Keeping in view the rapidly falling water quality level of the Ganga and its tributaries, a large number of water quality monitoring stations have been set up in this river basin. The entire basin is dotted with 101 water quality monitoring stations out of a total of 507 in the whole country. Out of these 101 stations, 27 are on the main Ganga river while the remaining 74 are on its tributaries. These stations are constantly monitoring the water quality in the Ganga and its tributaries. Out of its total length of 2,525 km from its source in Gangotri to its mouth in the Bay of Bengal, as much as 600 km or about one-fourth of total length is reported to be badly polluted. The main cause of water pollution in the Ganga is rapid growth of urban and industrial centres all along the length of its banks.

The story of polluting the holy Ganga starts from Rishikesh and continues upto Kolkata. Following cities/towns are primarily responsible for pollution of the holy Ganga :

Haridwar. The industrial wastes from Bharat Heavy Electricals Limited (BHEL) and Indian Drug and Pharmaceuticals Ltd. (IDPL) cause large scale pollution of the river. About 15 large and small drains

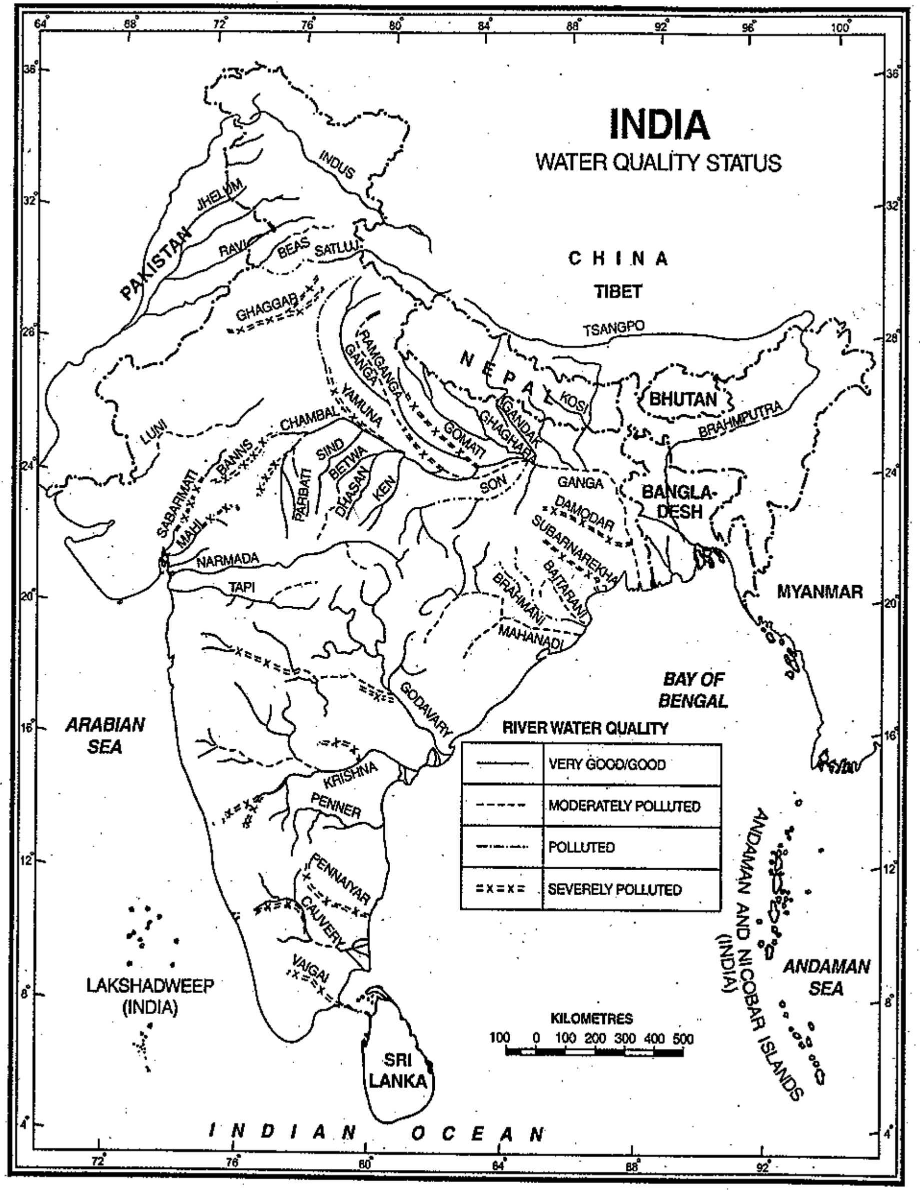

FIG. 9.7. India : Water Quality Status

TABLE 9.11. Difference between sewage generation estimates

State	Sewage generation (MLD)	BOD load tonnes/day	Gap untreated waste
Uttarakhand	61.30	42	95%
Uttar Pradesh	937.40	761	86%
Bihar	407.20	97	71%
West Bengal	1317.30	97	69%
Ganga Mainstream	2723.30	999	80%

***Source* :** State of India's Environment 2014, Centre for India and Environment, p. 23.

> According to a report published in the international journal '*Nature*' in 2013, the Ganga was ranked as the second-most polluted river in the world after Citarum river of Indonesia. The pollution level of the Ganga was about 3,000 times of the safe limit prescribed by the World Health Organisation (WHO) for human use. Only 45% of sewage that flows into the Ganga is treated. People living in the vicinity of the river are vulnerable to cancer.

discharge urban wastes into the river at Haridwar. Haridwar is one of the holiest places of the Hindu religion. Thousands of people from all over the country come to this place to perform various religious rituals. Community bathing, discharges of milk pots, discharges of flowers and leaves, etc, cause pollution of the Ganga water at Haridwar. According to the latest findings, the Ganga water at Haridwar is unfit for drinking, bathing and even for irrigation.

Kanpur is a big industrial city where the story of the Ganga becomes pathetic. The World Health Organisation (WHO) has declared Kanpur as one of the 10 most polluted cities of the world. The city has also come to be known as ***'industrial graveyard'*** and the ***'capital of tuberculosis'*** in the recent past. The city generates over 360 Mld of sewage. Besides there are 300 odd tanneries that keep dumping toxic wastes. Industrial wastes from cotton and woollen textile mills, jute mills, synthetic rubber mills, paper and pulp mills, distilleries, sugar mills and factories manufacturing synthetic chemicals like D.D.T., pesticides, etc. are also discharged into the river. Ironically people living in 100 towns along the river banks use the river water for various purposes including drinking. Intestinal and skin ailments are rampant.

Allahabad represents the sacred confluence of the Ganga and the Yamuna. The city has 13 drains discharging 110 Mld of sewage, partly into the Ganga and partly into the Yamuna. Besides urban effluents from the city itself, industrial wastes from Naini Industrial complex and Chemical fertilizer plant at Phulpur are also released into the river. Venerated as a pilgrim centre by the Hindus, Allahabad is also the venue of the 12 yearly *Kumbh* Fair, which is said to attract the largest crowd in the world. This causes large scale pollution of the Ganga water at Allahabad.

Varanasi. According to studies conducted by Uttar Pradesh Pollution Control Board (UPPCB), the Ganga becomes very polluted in Varanasi where dissolved oxygen (DO) is less than the permissible limit of 5 mg/l and B.O.D. is as high as 8.8 mg/l which is much higher than the permissible limit of 3 mg/l. There are about 71 large and small sewer drains which discharge huge quantities of effluents from the city into the Ganga. Even more significant reason of pollution of the Ganga is the dumping of cadavers into the river. Police sources admit that the Ganga is a major dumping site for victims killed in gang wars and shootouts in the crime-prone eastern Uttar Pradesh districts. The problem peculiar to Varanasi arises from the Hindu belief that the dead cremated here attain *moksha* (salvation). This results in hundreds of bodies being cremated at the *ghats* every day. Every year about 40,000 bodies are burnt in the two burning *ghats* of the city—Manikarnika and Harishchandra. This amounts to nearly 15,000 tonnes of ash per month, which is dumped into the river. Partially burnt wood, unburned portions of dead bodies and unburned or partially burnt skeletons are also thrown into the river which highly pollute the water near several *ghats*. Wood required to burn dead bodies at Varanasi results in deforestation of over one hundred hectares of forest land each year. Burning of dead bodies raises the water temperature between 30 to 50°C which reduces the dissolved oxygen by 30 to 50 per cent. Besides, about 7,000 dead animals are also thrown into the Ganga near Varanasi every year.

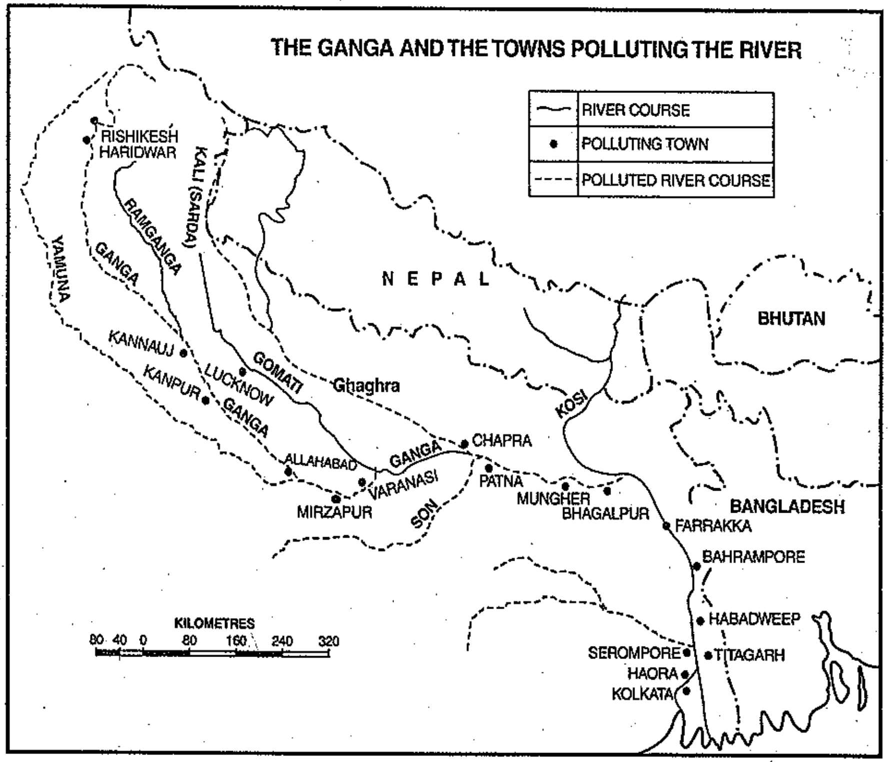

FIG. 9.8. The Ganga and the towns polluting the river

Like Haridwar and Allahabad, Varanasi is a very important place of the Hindu religion. As such it attracts lakhs of pilgrims every year. The river has to bear the brunt of this onslaught with pilgrims defecating, bathing and washing their clothes on the river banks. The pollution problem of the Ganga at Varanasi is further complicated by effluents from the diesel locomotive works located in the city. It is estimated that Varanasi is responsible for about one-fourth of Uttar Pradesh's contribution of pollutants to the Ganga.

Patna has become a major polluting city of the Ganga during the last few years. About 100 Mld of wastewater is discharged into the Ganga through nine major outfalls in the cities. Patna has extended mostly along the Ganga which means more garbage is dumped into the river. Large amount of toxic effluents are discharged by Bata factory and McDowel Distillery. One redeeming factor is the high discharge of fresh water even during dry months because the Ganga is augmented by the Ghaghra and the Son upstream of Patna, and the Gandak joins it downstream. Oil refinery at *Barauni* throws large quantities of chemical wastes in the river.

The Ganga is known as ***Padma*** after Farrakha barrage, flowing into Bangladesh and part of the river flowing into West Bengal is called the ***Hugli***. The fairly large volume and high flow of water between Allahabad and Farrakka renders this stretch less vulnerable to pollution, as compared to downstream of Farrakka. The annual flow of the river at Behrampore is in West Bengal is much less than the annual flow and Patna in Bihar. This is because some water is to be released into the Padma in Bangladesh as per agreement between the two countries. Huge amounts of residential wastewater and toxic effluents from industries are discharged in a long stretch of about 100 km along the Hughli river. **Figure 9.8** shows the major cities which are primarily responsible for pollution of the holy Ganga.

Some of the tributaries of the Ganga like the *Kali*, the *Gomati*, *the Sone*, *the Damodar*, etc. are badly polluted. The water of the *Gomati* river is polluted by sugar mills at Sitapur and distilleries of Lucknow. The effluents discharged by the distilleries contains a toxic substance called ***aldehyde***, which caused death to a large number of fish in 1986. Shahdol near the bank of the *Sone* river has one of the largest paper manufacturing mill in India. This mill takes about 73,000 kilolitres of fresh water from the river and throws back about 25,000 kilo litres of black, foul smelling and foaming water into the river per day. The river water is polluted for a stretch of about 70 km downstream of the mill.

THE DAMODAR deserves a special mention with respect to water pollution. Traditionally notorious as the sorrow of Bengal, the river is now the sorrow of both Bengal and Jharkhand. It is one of the most polluted rivers of the country. The high level of pollution of this river has rendered its water unfit for drinking, bathing and even for agriculture. Indiscriminate and uncontrolled discharge of industrial effluents has led to this sad state of affairs. The presence of high concentration of oil and grease (mostly mineral oils), toxic substances, etc., have made the Damodar water harmful and useless. These substances are of industrial origin and have rendered the river a ***'biological desert'*** showing hardly any existence and propagation of aquatic life in the vulnerable stretch of about 300 km between Girdih and Durgapur. Nevertheless, the river is the main source of drinking water for immunerable rural, urban and industrial people along its banks. Raw materials are available in plenty and the requisite infrastructure has been developed. Thus, the region has seen unprecedented industrial growth (**Fig. 9.9**). This has resulted in gross pollution of the river, rampant deforestation, soil erosion and siltation of the river course. Most of the catchment area of the river falls in the mining belt. Overburden from open cast mines are often dumped near the mined areas and are carried off with surface runoff. At places, this has even blocked the river. At present, many stretches of the Damodar and its tributaries (Konar and Barakar), resemble large drains carrying black, highly turbid water. The total suspended soils (TSS) count at most places is 40

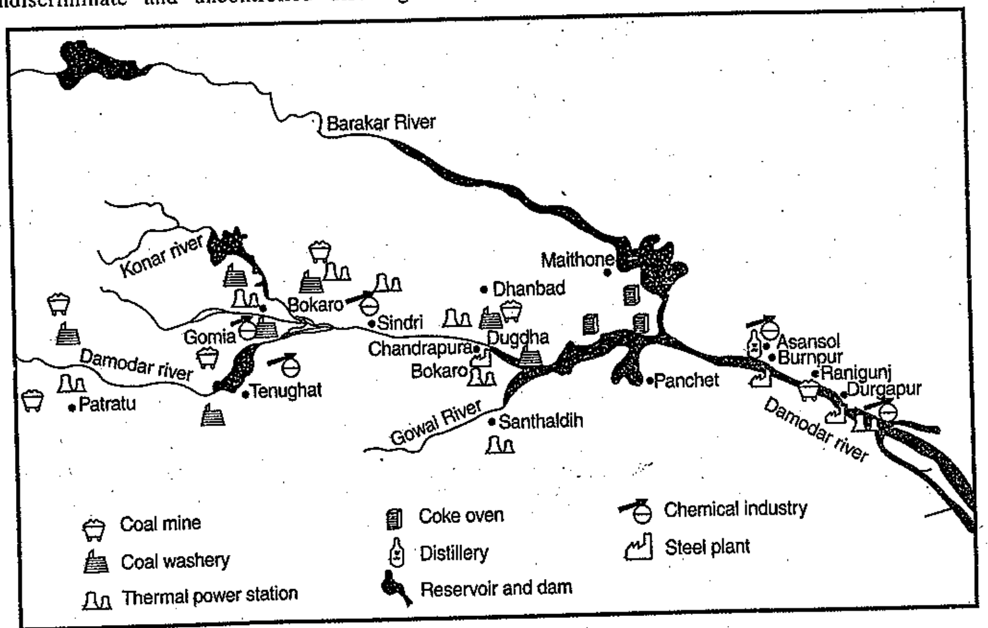

FIG. 9.9. Industries responsible for water pollution in the Damodar River

to 50 times higher than the permissible limit. For most parts the river carries a film of oil and grease from industrial effluents. The Damodar basin has about one-third of India's coal reserves and is the most outstanding producer of coal in the country. Consequently over half of the industries of the region comprise coal mining, coal washeries—and coke oven plants. Since coal is easily available, several thermal power plants, steel plants and ancillary industries have come up in the basin.

As many as 50 medium and 100 small scale industries are concentrated in the middle-stretch of the river. A total of about 6,000 Mld of mostly untreated industrial wastewater is discharged into the river. This excludes the wastewater from mine based activities and sewage from towns and cities on the course of the river. Conservative estimates put the daily outfall of pollutants and effluents at 60 tonnes of BOD (Biochemical Oxygen Demand) load, 2 tonnes of non-metallic toxins and 1.2 tonnes of toxic metallic substances. Industrial effluents generally carry high suspended solids in terms of fine coal particles and flyash. According to recent studies, the lowest observed concentration of oil and grease is no less than 2 milligrammes per litre which is 200 times higher than the accepted limit for use as source for public water supply. An estimated 3,100 tonnes of nitrogen, 500 tonnes of phosphorus (from fertilizers) and 30 kg of persistent pesticides reach the river annually, through surface runoff from agriculture. Coal washeries account for bulk of pollution in terms of TSS, oil and grease.

THE YAMUNA. The Yamuna, the most important and sacred tributary of the Ganga, is also

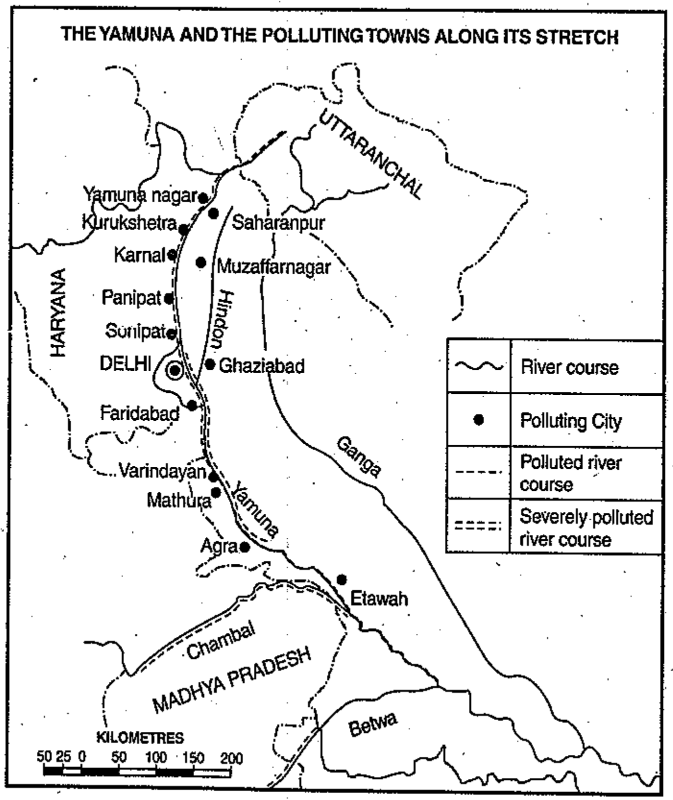

FIG. 9.10. The Yamuna and the polluting towns along its stretch

one of the most polluted river of India. Sewage and runoff from industries, towns and vast agricultural tract in Haryana and Uttar Pradesh have been emptied into the Yamuna for the last several years. Still it is the main source of drinking water for millions of inhabitants of Delhi, Faridabad, Mathura, Agra and so many other towns located on its banks. The water quality of the river begins to deteriorate as soon as it enters the plain area after coming down from the mountain area. At every step, fresh water is drawn from the river and large loads of polluted water are poured into it. This results in successive degradation of the river water. The Hindon, Chambal, Sindh, Betwa and Ken join the river at various places in its 1376 km long journey through the plains. From pollution point of view, the Yamuna's course has been divided into five segments—Himalayan (172 km), Upper (224 km), Delhi (22 km), Eutrophicated (490 km) and Diliated (468 km). Of these, the Upper segment, the Delhi segment and Eutrophicated segment are badly polluted stretches.

Upper Segment. The deterioration of the water quality starts right at the beginning of the upper segment at Tajewala barrage. At the Tajewala barrage, 172 km from its source, the West Yamuna Canal and the East Yamuna Canal take away almost the entire water of the river. Thus the flow of water downstream Tajewala is reduced drastically leaving the river with little diluting capacity. Besides, the Yamuna itself and the West Yamuna Canal flow through the industrial belts of Yamuna Nagar, Kurukshetra, Karnal, Panipat and Sonepat before entering Delhi. These towns discharge domestic wastewater and industrial effluents into the river. Discharge of effluents from domestic, industrial and agricultural sources are reflected in the water quality of the Yamuna river in the West Yamuna Canal.

Delhi Segment. Delhi is the largest polluter of the Yamuna river. The Yamuna is comparatively less polluted before entering into Delhi. But as soon as it enters Delhi, the river is polluted at a much faster rate. In Delhi, the Yamuna seems to be *dying a slow death*. Everyday about 3,600 million litres of domestic and 300 million litres of industrial waste water is discharged into the Yamuna through 17 open drains (**Table 9.12**). While Delhi has a capacity to treat 2330 Mld, only 1478 Mld is actually treated. The toxic effluents discharged into the *Yamuna* carry 132

TABLE 9.12. Estimated Pollution Load Generation along the Yamuna

Name of town	Wastewater flow (mld)	BOD load (tonne/day)
Yamunanagar**	28	4.15
Karnal*	23	3.45
Panipat*	25	3.75
Sonepat*	19	8.10
Gurgaon	20	3.03
Faridabad	102	15.15
Delhi	3600@	300@
Saharanpur	45	6.75
Muzzafarnagar	35	5.25
Ghaziabad	180	27.00
Noida	75	11.25
Vrindavan	5	0.75
Mathura	31	4.65
Agra	90	13.50
Etawah	15	2.25

Note : *Waste from these towns enters the Yamuna.
**Waste from these towns enters the Western Yamuna Canal.
BOD : biochemical oxygen demand.
mld : million liter per day.
@ : Figures for 2004.

Source : Citizen's Fifth Report (October, 2002), Centre for Science and Environment, p. 71.

tonnes each of B.O.D. (Biological Oxygen Demand) and suspended solids and 250 tonnes of dissolved solids. Before the Yamuna enters Delhi, 100 millilitres of its water contain only 7,500 disease causing bacteria but after getting polluted by Delhi the same amount of water contains 24 million disease causing bacteria. The Yamuna is rightly described as the ***'Open sewer of Delhi'***. Interestingly, the length and the basin area of the Yamuna in Delhi is only 2 per cent of the total length of the river, but the pollution loads contributed by this city are 71 per cent of the total waste water and 55 per cent of total BOD discharged into the river every day. Industrial waste from 20 large, 25 medium and about 93,000 small scale industries located in Delhi also flows through these drains. Through the large and medium industries form only about 0.05 per cent of the total industries located in Delhi, they contributed about 50 per cent of the total industrial waste. These are mostly engineering, textiles, chemicals, electronics and electrical goods factories. Common service industries, including service stations and garages catering to automobiles, discharge oils and other effluents. Manufacturing industries like electroplating units, dyeing, metal-pickling and anodizing units—discharge acids and similar effluents into the open drains. Efforts to re-locate non-conforming industries from the residential areas to alternate site at Bawana have not been able to make much difference. The problem of the Yamuna water in Delhi is becoming more complicated with the passage of time because Delhi administration lacks sufficient sewage treatment facilities.

Entrophicated Segment continues for a distance of about 490 km from the Okhla barrage in Delhi to the confluence of the Yamuna with the Chambal in Etawah district of Uttar Pradesh. Beyond this point, is the diluted segment for a distance of 468 km upto its confluence with the Ganga at Allahabad. This is **diluted segment** because Sindh, Betwa and Ken flow into the Yamuna and dilute the pollutants in the river water.

2. The Indus Basin

The Indus basin consists of the main Indus river and its five major tributaries *viz*. the Jhelum, the Chenab, the Ravi, the Beas and the Satluj. The basin is the home of about six million urban people living in Class I and Class II cities and towns. These cities and towns generate about 800 million litres of wastewater and 1700 tonnes of solid waste every day.

Three polluted river stretches have been identified in this river system. These are the Satluj from down stream of Ludhiana to Harike, the Beas from upstream of Manali to Mandi and from down stream of Mandi to Himachal Pradesh state border.

3. The Brahmaputra Basin

The Brahmaputra river basin covers large parts of Assam, Arunachal Pradesh, Nagaland, Meghalaya and West Bengal. The basin and catchment area receives heavy rainfall and the Brahmaputra has the highest discharge of all the rivers of India. There are a number of class I and Class II cities in this basin which generate about 233 Mld of wastewater and 414 tonnes of solid waste every day. Guwahati produces the largest amount of wastewater and solid waste of all the towns located in this basin. Although the water quality of the river and its tributaries is not affected much due to enormous dilution available in the river, still there is need for water management.

One of the 22 problem areas identified by CPCB for priority action is Digboi which is located in this basin. It has caused water pollution in the Digboi Nadi which is a sub-tributary of the river Brahmaputra. Oil refinery located at Digboi is primarily responsible for deterioration of the water quality of the Digboi Nadi. To restore water quality of the Digboi Nadi, modernization of the refinery along with the installation of catalytic reforms unit in the existing plant have been recommended as part of the action plan. Processing of oil bearing sludge containing 50-60% hydrocarbons has also been suggested.

Fertilizer units at Kamrup and Namrup as well as thermal power stations and oil refineries in Kokrajhar, Kamrup, Dibrugarh, Guwahati, Numaligarh and Bongaigaon also add to the problem of water pollution in this basin.

4. The Mahi and the Sabarmati Basins

The Mahi basin extends in the states of Gujarat, Madhya Pradesh and Rajasthan. The Sabarmati basin extends in the states of Gujarat and Rajasthan. Both the river basins have a number of class I and class II cities. The cities of the Mahi basin generate about 160 Mld wastewater and 514 tonnes of solid wastes per day. The respective figures for the Sabarmati basin are about 677 Mld wastewater and 1877 tonnes of solid waste. The water quality monitoring results indicate that organic pollution is the major problem in these river basins. Vadodara and Ahmedabad are the two main polluting cities.

5. The Narmada Basin

The Narmada is the largest west flowing river of the peninsular India. The major urban centres in this basin are Jabalpur, Hoshangabad, Dewas and Khandwa in Madhya Pradesh and Bharuch in Gujarat. Class I and Class II cities generate 68.6 Mld of wastewater and about 430 tonnes of solid waste every

day. Dhar, Jabalpur, and Bharuch are the main industrial districts. These districts are marked by clusters of pharmaceuticals, pesticides, dyes and distilleries, leather and fertilizer units. In Jabalpur, Khandwa and Hoshangabad, the main industrial activity consists of paper mills.

6. The Tapi Basin

The urban areas of the Tapi basin generate about 293 Mld wastewater and nearly 1650 tonnes of solid wastes per day. The most populous city in the Tapi basin is Surat followed by Amravati and Dhule. Industrialisation has taken place in the East Nimar (Khandwa) district of Madhya Pradesh and Jalgaon district of Maharashtra. Distillery units contribute the largest share of pollution in Maharashtra whereas textiles occupy the predominant place in Gujarat followed by food and beverages and chemical industries. The Tapi river from Nepanagar to Burhanpur has been identified as a polluted stretch under the National River Action Plan (NRAP).

7. The Mahanadi Basin

The Mahanadi, along with its tributaries like Seonath, the Kharoon, the Hasdeo, the Mand, the Ib and the Tel forms an important river basin in the north east of the Deccan plateau. Mahanadi river basin is comparatively less polluted. However, certain stretches like downstream portion of river Ib at Brajrajnagar, downstream of Sambalpur and Cuttack have higher degree of pollution. The Ib river is seriously polluted by discharges from the paper mill at Brajrajnagar. A large number of towns on the banks of the main Mahanadi river and its tributaries discharge domestic and industrial wastewater. Korba has been identified as a critically polluted area in this basin. Industrial as well as domestic wastewater is being discharged into the Hasdeo river. Besides iron and steel industry at Bhilai, cement industries at Durg and Raipur, distillery at Raipur, textile industry at Rajnandgaon are the main pollutants.

The Odisha portion of the Mahanadi basin is marked by paper, textiles and thermal power plants at Choudwar, fertilizer and breweries at Paradeep, sugar industry at Nayagarh, Badamba, cement industry at Bargarh, paper industry at Brajrajnagar, coal mining areas of Rampur and Ib valley and an aluminium smelter at Hirakud.

8. The Godavari Basin

The Godavari is the largest river basin of the peninsular India and extends over ten per cent of the total geographical area of the country. It may be mentioned here that inspite of its massive catchment area, the discharge of water is not very impressive due to moderate annual average rainfall in the basin. On account of high concentration of population and industries, towns and cities in this basin discharge large quantities of domestic and industrial waste into the river. It is observed that Class I cities and Class II towns of the basin generate about 761 Mld of wastewater and 2773 tonnes of solid waste every day. Out of the total wastewater only 85.4 Mld is treated.

Amongst the five states which share the Godavari river basin, Odisha is the least industrialised followed by Madhya Pradesh, Chhattisgarh and Karnataka, with Maharashtra having high concentration of industrial pockets. The highest concentration of industries is found in Aurangabad and Nashik in Maharashtra and East and West Godavari districts of Andhra Pradesh. In Maharashtra, sugar and distillery units are in large number. This is followed by pharmaceuticals, leather, pulp and paper and pesticide units. In Andhra Pradesh, sugar and distillery units are in large number followed by pulp and paper and fertilizer industries. All these industries consume a lot of fresh water and generate large quantities of wastewater.

The river Godavari from downstream of Nashik to Nanded in Maharashtra and upstream of Bhadrachalam at Mancheral and Ramgundam in Andhra Pradesh have been identified as the polluted stretches to be taken up under the National River Action Plan (NRAP). The major sources of pollution in the polluted stretches are from domestic and industrial wastewater generated from cities between Nashik and Nanded cities in Maharashtra and Mancheral, Ramgundam and Bhadrachalam cities in Andhra Pradesh.

9. The Krishna Basin

Though the Krishna is the third largest river of India, yet it has poor water wealth because of low rainfall in the basin. Lying in the Deccan plateau, this basin covers large areas in the states of Maharashtra, Karnataka and Andhra Pradesh. The river has two large tributaries—the Bhima and the Tungabhadra and four smaller tributaries—the Ghataprabha, the Malprabha, the Musi and the Muneru.

The urban areas of this basin generate about 1,404 million litres of wastewater (out of which only 204 Mld is treated) and 4,488 tonnes of solid waste every day.

With an annual consumption of about 7,941 tonnes of pesticides, agricultural runoff adds 120 mg/l nitrogen, 26 mg/l phosphorus and 31 mg/l potassium to the river basin. The total domestic pollution load in the Krishna basin is 1,433,084 kg per day—50.6% rural and 49.4% urban. Of the total BOD load generated, Andhra Pradesh accounts for 40.6%, Karnataka 32.7% and Maharashtra 26.7 per cent. Urban BOD load is 707.8 tonnes per day of which domestic is 77.6 per cent and industrial 22.4 per cent.

Several industrial units have come up along the river and the load of industrial waste is quite high in this river. The largest industrial pollution load in Maharashtra part of the basin comes from Pimpri Chinchwada New Corporation part of Pune urban agglomeration. In Karnataka, the Harihar Polyfibres Ltd. at Harihar in Dharwar district abstracts nearly 35,000 cum per day of water from the Tungabhadra and discharges about 33,000 cum per day of wastewater into the river. Bhadra river is badly polluted by Mysore Paper Mills and Visveswaraya Iron and Steel Limited.

10. The Cauvery Basin

With almost 95 per cent abstraction of water, the Cauvery is one of its most exploited rivers of India. The Cauvery has watered agricultural lands of Tamil Nadu, Karnataka and Kerala. Sharing of the Cauvery waters has been the bone of contention between the two contending states, *viz.*, Tamil Nadu and Karnataka. High rate of application of chemical fertilizers and insecticides in agricultural field results in discharge of large quantities of chemicals in the river water, thereby polluting the river to a great extent. Coffee production in the districts of Coorg, Hassan and Chickmagalur contributes heavily to the BOD level of the river water which ranges from 2,000-4,000 mg/l. Coffee industry contributes 4,730 tonnes of BOD load in each season.

The urban areas in this basin generate about 750 million litres of wastewater and 3,500 tonnes of solid waste every day. Important cities are in Karnataka (Bengaluru, Hassan, Mandya and Mysore) and Tamil Nadu (Salem, Erode, Coonoor, Tiruppur, Valparai, Dindigul, Tiruchchirapalli, Kumbakonam, Thanjavur and Coimbatore). The industrial activity is very high in this basin, particularly in the Bengaluru area in Karnataka and Methur as well as Coimbatore in Tamil Nadu, followed by districts of Mysore and Mandya in Karnataka and Periyar and Salem in Tamil Nadu. A total of 61 industries in Karnataka and 1,139 in Tamil Nadu contribute heavily to the pollution load, especially during the lean flow period of the year. In Tamil Nadu, some water-intensive industries such as textiles, sugar mills, paper mills, chemical units, engineering units, tanneries, etc., have come up which contribute to the pollution load of the river.

Noyyal is one of the most polluted tributaries of the Cauvery river. It is polluted by 800 odd dyeing and bleaching units located at Tiruppur. This 173 km long river carries untreated sewage and industrial effluents from the towns of Coimbatore and Tiruppur for most part of the year.

GROUNDWATER QUALITY

The term 'groundwater' is defined as the water that occurs below the surface of the earth. The source of groundwater is precipitation and infiltration of surface water from runoff and streams. In a country of monsoon climate like India, where rainfall is seasonal, erratic, undependable and variable and where the surface water is always in short supply, groundwater plays a vital role in everyday life of the masses. Most of the drought prone areas largely depend on groundwater.

Sources and Types of Groundwater Contaminants

Groundwater contamination leads to several problems like taste, colour, hardness and foaming. The problem of groundwater contamination becomes serious when pathogenic organisms, flammable or explosive substances or toxic chemicals are present. Once polluted, groundwater may remain unusable or even in hazardous condition for decades or even centuries. It is often difficult to identify the nature and sources of groundwater pollutants and water quality problems. Normally speaking, the quality of

groundwater is affected by waste disposal and land use. The water-soluble substances which are dumped, spilled, spread or stored on the land surface eventually may infiltrate into the ground water. The disposal of fluids through wells and sinkholes directly into acquifers also results in contamination of the groundwater. Infiltration of contaminated water also causes groundwater contamination.

SOIL OR LAND POLLUTION

Soil is a very important environmental attribute because it supports all sorts of plant life found on land. Soil becomes polluted due to the *misdeeds of man* or at times the *mischiefs of nature*. The main factors of soil pollution are the high state of soil erosion, excessive use of chemical fertilizers, biocides (pesticides, insecticides and herbicides), polluted liquids and solids from urban and industrial areas, forest fires, water-logging and related capillary processes, leaching, drought, etc. Some of the micro-organisms and unwanted plants enter the soil and result in soil pollution. Some of the air-borne pollutants from the industries are deposited on the land surface and pollute the soil. Solid particles from mining areas pollute the neighbouring land to a great extent redering it unsuitable for agriculture. Many areas near mica and manganese mines in Jharkhand have fallen prey to this type of pollution. Soils near copper smelting units are so polluted that no plant growth is possible there. Main sources of land pollution are briefly described as under :

1. Chemical Fertilizers and Biocides. The accelerated use of chemical fertilizers and biocides in agriculture is the major cause of soil pollution. They are used to increase the yields and to save the crops from insects, pests and unwanted plant growth. It should be particularly noted that biocides first kill germs and unwanted plants and then degrade the quality of soil. Among the pesticides, the most widely used are the chlorinated hydrocarbons, *e.g.* D.D.T., B.H.C., endrin, aldrin, dieldrin and lindane and organophosphorus compounds such as parathion and malathion. When these are used in excess, their remnants are absorbed by soil particles and contaminate crops grown in such soils. They are further transferred into carnivores through herbivores and finally enter the human bodies in course of food chains. They are responsible for several incurable diseases and even cause death. Biocides are, thus, called as ***creeping deaths.***

The use of biocides gained momentum in India with the commencement of Green Revolution in 1966-67. The introduction of high yielding varieties (HYV) of seeds gave birth to heavy dozes of chemical fertilizers and biocides. The overall per hectare consumption of fertilizers rose from a mere 0.55 kg in 1950-51 to 67 kg in 1992-93 and to 144.33 kg in 2011-12.

For reducing the impact of chemical fertilizers, it is suggested that use of organic manures, composts, and agricultural wastes should be encouraged. Composition of NPK in different farmyard manures and composts is given in Table 9.13. Organic farming refers to farming which does not use any form of chemical fertilizers or other agro chemicals and is dependent entirely on organic sources of crop nutrition and crop husbandry. Organic farming can also be defined as system in which the maintenance of soil fertility and the control of pests and diseases are achieved through the enhancement of biological process and ecological interaction. The major component of organic farming is the maintenance of

TABLE 9.13. Composition of NPK in different Farmyard Manure and Compost (in percentage)

Waste	Nitrogen (N)	Phosphorus (P)	Potassium (K)	Total Nutrient
Rural compost	0.75	0.5	0.5	1.75
Urban compost	1.00	1.00	1.00	3.00
Neem cake	5.20	1.00	1.40	7.60
Farmyard Manure	0.60	0.20	0.60	1.40
Poultry droppings	3.00	2.60	1.40	7.00

Source : Environmental Atlas, (June 2001), Central Pollution Control Board, p. 97.

soil fertility through maximizing nutrient recycling and minimizing losses. Organic farming also helps in improving the physical properties, microbial production and humus content of soil while increasing its water holding capacity.

Organic farming involves the use of farmyard manure (FYM) which has been used as a resource for plant nutrient since ancient times. It also includes the application of vermicomposts, green manuring and biofertilizers. FYM consists of animal dung, waste, crop residue, poultry manure/litter, etc. The urban or rural wastes composted are also sources of plant nutrients.

Green manuring involves cultivation of fast-growing leguminous crops and ploughing them back into the soil as fertilizers. Biofertilizers help leguminous crops fix atmospheric nitrogen into the soil.

2. Municipal Solid Waste. Municipal solid waste (MSW) is a heterogeneous mixture of various constituents. According to Scavenging and Cleaning Act, MSW includes :

- dust, ashes, refuse and rubbish.
- trade refuse.
- carcasses of dead animals and other matter.
- sweeping, sand stones, leaves and other dead vegetation.
- wastes from shops and market areas including paper, straw and cardboard packing, decaying fruits and vegetables and other described items; and
- other solid wastes generated from establishments such as hospitals, schools, offices and small cottage industries.

Depending upon putrescibility municipal solid waste (MSW) can be classified into two categories *viz.* 'garbage' and 'rubbish. The term ***garbage*** is defined as the fraction of waste associated with preparation and consumption of food (*e.g.* meat and vegetable scraps), often called putrescibles. All other wastes not classified as 'garbage' are designated as '***rubbish***'.

Municipal Solid Waste Generation Status in Class-I Cities

The quantity of municipal solid waste generated by a city depends upon a number of factors of which size of population, standard of living, food habits, scale of commercial and industrial activities, etc. are of primary importance. As such the per capita generation of solid waste differs greatly from one city to another. It varies from 200 to 500 gm/person/day with an average of 376 gm/person/day. With the passage of time the level of urbanisation and standard of living of the urban people is likely to improve which will result in increased generation of total solid waste as well as per capita solid waste.

Disposal of such large quantities of garbage is a difficult job. The dumping grounds of such garbage are invariably polluted. It is estimated that about 25 human diseases are associated with solid wastes. Rats and flies flourish on garbage heaps. Rats are carriers of insects and other bio-organisms and are responsible for spreading deadly diseases like *plague, cholera*, etc. The flies which carry pathogenic organisms cause diseases such as dysentery, diarrhoea, etc. Studies reveal that an approximate of 70,000 flies can be produced on one cubic foot of garbage.

Management of Municipal Solid Waste (MSW)

In India, recently solid waste management systems are assuming larger dimensions in keeping with the Municipal Solid Wastes (Management & Handling) Rules, 2000. Many of the municipalities are taking appropriate actions to improve various component systems like collection of solid waste from generation areas, its transportation to processing and disposal site(s), utilising the recycling potential of Municipal Solid Waste (MSW) and ultimately disposing of by landfilling.

In view of this, under the sponsorship of Central Pollution Control Board (CPCB), NEERI has carried out extensive studies to assess the pathways of pollution for various environmental media. Further, a site selection criteria has been developed in the form of guidelines to suit Indian conditions in keeping with the findings of the other studies.

The urban solid waste management is an essential municipal service for protection of environment and health of citizens. All the citizens, industries, hospitals and NGOs should co-operate with the Municipal authorities to ensure safe management of urban solid waste. Segregation of

inorganic recyclable materials like plastic, glass, metal, paper at the source should be promoted and every effort should be made to provide collection of these in separate containers or bags in each house. Solid waste should be collected from each house on a daily basis and transported to the disposal site. Direct transfer of garbage from primary collection carts to covered transportation vehicles should be encouraged.

Refuse from vegetable and fruit markets should be collected and transported to the composting facilities. Large restaurants/hotels should be encouraged to develop their own onsite treatment facilities.

Sanitary landfills would be the main option for disposal of urban solid waste. The concerned authorities must make adequate provision of land allocation for scientific landfill sites.

Composting along with land disposal on non-compostables are the most preferred options for MSW and could take care of up to 20-30 per cent of municipal solid waste/organic fraction. The urban solid wastes of Indian cities have low calorific value and high moisture content with high percentage of non-combustible materials and hence it is unsuitable for thermal technologies. However, application of technologies such as incineration, palletisation and pyrolysis-gasification should be evaluated through research and development and pilot scale studies.

According to latest figures (2013) Delhi is generating about 9,500 metric tonnes of garbage everyday and is fast running out of landfill sites. It appears that garbage will soon become the single most important issue for Delhi which requires immediate solution. It is felt that unless a new technology is adopted, there will be no space left for garbage in the next few years.

Hazardous Waste Generation. The term 'hazardous waste' is generally used for wastes, which are highly toxic and hazardous in nature. According to "Hazardous Waste (Management and Handling) Rules" notified in 1989, 'hazardous substance' means any substance or preparation of which, by reason of its chemical or physio-chemical properties, or handling, is likely to cause harm to human beings, other living creatures, plants, micro-organisms, property or environment." As per Hazardous Waste (Management and Handling) Amendment Rules, 2000, 'hazardous waste' is defined as "Waste substances, which are generated in the process, and consists of wholly or partially of the waste substances referred to in the schedule."

Prevention and Control of Soil Pollution

Maximum soil pollution is done by use of biocides (pesticides, insecticides and herbicides) and chemical fertilizers. Farmers should be properly educated to make judicious use of these chemicals. Immediate restriction should be imposed on the use of DDT. At the same time, efforts should be made to develop less harmful and more useful chemicals for use in agriculture.

Urban and industrial effluents can be used for irrigation after proper treatment. Compostable organic substances such as vegetables, plant leaves, animal and human wastes should be properly composted, so that there is proper disposal of the solid waste and it can also produce organic manure. According to an estimate, a town with one lakh population may produce 20,000 tonnes of garbage and 8,000 tonnes of night soil which can be converted into 18,000 tonnes of compost (organic manure). Today, plastics are proving to be a big environmental hazard because they are practically indestructable. It takes hundreds of years for plastics to disintegrate, adding to solid waste buildup, especially in urban and industrial areas. There is an urgent need to restrict the use of plastics and to find out ways and means of recycling them.

NOISE POLLUTION

Noise is unwanted sound and covers all sounds which can result in hearing impairment or are harmful to health, or otherwise dangerous. According to **K.E. Maxwell**, "Noise is any sound that is not wanted. It is one of the more common forms of atmospheric pollution." *Noise pollution may be defined as the state of discomfort and restlessness caused to humans by unwanted high intensity sound.* More and more noise is created as the modern civilization moves ahead. It has now become a major environmental pollutant especially in urban areas. In 1972, the UN Environment Conference at Stockholm, noise pollution has been accepted as a problem, which needs proper control.

Measurement of Sound/Noise and Its Intensity

The most popular measure of noise level is the *decibel* measured by an instrument known as ***decibel meter***. A sound between 0 and 1 decibel is about the weakest that the average human can hear. For testing purposes, 0 decibel is considered to be the threshold of hearing. A whisper is about 20 decibels and an average speaking voice is about 60 decibels. The loudest sound that a person can stand without discomfort is about 80 decibels. Automobile horns may reach 90 decibels and a jet airplane may have an intensity of about 140 decibels. The levels of common noise is given in **Table 9.14** and has also been depicted in **Fig. 9.11.**

Actually, loudness alone is not the sole cause of noise problem, although this is the most apparent characteristic of noise that creates environmental problems. Pitch of the noise also influences the degree of annoyance—the higher the pitch, the greater the annoyance. Similarly, duration of the noise also determines how annoying or irritating noise will be. The degree of noise in an enclosed space or indoors is different from the level of outdoor noise.

TABLE 9.14. Intensity of Various Sounds

Sound Source	Intensity (in decibels)	Response Criteria
	0–10	Just audible
Broadcasting studio	20	—
Soft whisper	30	very quiet
Library, bedroom slow radio	30–50	quiet
Light auto traffic, air conditioning unit	50–70	intrusive
Freeway traffic, freight tram	70–80	annoying
Motor cycle, heavy traffic	80–100	very annoying, hearing damage
Rail noise	110-130	intolerable
Lighting thunder	120	intolerable
Carrier deck jet operation	140–150	painfully loud

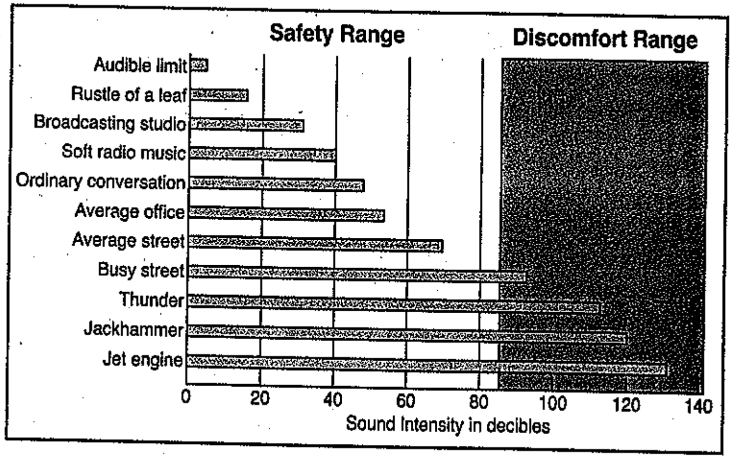

FIG. 9.11. Levels of Common Noise (After T. Berland)

NOISE POLLUTION IN INDIA

Noise pollution in India has increased considerably with the increase in urbanization and industrialization. In most of the Indian cities, early morning tranquillity is shattered by automobiles, factory machines and loudspeakers from religious places. Television and radio sets played at very high pitch, marriages and other processions, festivals, cultural programmes and a host of other sources of noise add to the problem of noise pollution. Most of the big cities of India have noise pollution much higher than the permissible limit of 60-70 dB. Delhi (89 dB), Kolkata (87 dB), Mumbai (85 dB), Chennai (82 dB), Kochi (80 dB), Madurai (75 dB) and Nagpur (75 dB) are some of the examples of cities suffering from noise pollution.

Effects of Noise Pollution

Continuous and prolonged exposure to noise pollution leads to many disorders and ailments. The most immediate and acute is the impairment of hearing. It also results in mental tension, blood pressure, heart diseases and stomach trouble. Noise pollution also causes annoyance, irritation and fatigue which result in low efficiency and high rate of errors. High and sudden noise may lead to abortion in early stages of pregnancy. According to Kudesia, "It is possible that due to disco dance and rock 'n' roll music we are raising a nation of teenagers who will be hard of hearing before they reach the age of 35 years. Those who listen songs from radio on loud pitch fall in the same line". A study to measure the Noise Induced Hearing Loss (NIHL) among the factory workers in the textile, automobile, fertilizers and chemical industries in Chennai, Coimbatore, Madurai, Kochi and Thiruvananthapuram revealed that about 25% of the factory workers and 10% people such as traffic constables and pavement vendors suffer from NIHL. About 60% of the students in the age group of 5-10 years living in industrial areas, railway colonies and other areas of high noise cannot concentrate on their studies.

Prevention and Control of Noise Pollution

It has been observed that noise pollution, like other forms of pollution, has become a serious problem. Since noise pollution is created by man, it can be controlled by adopting certain measures. Some of the measures are as follows :

(*i*) Noise producing industries should be located away from residential areas.

(*ii*) Inside industries proper arrangements to minimise noise be done by constructing sound proof walls and also to provide such instruments to workers which can protect their ears from noise.

(*iii*) Much of the industrial noise can be reduced by replacement of old noise producing machines with quieter alternatives, proper maintenance, greasing and oiling of the machines.

(*iv*) The automobile horn should be designed in such a way that the noise it produces may not be harmful.

(*v*) Use of horn should be minimum and pressure horn should be banned as has been done in many countries.

(*vi*) Noise pollution by road transport can be reduced by quieter engines, enforcing speed limits and laying the transport routes away from the residential areas such as by-passes. Tree plantation along the road side reduces the noise by 10 to 15 dB.

(*vii*) The noise created by railways can be checked by construction of ballastless rail tracks.

(*viii*) Special arrangements be done to check noise near air bases. Control of aircraft noise requires several changes, which should be done.

(*ix*) Intensity of noise can be reduced to a great extent by proper acoustic designing of cinema, dance and community halls, as well as religious places and other buildings of high noise intensity.

(*x*) The noise created by musical instruments, and other indoor equipments can be checked by individuals in their own interest.

(*xi*) Effect of noise on the ear can be reduced by 40 to 50 dB by putting ear-plugs or earmuffs.

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CHAPTER 10

Population : General Characteristics

SIZE OF INDIAN POPULATION

With a total population of 1,210.2 million according to 2011 census figures, India is the second most populous country of the world, next only to China, a country with a population of 1,341.0 million in 2010. India covers only 2.4 per cent of the land area of the world, but is the home of about 17.5 per cent of the world's population as compared to 19.4 per cent of the world's population living in China. Thus a little more than one out of every six persons in the world is from India. With about 308.7 million population, the USA is the third largest country of the world with respect to population size. However, there is yawning gap of more than 901 million between the population of India and the USA which is about three times the total population of that country. Further it is worth noting that gap between population of India and China is only 130.8 million (*i.e.* 1.9%) while between population of India and the USA is 901.5 million (*i.e.* 13%). Our population is almost equal to the combined population of the USA, Indonesia, Brazil, Pakistan, Bangladesh and Japan put together, the population of these six countries totals 1214.3

TABLE 10.1. Population of ten most populated countries of the world

Sl. No.	Country	Reference date	Population (in millions)	Percentage of total world population
1.	China	01-11-2010	1,341.0	19.4
2.	India	01-03-2011	1,210.2	17.5
3.	U.S.A.	01.04.2010	308.7	4.5
4.	Indonesia	31.05.2010	237.6	3.4
5.	Brazil	01.08.2010	190.7	2.8
6.	Pakistan	01.07.2010	184.8	2.7
7.	Bangladesh	01.07.2010	164.4	2.4
8.	Nigeria	01.07.2010	158.3	2.3
9.	Russian Fed.	01.07.2010	140.4	2.0
10.	Japan	01.10.2010	128.1	1.9
	Other Countries	01.07.2010	2844.7	41.2
	World	01.07.2010	6908.7	100

Source : Data computed from Census of India 2011, Provisional Population Totals, Paper 1 of 2011 Series 1, p. 39.

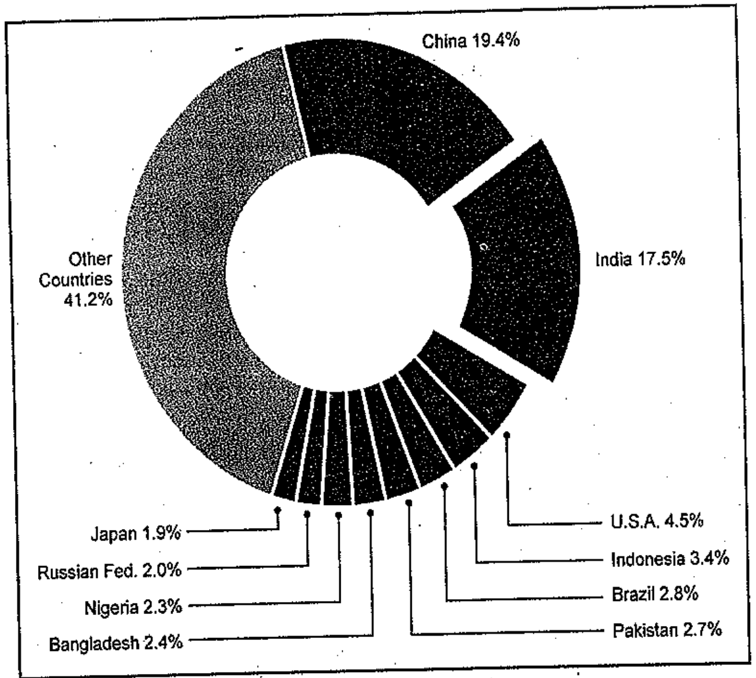

FIG. 10.1. India in world population

million. If we look at the area of the major countries of the world, Russian Federation is more than five times, Canada is over three times, the USA is 2.8 times, Brazil is 2.6 times and Australia is 2.3 times as large as India. But their combined population is only 63 per cent of the total population of India. India's population is a little over twice the population of Latin America and 1.2 times the population of whole of Africa.

Table 10.1 gives an idea of India's dominant position among ten most populous countries of the world.

CENSUS OF POPULATION

Data regarding population are collected through censuses all over the world. A census count offers a spectrum of population at a particular point in time covering a wide range of demographic, social and economic attributes of population. The year 1872 marked the beginning of census taking in India. Although it marked an auspicious beginning, it was neither a synchronous project nor did it cover the entire country. The first complete and synchronous census covering the entire country and providing vital demographic data was conducted in 1881. Since then the census in India has been conducted regularly after every ten years. The 2011 census represents the fifteenth census of India as reckoned from 1872 and seventh after Independence. With a view to widen the scope and improve the quality of census data, modifications in its schedule and questionnaire have been introduced from time to time.

India's population is so large that population of some states is larger or almost equal to the total population of several large countries of the world (*see* box on next page).

Growth of Population : Basic Concepts

1. Growth Rate. Growth of population is the change in the number of people living in a particular area between two given points of time. The net change between two points of time is expressed in percentage and is described as the growth rate of population.

Comparison of population of some Indian states with that of some large countries of the world.

Population in millions (2011)

Indian States	Countries
1. Uttar Pradesh : 199.6	Brazil : 190.7
2. Maharashtra : 112.4	Japan : 128.1
3. Bihar : 103.8	Philippines : 98.0
4. West Bengal : 91.3	Germany : 82.3
5. Madhya Pradesh : 72.6	Egypt : 73.0
6. Gujarat : 60.4	Italy : 59.3, UK : 61.0
7. Odisha : 41.9	Argentina : 41.0
8. Kerala : 33.4	Iraq : 33.0; Afghanistan : 32.9
9. Chhattisgarh : 25.5	Ghana 25.4, Australia : 21.9
10. NCT of Delhi : 16.7	Angola : 16.3

The combined population of Uttar Pradesh and Maharashtra is about 312 million which is substantially greater than the population of U.S.A., third largest country of the world with respect to population.

2. Natural Growth. The difference between the natural birth-rate and death-rate is called the *natural growth* of population.

3. Migratory Growth. This growth of population is caused by migration of people.

4. Positive Growth. When the population increases between two given points of time, it is called ***positive growth***. It takes place when the birth rate is higher than the death-rate or people migrate from other countries.

5. Negative Growth. The growth of population is called ***negative*** if the population decreases between two given points of time. It takes place if the birth-rate is lower than the death-rate or people migrate to other places.

There has always been positive growth rate of population in India ever since first census of India was conducted. However, 1921 is an exception when the growth was negative.

Several attempts have been made to estimate the population of India before first census was conducted in 1872. According to an estimate, India's population was just 100 million in 1600 A.D. It rose to 120 million in 1800, 130 million in 1841, and 255 million in 1871. This can be termed as a negligible growth compared to the present trends.

Population Growth Since 1901

Trends in population growth since 1901 have been given in Table 10.2. A close look at this table shows that there have been significant demographic divides as far as trends in population growth are concerned. These significant turning points are the census years 1921, 1951 and 1981. Thus the demographic history of India can be charted and classified into the following four distinct phases.

1. Period of Stagnant Population (1901-1921)
2. Period of Steady Growth (1921-1951)
3. Period of Rapid High Growth (1951-1981)
4. Period of High Growth with Definite Signs of Slowing Down (1981-2011)

1. Period of Stagnant Population (1901-1921)

During most of the 19th century India witnessed sporadic, irregular and slow growth of population which drifted into twentieth century until 1921. Thus the population growth during this period can be termed more or less stagnant when compared to the growth rates observed during the consequent periods. The high birth rate was counterbalanced by high death rate. The progressive growth rate in 1921 over 1901 was only 5.42 per cent. In fact, the census year 1921 registered a negative growth rate of –0.31 per cent which happened only once throughout the demographic history of India. It is because of this decline in place of rise in population that the year 1921 is called the ***'demographic divide'*** in the demographic history of India. The high mortality during this period was the product of large scale abnormal deaths due to epidemics of influenza, plague, small pox, cholera, etc. Influenza alone claimed 12 million lives in 1918. Food shortages caused by severe droughts in 1911, 1913, 1915, 1918 and 1920 claimed their own toll. In addition, thousands of Indian soldiers lost their lives during the World War I (1914-18). Lakhs of people emigrated to a number of countries in Africa.

From the view point of population studies, India has been divided into six zones. They are : (*i*) **northern zone** (Haryana, Himachal Pradesh, Jammu and Kashmir, Punjab, Rajasthan, Chandigarh and Delhi), (*ii*) **eastern zone** (Bihar, Jharkhand, Sikkim, West Bengal, Odisha and Andaman and Nicobar Islands), (*iii*) **north-east zone** (Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Tripura), (*iv*) **central zone** (Chhattisgarh, Madhya Pradesh, Uttar Pradesh, Uttarakhand), (*v*) **western zone** (Gujarat, Maharashtra, D & N Haveli, Daman and Diu) and, (*vi*) **southern zone** (Andhra Pradesh, Telangana, Karnataka, Kerala, Tamil Nadu, Lakshadweep, Telangana, Puducherry and Goa.)

During the period 1901-1921, the northern zone suffered a net loss of 1.4 per cent of its population due to various famines and epidemics. In contrast the

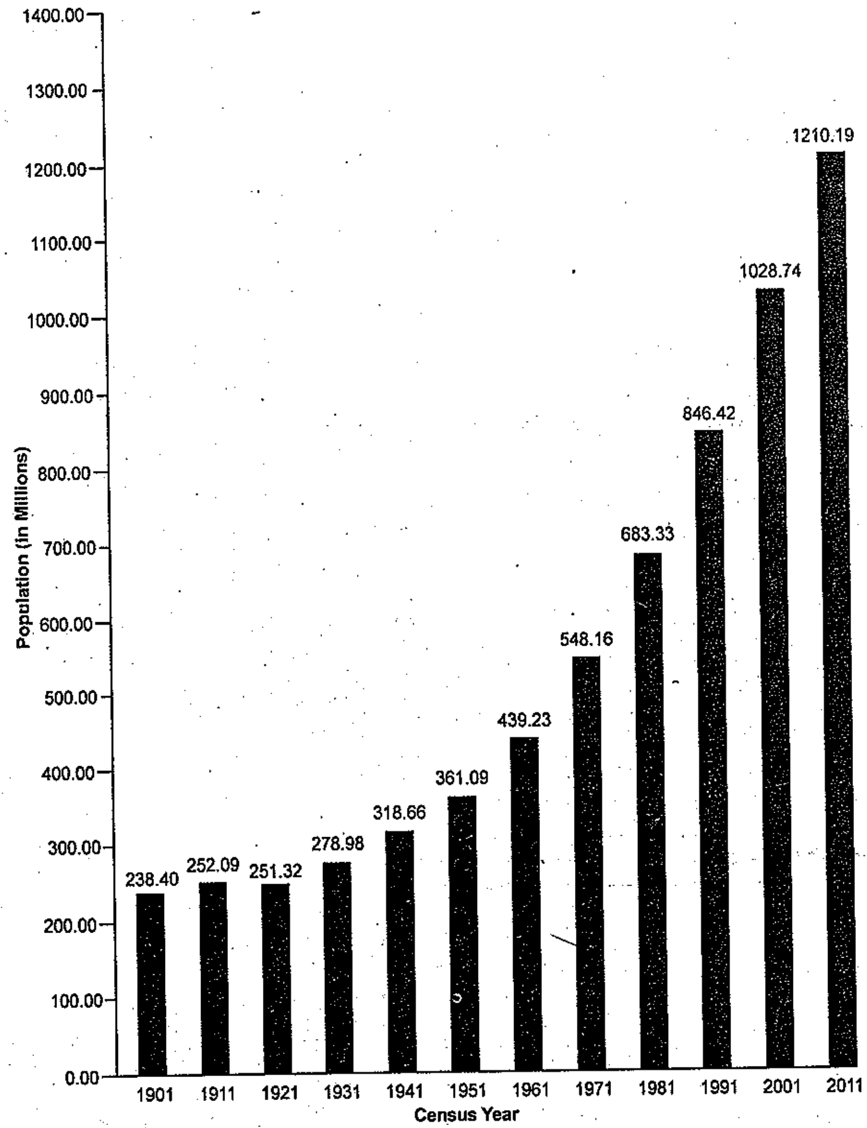

FIG. 10.2. India : Decadal Growth of Population 1901-2011.

north-eastern zone registered a very high growth rate mainly due to large scale inmigration/immigration and to some extent lesser sufferings from famines and epidemics. Assam, Manipur, Tripura and Nagaland experienced very high population growth. Assam attracted large number of immigrants in its tea gardens. The southern zone experienced normal growth rate of 11.1 per cent because it did not suffer from famines and epidemics. However, Kerala was an exception which registered a sharp growth of 22 per cent.

2. Period of Steady Growth (1921-51)

During 1921-51, the population of India increased from 251 million to 361 million (Table 10.2). This duration of 30 years has thus registered a growth of 47.3 per cent. Therefore, this period is called the period of steady growth rate. The mortality rate started showing downward trend as a result of improvement in general health and sanitation conditions after 1921. These developments helped in controlling epidemics like plague, cholera and malaria. The crude death rate which stood at a high of 47 per thousand in 1921 declined to 27 per thousand in 1951 (*see* **table 10.3**). On the contrary, the crude birth rate continued to stay at an abnormally high level and decline only to 40 per thousand in 1951 as against 48 per thousand in 1921. Decline in death rate was also achieved partly through the improvement in

TABLE 10.2. Decadal Growth Rates in India, 1901-2011

Census Year	Total Population	Growth Rate*	
		Absolute Number	% of Growth
1901	238396327	.....	.....
1911	252093390	(+) 13697063	(+) 5.75
1921	251321213	(–) 772117	(–) 0.31
1931	278977238	(+) 27656025	(+) 11.00
1941	318660580	(+) 39683342	(+) 14.22
1951	361088090	(+) 42427510	(+) 13.31
1961	439234771	(+) 78146681	(+) 21.64
1971	548159652	(+) 108924881	(+) 24.80
1981	683329097	(+) 135169445	(+) 24.66
1991	846421039	(+) 163091942	(+) 23.87
2001	1028737436	(+) 182316397	(+) 21.54
2011	1210193422	(+) 181455986	(+) 17.64

*Decadal growth rate $g = \frac{P_2 - P_1}{P_2} \times 100$

Where P_1 = Population of the base year
P_2 = Population of the present year

Source : Census of India, 2011, Provisional Population Totals Paper 1, p. 41.

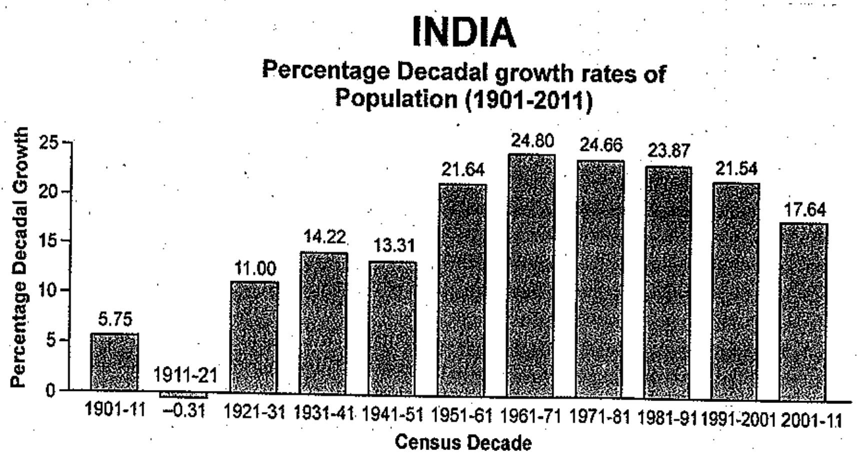

FIG. 10.3. India's Percentage Decadal Growth Rates of Population 1901-2011

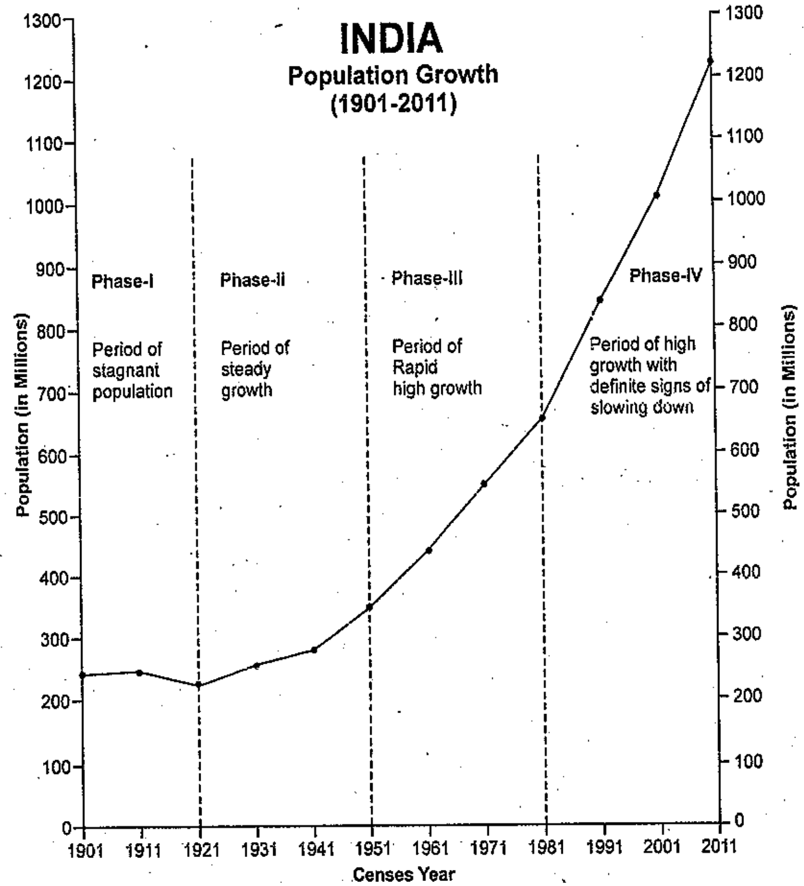

FIG. 10.4. India : Population Growth : 1901-2011

the distribution system as a result of improved transportation so that timely supplies of food could be made available to drought and famine stricken areas. The combined effect of these factors was that the population started increasing steadily. Since crude death rate declined considerably and crude birth rate remained very high, the population growth during this period is called ***mortality induced*** growth. During this period, the northern, eastern and southern zones registered growth rates close to the national average. The central zone registered comparatively low growth rate of 35.6 mostly due to higher rate of mortality and substantial out migration. The western zone experienced high growth rate of 56 per cent partly due to national growth and mainly due to immigration caused by industrial growth in Mumbai, Ahmedabad, Vadodara and Surat.

3. Period of Rapid High Growth (1951-81)

After 1951, there was a steep fall in the mortality rate but the fertility remained stubbornly high. Therefore, this period experienced very high rate of population growth and is often referred to as the ***period of population explosion***. As a matter of fact, the birth rate increased from 40 per thousand in 1951 to 42 per thousand in 1961 and stayed at 36 per thousand in 1981. In contrast, death rate fell rapidly from 27 per thousand in 1951 to 12 per thousand in 1981. Consequently the natural rate of growth, which fell slightly from 14.0 per thousand in 1941 to 13 per

TABLE 10.3. India—Changing Birth Rates, Death Rates and Natural Increase, 1911-2009

Year	Crude Birth rate per thousand	Crude Death rate per thousand	Natural rate of increase per thousand
1911	49	43	6
1921	48	47	1
1931	46	36	10
1941	45	31	14
1951	40	27	13
1961	42	23	19
1971	39	15	24
1981	36	12	24
1991	31	11	20
2001	25	8	17
2009	22.5	7.3	15.2

*Census of India, Sample Registration System (SRS) Bulletin.

thousand in 1951 rose steeply to 4 per thousand in 1971 and remained at the same level in 1981 also. The total population of the country increased from 361.09 million in 1951 to 683.3 million in 1981 recording an increase of 89.36 per cent in a short span of thirty years. This unprecedented growth rate was due to the accelerated developmental activities and further improvement in health facilities. The living conditions of the people improved enormously. Death rates declined much faster than the birth rates (**Table 10.3**). This situation resulted in high natural increase. Thus, it was ***fertility induced growth***. During this period, the northern zone experienced the high growth rate of 111 per cent whereas the southern zone, which had higher than the national average during 1901-21 and 1921-51 had the lowest growth rate during 1981-81.

4. Period of High Growth Rate with Definite Signs of Slowing Down (1981-2011)

The last phase of 20th century and the early phase of 21st century *i.e.*, the period between census years 1981 and 2011 is known as the period of high growth with definite signs of slowing down. Although the rate of growth was still very high, it started declining after 1981. The highest ever growth rate of 2.48 per cent was recorded in 1971 which remained at a high of 2.46 in 1981 also. It declined to 2.38 per cent in 1991, 2.15 per cent in 2001 and further to 1.76 in 2011. Thus the growth rate registered the sharpest declines of 2.46 per cent per annum during the decade 2001-2011. During the period 1981-2011, the northern zone and the southern zone had the highest and lowest growth rates respectively. This declining trend marks the beginning of the new era in the country's demographic history. During this period, birth rate declined rapidly, from 36 per thousand in 1981 to 22.5 per thousand in 2009 (**Table 10.3**). Declining trend of death rate continued but at a slower rate. The difference between birth and death rates narrowed to 15.2 per thousand. This declining trend is a positive indicator of the official efforts of birth control and people's own inclination to opt for smaller families. Although population growth rate in India continues to decline since the 1971 census year yet India's population growth rate is much higher as compared to that of China, U.S.A., Japan, Brazil, Indonesia, Bangladesh, etc. (**Fig. 10.5**). Russian Federation and some other European countries have recorded negative growth. During 2001 and 2011, India's population increased by 181.45 million which is slightly less than the total population of Brazil and much more than that of Bangladesh, Nigeria, Russian Federation or Japan. These countries are amongst the ten most populated countries of the world. In fact we, each year we are adding to our population which is almost equal to the population of Australia.

According to the United Nations population report released on June 13, 2013, India would pip China as the most populated country in the world by 2028 when India's population will be about 1448 million as compared to China's 1443 millions. The report based on new fertility data says that India's population would increase to 1620 million till 2050 and then decline to around 1540 million by the end of the 21st century. China would enter the downturn era in population from 2025 onwards and lose its top spot to India in 2028.

Growing longivity will be another major factor responsible for population growth as the life expectancy would increase from 64.9 years in 2013 to 80.6 years in 2100 and would just be one per cent point below the global average. Now it is 2.2 per cent

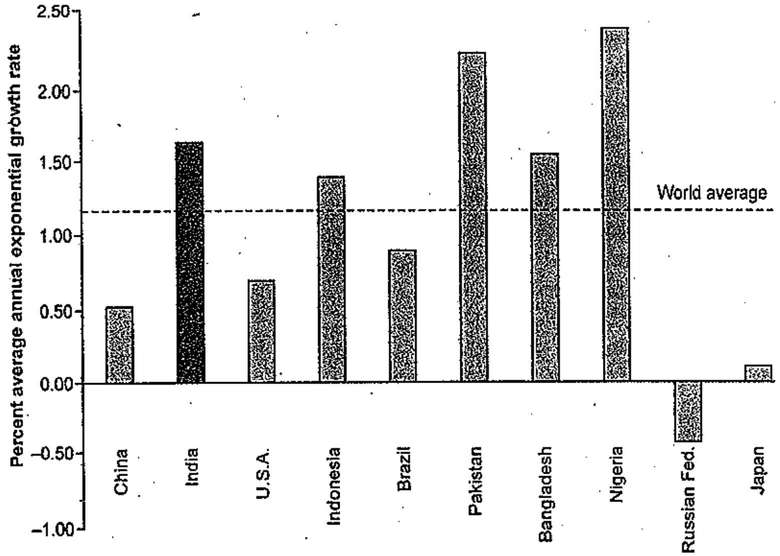

FIG. 10.5. Population Growth Rate of Ten most populated countries of the world (2000-2010)

points below the world average of 67.1 years. However, the fertility rate per woman will fall below 2 in 2050 to 1.84 in 2100. It would result in proportion of the children below the age of 14 years to fall by ten percentage points between 2013 and 2050. Even this fall will not help India much in

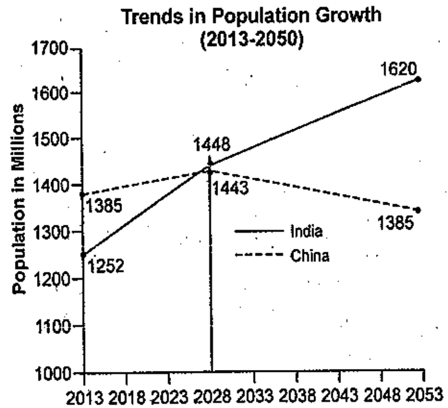

FIG. 10.6. Trends in population growth in India and China from 2013 to 2050 according to UN Department of Economics and Social Affairs.

controlling the population growth because the base population would be too large for any desired results.

The report also says that India will have one of the worst sex ratios in the world. India's sex ratio could be behind only the Middle East. Presently, India has 107 men for every 100 women, a ratio worse than Pakistan, Bangladesh and Sri Lanka. The world population will increase from 7162 million in 2013 to 8193 million in 2028 and 9580 million in 2050.

Demographic Transition. Demographic transition is the process of change in population of a society. It consists of the following four stages :

(*a*) ***Stage 1.*** High death and birth rates, low growth rate.

(*b*) ***Stage 2.*** Rapid decline in death rate, continued high birth rate, very high growth rate.

(*c*) ***Stage 3.*** Rapid decline in birth rate, continued decline in death rate, growth rate begins to decline.

(*d*) ***Stage 4.*** Low death and birth rates, low growth rate.

The story of population growth in India is fairly in tune with the classical theory of demographic transition. During most of the nineteenth century India witnessed a fluctuating but ultimately more or less a stagnant growth of population, which drifted into the twentieth century until 1921. Thereafter, country passed through successively all the phases of demographic transition and is now widely believed to have entered the final phase which is normally characterised by rapidly declining fertility. It is yet to be seen as to how long will this phase extend and when India will achieve a stable population. However UN Department of Economics and Social Affairs has estimated that India's population will continue to increase till 2050 when it will reach a staggering figure of 1620 millions after which it will start decreasing and by the end of 21st century it will stand at 1540 million.

Spatio-Temporal Variations in Population Growth

The average population growth rate of 17.64 per cent during 2001-11 does not give true picture as there are differences in the growth rate with reference to space and time. These are called spatio-temporal variations in population growth. There can be different reasons for differential growth-rate in different parts of India. A study of **Table 10.4** and **Fig. 10.7** gives an idea of regional variations in population growth.

Exactly half of the 20 most populous states, each with a population of ten million or more, have added lesser persons in the decade 2001-2011 compared to the decade 1991-2001. Had these ten states added the same number of persons during 2001-2011 as they did in the previous decade, India would have added another 9.7 million more persons during this decade. The phenomenon of low growth has spread beyond the boundaries of the southern states during 2001-2011, where in addition to Andhra Pradesh, Tamil Nadu and Karnataka in the south, Himachal Pradesh and Punjab in the north, West Bengal and Odisha in the east and Maharashtra in the west have registered growth rate between 11 and 16 per cent in 2001-2011.

Among the smaller states and union territories, Dadar and Nagar Haveli and Daman and Diu registered the highest growth rate of 55.5 and 53.54 per cent respectively. In contrast, Lakshdweep, Andaman Nicobar Islands and Goa have registered low growth rate remaining in single digit only. A glaring down trend in the growth has been observed in Nagaland, where there had been a steep fall in growth rate from 64.53 per cent in 1991-2001 to negative growth rate of –0.47 per cent. The second minimum growth of 4.86 per cent has been recorded by Kerala. This state has reached high level of demographic transition and can be easily compared with the advanced countries of Europe and America. Some of the more populous states have registered very high growth rate of over 20 per cent. Among them Bihar (25.07%), Jammu & Kashmir (23.71%), Chhattisgarh (22.59%) and Jharkhand (22.34) are worth noting. Some other states with small population but higher growth rate are Meghalaya (27.82%) and Arunachal Pradesh (25.92%).

Fifteen states and union territories registered a decline of over five percentage points in decadal growth rate from the previous census decade. These states and union territories are Jammu & Kashmir, Punjab, Haryana, Rajasthan, Uttar Pradesh, Sikkim, Nagaland, Manipur, Mizoram, Maharashtra, Goa, Delhi, Chandigarh, Lakshadweep and Andaman and Nicobar Islands and account for more than 39% of India's population. Delhi has registered the sharpest drop of 26 percentage points during 2001-2011, followed by Haryana (8.53), Rajasthan (6.97) and Maharashtra (6.74). Seventeen stages and union territories have shown 1 to 5 per cent points fall in their growth rates during 2001-11 as compared to 1991-2011. These states and union territories account for more than 52% of total population of India. Thus more than nine out every ten Indians live in states and union territories that have registered declining trend in population growth.

TABLE 10.4. Population, percentage decadal growth and average annual exponential growth rates 1991-2001 and 2001-2011

State/UT Code	India/State/Union Territory	Total Population		Percentage Decadal growth	
		2001	2011	1991-2001	2001-2011
1	2	3	4	5	6
	INDIA	**1,02,87,37,436**	**1,21,01,93,422**	**21.54**	**17.64**
1	Jammu & Kashmir	1,01,43,700	1,25,48,926	29.43	23.71
2	Himachal Pradesh	60,77,900	68,56,509	17.54	12.81
3	Punjab	2,43,58,999	2,77,04.236	20.1	13.73
4	Chandigarh	9,00,635	10,54,686	40.28	17.1
5	Uttarakhand	84,89,349	1,01,16,752	20.41	19.17
6	Haryana	2,11,44,564	2,53,53,081	28.43	19.9
7	NCT of Delhi	1,38,50,507	1,67,53,235	47.02	20.96
8	Rajasthan	5,65,07,188	6,86,21,012	28.41	21.44
9	Uttar Pradesh	16,61,97,921	19,95,81,477	25.85	20.09
10	Bihar	8,29,98,509	10,38,04,637	28.62	25.07
11	Sikkim	5,40,851	6,07,688	33.06	12.36
12	Arunachal Pradesh	10,97,968	13,82,611	27	25.92
13	Nagaland	19,90,036	19,80,602	64.53	–0.47
14	Manipur	22,93,896	27,21,756	24.86	18.65
15	Mizoram	8,88,573	10,91,014	28.82	22.78
16	Tripura	31,99,203	36,71,032	16.03	14.75
17	Meghalaya	23,18,822	29,64,007	30.65	27.82
18	Assam	2,66,55,528	3,11,69,272	18.92	16.93
19	West Bengal	8,01,76,197	9,13,47,736	17.77	13.93
20	Jharkhand	2,69,45,829	3,29,66,238	23.36	22.34
21	Odisha	3,68,04,660	4,19,47,358	16.25	13.97
22	Chhattisgarh	2,08,33,803	2,55,40,196	18.27	22.59
23	Madhya Pradesh	6,03,48,023	7,25,97,565	24.26	20.3
24	Gujarat	5,06,71,017	6,03,83,628	22.66	19.17
25	Daman & Diu	1,58,204	2,42,911	55.73	53.54
26	Dadra & Nagar Haveli	2,20.490	3,42,853	59.22	55.50
27	Maharashtra	9,68,78,627	11,23,72,972	22.73	15.99
28	Andhra Pradesh	7,62,10,007	8,46,65,533	14.59	11.10
29	Karnataka	5,28,50,562	6,11,30,704	17.51	15.67
30	Goa	13,47,668	14,57,723	15.21	8.17
31	Lakshadweep	60,650	64,429	17.3	6.23
32	Kerala	3,18,41,374	3,33,87,677	9.43	4.86
33	Tamil Nadu	6,24,05,679	7,21,38,958	11.72	15.6
34	Puducherry	9,74,345	12,44,464	20.62	27.72
35	Andaman & Nicobar Islands	3,56,152	3,79,944	26.9	6.68

Source: Census of India, 2011; Provisional Population Totals, paper 1. p. 54.

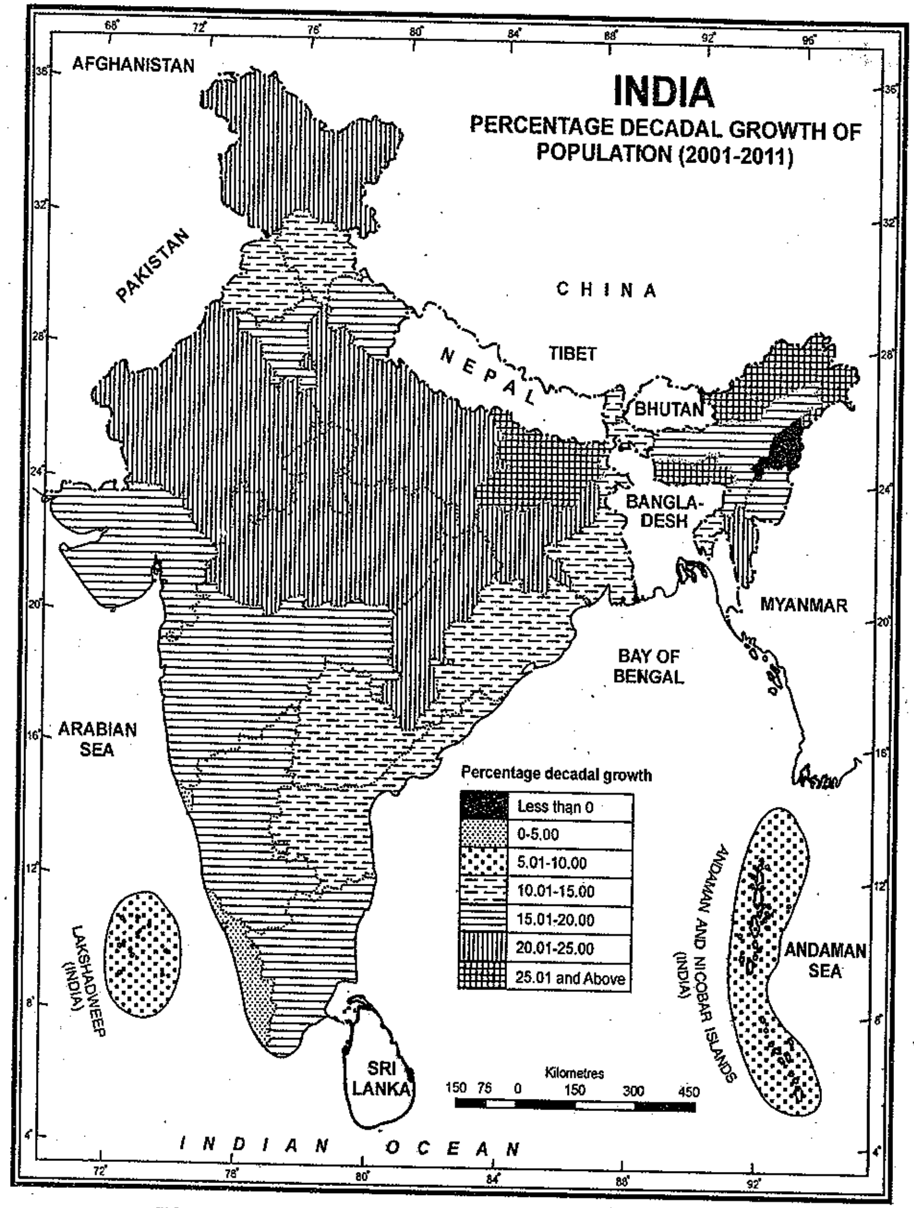

FIG. 10.7. India : Percentage decadal; growth of population (2001-2011)

Table 10.6 gives the distribution of states and union territories by ranges of percentage decadal growth as well as the percentage of population of these states and union territories which highlights the major shift in the distribution of states and union territories by ranges of growth rates between 1991-2011 and 2001-11. The number of states and union territories with percentage decadal growth below the

TABLE 10.5. States and union Territories arranged in descending order of growth rate or population : 1991 -2001 to 2001-2011

Rank	India/State/ Union Territory#	1991 -2001	India/State/ Union Territory#	2001 -2011
1	Nagaland	64.53	Dadra & Nagar Haveli#	55.50
2	Dadra & Nagar Haveli#	59.22	Daman & Diu#	53.54
3	Daman & Diu#	55.73	Meghalaya	27.82
4	NCT of Delhi#	47.02	Puducherry#	27.72
5	Chandigarh#	40.28	Arunachal Pradesh	25.92
6	Sikkim	33.06	Bihar	25.07
7	Meghalaya	30.65	Jammu & Kashmir	23.71
8	Jammu & Kashmir	29.43	Mizoram	22.78
9	Mizoram	28.82	Chhattisgarh	22.59
10	Bihar	28.62	Jharkhand	22.34
11	Haryana	28.43	Rajasthan	21.44
12	Rajasthan	28.41	NCT of Delhi#	20.96
13	Arunachal Pradesh	27.00	Madhya Pradesh	20.30
14	Andaman & Nicobar Islands#	26.90	Uttar Pradesh	20.09
15	Uttar Pradesh	25.85	Haryana	19.90
16	Manipur	24.86	Uttarakhand	19.17
17	Madhya Pradesh	24.26	Gujarat	19.17
18	Jharkhand	23.36	Manipur	18.65
19	Maharashtra	22.73	**INDIA**	17.64
20	Gujarat	22.66	Chandigarh#	17.10
	INDIA	**21.54**	Assam	16.93
21	Puducherry#	20.62	Maharashtra	15.99
22	Uttarakhand	20.41	Karnataka	15.67
23	Punjab	20.10	Tamil Nadu	15.60
24	Assam	18.92	Tripura	14.75
25	Chhattisgarh	18.27	Odisha	13.97
26	West Bengal	17.77	West Bengal	13.93
27	Himachal Pradesh	17.54	Punjab	13.73
28	Karnataka	17.51	Himachal Pradesh	12.81
29	Lakshadweep#	17.30	Sikkim	12.36
30	Odisha	16.25	Andhra Pradesh	11.10
31	Tripura	16.03	Goa	8.17
32	Goa	15.21	Andaman & Nicobar Islands#	6.68
33	Andhra Pradesh	14.59	Lakshadweep#	6.23
34	Tamil Nadu	11.72	Kerala	4.86
35	Kerala	9.43	Nagaland	-0.47

Union Territory

Source : Census of India, Provisional Population Totals, Paper 1 of 2011 Series 1, p. 167.

TABLE 10.6. Number of states and union territories by range of percentage decadal growth rates 1991-2001 and 2001-2011

Percentage decadal growth	Number of states/ union territories 1991-2001	Percentage of population to total population 2001	Number of states/ union territories 2001-2011	Percentage of population to total population 2011
12 and below	2	9.16	6	10.08
12-15	1	7.41	6	14.22
15-18	7	17.55	5	22.96
18-21	5	7.9	7	32.02
21-24	3	16.96	5	11.63
24-27	4	22.28	2	8.69
27-30	6	16.8	2	0.35
30 and above	7	1.94	2	0.05

Source : Census of India 2011, Provisional Population Totals, Paper I of 2011, Series 1, p. 56

national average of 17.64% has increased substantially from 10 in 1991-2001 to 17 in 2001-11 and the number of states and union territories with percentage decadal growth above the national average growth has reduced significantly from 25 to 18. The sum of total population of states and union territories which registered less than the national average has shown an impressive increase from about 34 per cent in 2001 to 47 per cent in 2011. As many as 12 states and union territories with a combined population of slightly more than 24 per cent of India have grown by less than 15 per cent during 2001-11. The number of such states and union territories was only 3 during 1991-2001.

Population Growth in EAG and non-EAG States

The demographic centre of gravity shifted from the Indus Valley into the Gangatic plain after the immigration by the Aryans about 3500 years ago. The patterns of growth rates in India remained more or less similar to those prevailing throughout the historic

Growth rates of India, EAG states and non-EAG states and Union Territories (1951-61 to 2001-11)

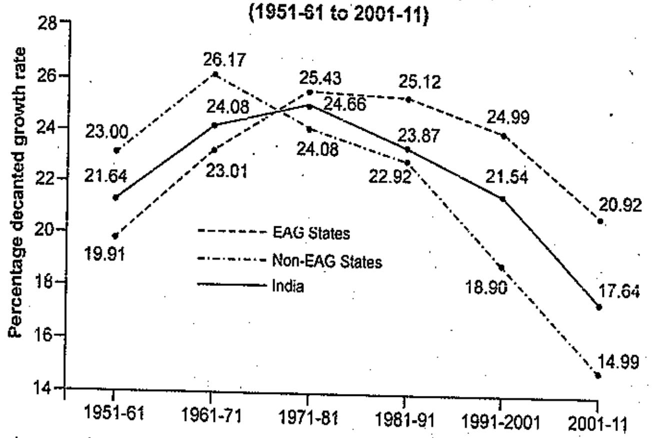

FIG. 10.8. Growth rates of India, EAG states and non-EAG states and union territories 1951-61 to 2001-2011

times. For a close analysis, the Indian states and union territories are divided into two broad groups namely Empowered Action Group (EAG) and non Empowered Action Group (non-EAG). EAG includes Rajasthan, Uttar Pradesh, Uttarakhand, Bihar, Jharkhand, Madhya Pradesh, Chhattisgarh and Odisha. The remaining states and union territories are included in non-EAG. **Fig. 10.8** shows the growth trajectory of India, the EAG group and the non-EAG group of states from 1951-1961 to 2011-2011. The EAG states hosted between 43 and 46 per cent of India's population.

During the period of two decades between 1951 and 1971, population of both EAG and non-EAG states and union territories increased which led to overall increase in population of India. During this period, the population of non-EGA states grew at a faster rate as compared to that of EAG states. From 1971 onwards, the growth rate in non-EAG states and union territories declined continuously due to decline in fertility rate. The growth rate in EAG states almost stagnated around 25 per cent. During 1991-2001, the growth rate for EAG states remained same as that in the previous decade, whereas there was continuous reduction in the growth rate of non-EAG states and union territories. This was primarily responsible for bringing about a significant fall of about 2.3 per cent in the growth rate of the country as a whole. During 2001-2011, for the first time in the demographic history of the country, the growth momentum for EAG states has given the signal of slowing down, falling by about 4 per cent points. Thus, together with similar reduction in non-EAG states and union territories has brought down the rate of growth for the country by 3.9 per cent. In fact, census 2011 marks a milestone in the demographic history of the country, as it is perhaps for the first time, there is significant fall in the growth rate of population in the EAG states after decades of stagnation.

District Level Patterns. Regional variations in population growth come in sharp focus when studied at the district level. Spatio-temporal variations in population growth are much larger at the district level as compared to the state level. It is important to note that the number of districts was 466 in 1991 which increased to 593 in 2001 and 640 in 2011 because several states came out with the creation of new districts for various political, social economic and administrative reasons. **Table 10.7** presents a frequency distribution of districts according to their 1991-2001 and 2001-2011 decadal growth rates. Decadal growth rates for 1991-2001 have been presented according to data for 640 districts and, therefore, may not tally with earlier analysis.

This table shows that 102 districts had very high growth rate of over 30 per cent in 1991-2001 and this number was reduced to 47 in 2001-11. Similarly the number of districts with growth rate 25.01-30.00 was reduced from 127 in 1991-2001 to 72 in 2001-11 and the number of districts with 20.01-25.00 growth rate was reduced from 132 in 1991-2001 to 108 in 2011-11. Wokha district of Nagaland had a population of 161,098 in 2001 and registered a very high growth rate of 95.16 per cent. Kiphire district of Nagaland registered the highest growth rate of 95.64 per cent in 1991-2001 (**Table 10.8**). Most districts in the north-eastern states registered growth rates during 1991-2001 which were much higher than the national average, and this was largely due to in-migration.

In contrast, the number of districts in lower growth range increased considerably. For example, the number of districts with 0-10 per cent growth rate increased from 58 in 1991-2001 to 89 in 2001-11. Similarly, the number of districts with negative growth rate has increased from 3 in 1991-2001 to 19 in 2001-11 (*see* **Table 10.7**). Majority of these

TABLE 10.7. Distribution of districts according to decadal population growth rate, 1991-01 and 2011-11

Decadal growth rate (per cent)	Number of districts	
	1991-2001	2001-11
Above 30.00	102	47
25.01-30.00	127	72
20.01-25.00	132	108
16.01-20.00	134	155
10.01-15.00	84	150
0.01-10.00	58	89
0 and Below	3	19
Total	640	640

Source : Census of India 2011, Series 1, India, *Provisional Population Totals*, Paper 1 of 2011; Districtwise data on *censusindia.gov.in* website.

districts are in Kerala and Tamil Nadu. These two states registered decadal growth rate of 9.43 per cent and 11.72 per cent respectively in 1991-2001. This achievement was made possible by decline in natural growth rate and outmigration from these districts.

It is worth noting that twelve districts including Mumbai, Kolkata and New Delhi (basically urban districts with no scope for growth) had growth rates below five per cent. Further, 'central' Delhi district and Mamit district in Mizoram had negative growth rates for different reasons.

It is important to note that in 1991-2001, six out of ten districts recording highest growth rate in India were in Nagaland. This situation has completely been reversed as there was not even a single district in the whole of Nagaland with high growth rate in 2001-11.

As a matter of fact, three of the districts which recorded high growth rate during 1991-2001 (Kiphire, Longleng and Mon) registered negative growth rate during 2001-11. Longleng district of Nagaland recorded largest negative growth rate of –58.39% during 2001-11. In addition to the above mentioned three districts of Nagaland, Lahul and Spiti (Himachal Pradesh), Mumbai (Maharashtra), Zunheboto and Mokokchung (Nagaland), Central Delhi, New Delhi, Nicobars (Andaman and Nicobar Islands) also recorded negative growth rate of more than –5.0 per cent during 2001-11 (Table 10.8). Although factors leading to negative growth rate in most districts of Nagaland requires close examination, negative growth rate in Central Delhi and New Delhi is largely due to outmigration.

TABLE 10.8. Ten districts with highest decadal growth rates, 1991-01 and 2001-11 and ten districts with lowest decadal growth rates, 1991-01 and 2001-11

State/UT	District	1991-01	State/UT	District	2001-11
Ten districts with highest decadal growth rates					
Nagaland	Kiphire	95.64	Arunachal	Kurung Kumey	111.01
Nagaland	Wokha	95.16	Puducherry	Yanam	77.15
Nagaland	Dimapur	86.13	Haryana	Gurgaon	73.93
Daman & Diu	Daman	83.55	Daman & Diu	Daman	67.43
Nagaland	Longleng	79.58	Dadra & N Haveli	Dadra & Nagar Haveli	55.50
Nagaland	Mon	70.12	Uttar Pradesh	Gautam Buddha Nagar	51.52
Nagaland	Tuensang	69.20	Arunachal	Upper Subansiri	50.34
Arunachal	Papumpare	67.56	Arunachal	Lower Subansiri	48.65
Manipur	Chandel	66.62	Andhra Pradesh	Rangareddy	48.15
Delhi	North East	62.92	Karnataka	Bengaluru	46.68
Ten districts with lowest decadal growth rates					
Tamil Nadu	Kanniyakumari	4.73	Maharashtra	Ratnagiri	–4.96
Maharashtra	Sindhudurg	4.41	Himachal Pradesh	Lahul & Spiti	–5.10
Tamil Nadu	Theni	4.25	Maharashtra	Mumbai	–5.75
West Bengal	Kolkata	3.93	Nagaland	Zunheboto	–8.79
Uttarakhand	Garhwal	3.91	Delhi	Central	–10.48
Kerala	Pathanamthitta	+3.84	A & N Islands	Nicobars	–12.39
Uttarakhand	Almora	3.67	Nagaland	Mokokchung	–16.77
Assam	Chirang	–0.08	Delhi	New Delhi	–25.35
Delhi	Central	–1.55	Nagaland	Kiphire	–30.54
Mizoram	Mamit	–2.77	Nagaland	Longleng	–58.39

***Source*:** Census of India 2011.

TABLE 10.9. India : Child Population in the age group 0–6 (2011)

India/State/Union Territory	Person	Male	Female	Decadal Change 2001-11	Percentage proportion of child population to total population
INDIA	**15,87,89,287**	**8,29,52,135**	**7,58,37,152**	**–50,48,108**	13.12
Uttar Pradesh	2,97,28,235	1,56,53,175	1,40,75,060	–18,96,393	14.90
Bihar	185,82,229	96,15,286	89,66,949	17,76,166	17.90
Maharashtra	1,28,48,375	68,22,262	60,26,113	–8,22,751	11.43
Madhya Pradesh	1,05,48,295	55,16,957	50,31,338	–2,33,919	14.50
Rajasthan	1,05,04,916	55,80,212	49,24,704	–1,46,086	15.31
West Bengal	1,01,12,599	51,87,264	49,25,335	–13,01,623	11.07
Andhra Pradesh	86,42,686	44,48,330	41,94,356	–15,29,171	10.21
Gujarat	74,94,176	39,74,286	35,19,890	–38,228	12.41
Tamil Nadu	68,94,821	35,42,351	33,52,470	–3,40,339	9.56
Karnataka	68,55,801	35,27,844	33,27,957	–3,26,299	11.21
Jharkhand	52,37,582	26,95,921	25,41,661	2,80,755	15.89
Odisha	50,35,650	26,03,208	24,32,442	–3,23,160	12.00
Assam	45,11,307	23,05,088	22,06,219	13,232	14.47
Chhattisgarh	35,84,028	18,24,987	17,59,041	29,112	14.03
Kerala	33,22,247	16,95,935	16,26,312	–4,70,899	9.95
Haryana	32,97,724	18,02,047	14,95,677	–37,813	13.01
Punjab	29,41,570	15,93,262	13,48,308	–2,30,259	10.62
Jammu & Kashmir	20,08,642	10,80,662	9,27,980	5,22,839	16.01
NCT of Delhi#	19,70,510	10,55,735	9,14,775	–46,339	11.76
Uttarakhand	13,28,844	7,04,769	6,24,075	–31,188	13.14
Himachal Pradesh	7,63,864	4,00,681	3,63,183	–29,273	11.14
Meghalaya	5,55,822	2,82,189	2,73,633	87,843	18.75
Tripura	4,44,055	2 27,354	2,16,701	7,609	12.1
Manipur	3,53,237	1,82,684	1,70,553	26,871	12.98
Nagaland	2,85,981	1,47,111	1,38,870	–3,697	14.44
Arunachal Pradesh	2,02,759	1,03,430	99,329	–3,112	14.66
Mizoram	1,65,536	83,965	81,571	21,802	15.17
Goa	1,39,495	72,669	66,826	–6,473	9.57
Puducherry#	1,27,610	64,932	62,678	10,451	10.25
Chandigarh#	1,17,953	63,187	54,766	2,340	11.18
Sikkim	61,077	31,418	29,659	–17,118	10.05
Dadra & Nagar Haveli#	49,196	25,575	23,621	8,997	14.90
Andaman & Nicobar Islands#	39,497	20,094	19,403	–5,284	10.40
Daman & Diu#	25,880	13,556	12,324	5,302	10.65
Lakshadweep#	7,088	3,715	3,373	–2,003	11.00

***Source*:** Census of India 2011, Provisional Population Totals, Paper 1 of 2011, Series 1, pp. 64-65.

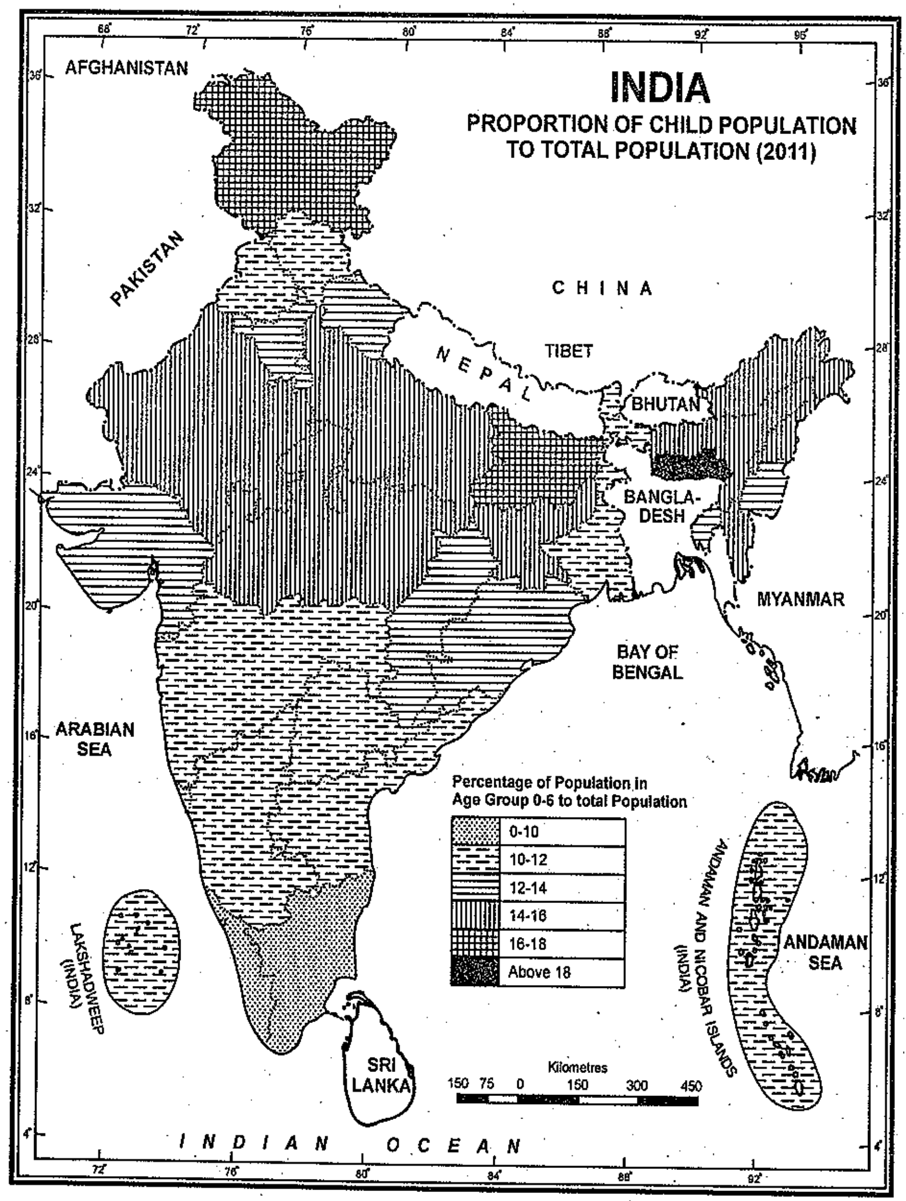

FIG. 10.9. India : Proportion of child population to total population (2011)

It has been found that districts with high growth rates are distributed in almost all parts of the country. However, there is a patch of five districts in Arunachal Pradesh, four in Jammu and Kashmir, three each in Uttar Pradesh and Chhattisgarh that have recorded high growth rates of above 30 per cent. Among ten districts with very high growth rates, Kurung Kumey in Arunachal Pradesh (111.01%),

Yanam in Puducherry (77.15%), Gurgaon in Haryana (73.93%), Daman (67.43%), Dadra and Nagar Haveli (55.50%), Gautam Buddha Nagar in Uttar Pradesh (51.52%) and Upper Subansiri in Arunachal Pradesh (50.34%) are seven districts which have reported more than 50 per cent growth during the decade 2001-2011 (**Table 10.8**).

Growth of Child Population

Child population in the age group 0-6 years has special significance in our demographic scene because this segment of population determines the future course of trends in population growth when it reaches the reproductive age. According to 2011 census figures, the total number of children in the age-group 0-6 years in 158.8 million which is about 5 million less than the number recorded in 2001. Reduction in child population in the age group of 0-6 years is an indication of a fall in fertility rate which is a positive sign. However, the total number of children in India is a little more than the total population of Nigeria—the eighth largest country of the world with respect to population. It is important to note that out of the absolute increase of 181 million in India's population during the decade 2001-2011, 88 per cent has been contributed by the Child Population. Five states namely Uttar Pradesh (29.7 million), Bihar (18.6 million), Maharashtra (12.8 million), Madhya Pradesh (10.5 million) and Rajasthan (10.5 million) have the largest number of children constituting 52% of India's child population. On the other hand, Lakshadweep, Daman & Diu, Andaman and Nicobar Islands, Dadra and Nagar Haveli and Sikkim have least number of children. A comparison of figures of census 2011 with those of census 2001 reveals that the maximum decline in absolute numbers of children has been in Uttar Pradesh. This is followed by Andhra Pradesh, West Bengal, Maharashtra, and Kerala. On the other extreme are the states of Bihar, Jammu and Kashmir, Jharkhand, Meghalaya and Chhattisgarh, where maximum increase in child population has been recorded between 2001 and 2011. As per gender composition of child population, it has been found that decline in females (29,91,976) has been much more as compared to decline in males (20,56,132) during the decade 2001-2011. **Table 10.9** shows that 20 states and union territories have over one million children in the age groups 0-6 years. On the other hand there are five states and union territories that are yet to cross one lakh mark.

DISTRIBUTION AND DENSITY OF POPULATION

One of the most important aspects of India's population is its uneven distribution. On one hand the population of India is highly concentrated in some pockets such as highly urbanized and industrialised areas and areas of high agricultural productivity, while on the other hand there are virtually demographic deserts in high mountains, arid lands, thickly forested areas and some remote corners of the country. Such a situation needs some explanation and the explanation is found, to a great extent, by the study of some geographical factors which affect the distribution and density of population in a given area. Besides some social, demographic, political and historical factors play their own role in influencing the distribution and density of population. It may further be emphasised that these factors act in totality and not individually. While some scholars attach more importance to natural factors, Clarke and Zelinsky are of the view that cultural factors are more prominent in determining the concentration of population in an area. According to Clarke, economic conditions, technological development, social organisation, government policy, etc. play a vital role in the distribution of population. Major factors influencing the distribution and density of population are described as under :

1. Terrain. Terrain of land is a potent factor which influences the concentration and growth of population. Normally speaking, plain areas encourage higher density of population as compared to mountain regions. The steep slopes in mountain areas restrict the availability of land for agriculture, development of transport, industries and other economic activities which may tend to discourage concentration of population and its proper growth. It is because of these adverse circumstances that the Himalayan region, though occupies about 13 per cent of India's land area, supports only 1-2 per cent of the country's population. In contrast to this, the Great Plain of North India is a land of extremely gentle slope and offers great opportunities for the growth of agriculture, transport and industries. This results in higher concentration of population. Although the

Great Plain of North India covers less than one fourth of the country's land area, it is the home to more than half of India's population.

2. Climate. Climate is as important as terrain in influencing population. Of all the climatic factors, twin elements of rainfall and temperature play the most important role in determining the population of an area. Man cannot go beyond the limits set by climate. Extremes of climate discourage the concentration of population. Such climates include the too cold climate of Himalayas, and the too hot and dry climate of the Thar Desert. A moderate climate, on the other hand, is favourable for population.

Of the twin factors of rainfall and temperature, rainfall is more effective in determining the distribution of population. It is generally said that *the population map of India follows its rainfall map*. Rainfall supplies sufficient water for agriculture which is the main occupation of Indian masses. As we move from the Ganga-Brahmaputra Delta in the east towards the Thar Desert in the west, the amount of rainfall and consequently the density of population decreases. However, there are a few exceptions to this general observation. The Assam valley in the north-east and the Circars coast on the Bay of Bengal have moderate density of population although these areas receive heavy rainfall. Similarly, southern face of the Himalayas is scarcely populated though this area receives sufficiently high rainfall. Some of the adverse factors such as steep slope, frequent floods, infertile soils and dense forests counterbalance the positive effect of rainfall. Increased use of irrigation facilities in north-west India comprising Punjab, Haryana and western Uttar Pradesh has resulted in higher concentration of population than normally expected considering the amount of rainfall received by this region.

Since India is a tropical country, temperature is fairly high and does not play as important a role as is done by rainfall except in extreme cases. On high altitudes, in the Himalayan region, climate is too cold beyond 2,000 m and population is sparse there. There is practically no population in areas over 3,000 m above sea level.

3. Soil. Soil is an important factor in determining the density of population in an overwhelmingly agricultural country like India. Fertile soil supports higher population density while infertile soil leads to low density. In the northern plain of India, the soil is regularly enriched by annual floods of the great rivers like the Indus, the Ganga and the Brahmaputra and their tributaries. Therefore, this is an area of high population density. The coastal plains also have fertile soils and are areas of high population density. The Black soil of the Deccan Plateau also supports high population density. On the other hand, desert soils, mountain soils, laterite soils are infertile soils and are not capable of supporting high population densities. However, new technology in the agricultural field may change the future population scenario to some extent.

4. Water Bodies. Availability of water plays a significant role in determining the population of a given area. Water is the basic necessity for several purposes including irrigation, industries, transport and domestic use. Rivers are the greatest source of fresh potable water. Therefore, most of the population is concentrated in the river valleys.

5. Mineral Resources. Minerals act as great source of attraction for people from different areas, which results in higher density of population. The higher population densities in the Chhota Nagpur Plateau of Jharkhand and in the adjoining areas of Odisha are largely due to the availability of minerals.

6. Industries. Industrial growth offers massive employment opportunities and acts as a great magnet to attract people, particularly from the neighbouring areas. This results in higher population density. Industrial areas are almost invariably associated with areas of high population densities. One hectare of industrial land is capable of supporting several thousand persons, while the most fertile area devoted to agriculture may not support more than a few hundred persons per hectare. One of the major causes of high population density in West Bengal, Bihar, Jharkhand, Odisha, Maharashtra and Gujarat is the phenomenal growth of industries in these states.

7. Transport. Growth of population is directly proportional to the development of transport facilities. The northern plain of India has a dense network of transport routes and is a densely populated region. The peninsular plateau has moderate network of transport routes and is moderately populated area.

The Himalayan region badly lacks transport facilities and is sparsely populated.

8. Urbanization. Urbanization and population concentration go hand-in-hand and are closely related to each other. All the urban centres are marked by high density of population. The minimum density, that an area should have to be designated as urban, is 400 persons per sq km. The highly urbanized districts of Kolkata, Chennai, Greater Mumbai, Hyderabad, Delhi and Chandigarh have population densities of over 6,000 persons per sq km. Delhi has the highest population density of 11,297 persons per sq km as per 2011 census figures.

DISTRIBUTION OF POPULATION

The total population of India according to the 2011 census is 1210.2 millions. A casual look at Table 10.10 will reveal that the distribution of India's population is very uneven. The contrasts in population distribution are quite clear at the level of the states, and are further sharpened at the level of districts. These contrasts are due to varying size of the states and wide variations in their resource base. Uttar Pradesh has the largest population of 199.5 millions. This is followed by Maharashtra (112.3 millions), Bihar (103.8 millions). West Bengal (91.3 millions) and Andhra Pradesh including Telangana (84.6 millions). These five states account for about half of the country's population. More than one-fourth of our people live in two-states of U.P. and Maharashtra alone. This, however, does not imply that states with large areas have large population also. For example, Rajasthan is the largest state of India accounting for over 10.4 per cent area of the country. But this state supports only 5.67 per cent population of India. Similarly, Madhya Pradesh, the second largest state in terms of area, has 6.0 per cent of population on 9.38 per cent of area of the country. Contrary to this, Uttar Pradesh supports 16.49 per cent of population on only 7.33 percent of area of the country. In fact, U.P. has more people than the two largest states of Rajasthan and Madhya Pradesh. The three southern states of Kerala, Karnataka and Tamil Nadu together have less population than Uttar Pradesh. Bihar has 9.29 per cent of population on 9.86 per cent of area. In all, in eleven states and six union territories population size is much larger in comparison to the areas. This means that these states have higher pressure of population than the national average. On the other hand, Jammu and Kashmir covers 6.76 per cent area but supports only 1 per cent population of India. Arunachal Pradesh has 0.11 per cent of population on 2.55 per cent of area. Sikkim, a Himalayan mini-state has only 6 lakh population which is only 0.05 per cent of the total population of India. In fact, Sikkim has the smallest population among all the states of India. Delhi with 16.75 million has the largest population among all the union territories. It is a matter of fact that more people live in Delhi than in the state of Jammu and Kashmir or in all the Union Territories put together.

Causes of Uneven Distribution of Population

The uneven distribution of population described above is the result of several factors of which physical, socio-economic and historical factors are more important.

(i) Physical Factors. Among the physical factors, relief, climate and availability of water are the chief factors which determine the population of an area. It is because of these factors that the North Indian Plains, deltas and coastal plains have higher proportion of population than the interior districts of southern and central Indian states, the Himalayas, some of the north eastern and the western states. However, development of irrigation facilities by Indira Gandhi Canal in Rajasthan, rich deposits of mineral and energy resources in Chotanagpur plateau of Jharkhand have resulted in moderate to high proportion of population in these areas which were previously very thinly populated (**Fig. 10.10**).

(ii) Socio-economic and Historical Factors. Evolution of settled agriculture and agricultural development; pattern of human settlement; development of transport network, industrialisation and urbanisation are some of the important socio-economic and historical factors which influence the distribution of population. Generally speaking river plains and coastal areas have larger concentration of population due to early history of human settlement and development of transport network. Urban areas like Delhi, Mumbai, Kolkata, Bengaluru, Pune, Ahmedabad, Chennai and Jaipur have high

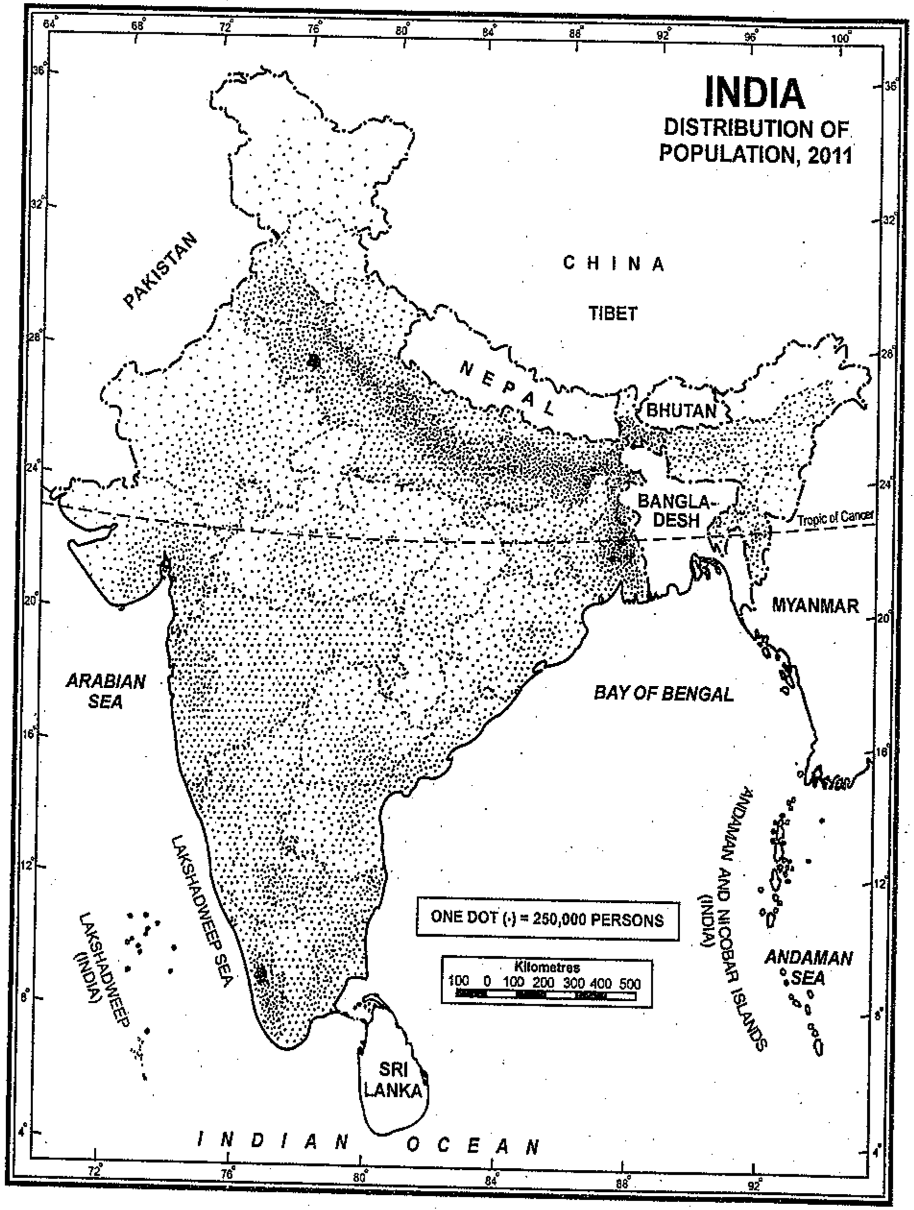

FIG. 10.10. India : Distribution of population, 2011

TABLE 10.10. Ranking of States and Union Territories by Population : 2001 and 2011

Rank in 2011	India/State/Union Territory	Population 2011	Percent to total population of India		Rank in 2001
			2011	2001	
	India	**1,21,01,93,422**	**100.00**	**100.00**	
1	Uttar Pradesh	19,95,81,477	16.49	16.16	1
2	Maharashtra	11,23,72,972	9.29	9.42	2
3	Bihar	10,38,04,637	8.58	8.07	3
4	West Bengal	9,13,47,736	7.55	7.79	4
5	Andhra Pradesh (including Telangana)	8,46,65,533	7.00	7.41	5
6	Madhya Pradesh	7,25,97,565	6.00	5.87	7
7	Tamil Nadu	7,21,38,958	5.96	6.07	6
8	Rajasthan	6,86,21,012	5.67	5.49	8
9	Karnataka	6,11,30,704	5.05	5.14	9
10	Gujarat	6,03,83,628	4.99	4.93	10
11	Odisha	4,19,47,358	3.47	3.58	11
12	Kerala	3,33,87,677	2.76	3.10	12
13	Jharkhand	3,29,66,238	2.72	2.62	13
14	Assam	3,11,69,272	2.58	2.59	14
15	Punjab	2,77,04,236	2.29	2.37	15
16	Chhattisgarh	2,55,40,196	2.11	2.03	17
17	Haryana	2,53,53,081	2.09	2.06	16
18	NCT of Delhi#	1,67,53,235	1.38	1.35	18
19	Jammu & Kashmir	1,25,48,926	1.04	0.99	19
20	Uttarakhand	1,01,16,752	0.84	0.83	20
21	Himachal Pradesh	68,56,509	0.57	0.59	21
22	Tripura	36,71,032	0.30	0.31	22
23	Meghalaya	29,64,007	0.24	0.23	23
24	Manipur	27,21,756	0.22	0.22	24
25	Nagaland	19,80,602	0.16	0.19	25
26	Goa	14,57,723	0.12	0.13	26
27	Arunachal Pradesh	13,82,611	0.11	0.11	27
28	Puducherry#	12,44,464	0.10	0.09	28
29	Mizoram	10,91,014	0.09	0.09	30
30	Chandigarh#	10,54,686	0.09	0.09	29
31	Sikkim	6,07,688	0.05	0.05	31
32	Andaman & Nicobar Islands#	3,79,944	0.03	0.03	32
33	Dadra & Nagar Haveli#	3,42,853	0.03	0.02	33
34	Daman & Diu#	2,42,911	0.02	0.02	34
35	Lakshadweep#	64,429	0.01	0.01	35

Union Territory

Source : Census of India, 2011 : Provision Population Totals, Paper 1, p. 47.

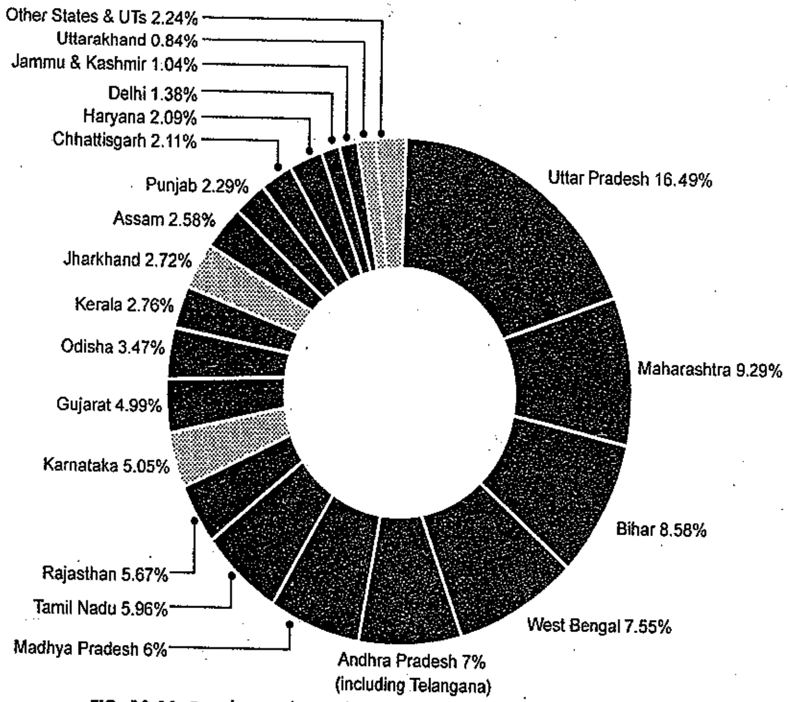

FIG. 10.11. Population Share of States and Union Territories, India: 2011.

concentration of population due to high level of industrialisation and urbanisation. People in large numbers migrate from rural to urban areas.

DENSITY OF POPULATION

Density of population is a better measure of understanding the variation in the distribution of population. It is expressed as number of persons per unit area. In other words, it is the ratio of total population to the total area of the country or a part thereof. For example the total population of India according to 2011 census is 1210.1 million living on a total area of 3.17 million square kilometres (excluding the area of Jammu and Kashmir illegally occupied by Pakistan and China). Therefore, the density of population of India in 2011 is :

$$\frac{\text{Totgal population}}{\text{Total area}} = \frac{1210.1}{3.17} = 382 \text{ persons per sq. km)}$$

India's population density of 382 persons per sq. km is much higher than China's 141 persons per sq. km. Among the most populous ten countries of the

TABLE 10.11. Density of Population, India : 1901-2011

Census Year	Density (per sq km)	Absolute Increase	%age Increase
1	2	3	4
1901	77		
1911	82	5	6.5
1921	81	–1	–1.2
1931	90	9	11.1
1941	103	13	14.4
1951	117	14	13.6
1961	142	25	21.4
1971	177	35	24.6
1981	216	39	22
1991	267	51	23.6
2001	325	58	21.7
2011	382	57	17.5

Source : Census of India 2011, Provisional Population Totals, Paper 1 of 2011 Series 1, p. 138.

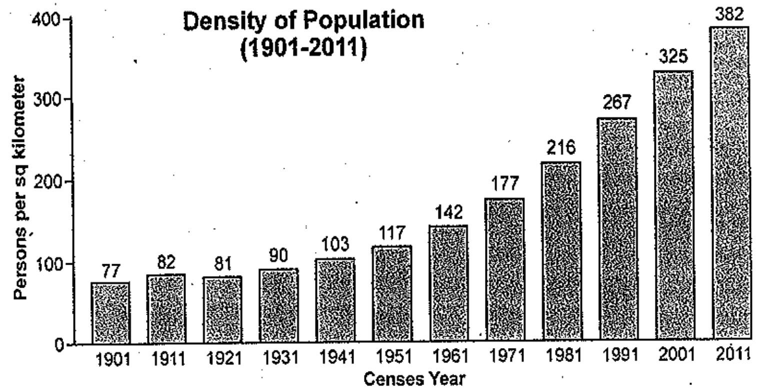

FIG. 10.12. India : Density of population (1901-2011)

world, India stands second in density; the first being Bangladesh (1141 persons per sq km). Thus heavy pressure of population on land is one of the serious problems of the country. The main cause of worry is that the population density in India has been consistently increasing since 1921 (Table 10.11). There has been almost five fold increase in the density of population between 1921 and 2011. The density of population increased rapidly between 1951 and 2011.

It is clear from **table 10.11** and **Figure 10.12** that density of population in India is very high and is increasing at a very fast rate. During the decade 2001-11 alone, India's population density increased by 57 persons per sq km which means each sq km of land has to feed 57 new mouths. This is a matter of great concern as it puts immense pressure on our natural resources. This increase is nearly double the existing density of the USA (30 persons/sq km), seven times the existing density of Russia (8 persons/sq km) and a more than one-third the existing density of China (141 persons/sq km). Hence among the large sized countries of the world, India is not only the most densely populated but is also adding to its density at an alarming rate.

State Level Patterns

Table 10.12 shows that there are large scale variations in the population density from one state/union territory to another. These variations are depicted in **Figure 10.13.**

Table 10.12 shows that the national average of 382 persons per sq km does not give a clear idea of nature of unevenness of population density as it varies from a minimum of 17 persons per sq km in Arunachal Pradesh to a maximum of 1102 persons per sq km in Bihar. Among the union territories, Delhi is the most thickly populated with 11,297 persons per sq km, while Andaman and Nicobar Islands have the lowest density of only 46 persons per sq km.

For the sake of convenience, the spatial distribution of population density is classified into following categories :

1. Areas of Extremely Low Density. Areas having 100 persons per sq km and less than that are included in this class. They include Arunachal Pradesh (17), Mizoram (52), Andaman and Nicobar Islands (46) and Sikkim (86). Arunachal Pradesh and Mizoram are located in a remote and inaccessible part of north-east India. Sikkim is also a mountainous area with low density of population. Andaman and Nicobar Islands are situated far away from the Indian mainland. Hot and humid climate of these islands is injurious to health and very little economic development has taken place here.

2. Areas of Low Density. Areas having population density of 101 to 250 persons per sq km are included in this class. These states are Nagaland (119), Manipur (122), Himachal Pradesh (123), Jammu and Kashmir (124), Meghalaya (132), Chhattisgarh (189), Uttarakhand (189), Rajasthan 201) and Madhya Pradesh (236). Meghalaya, Manipur, and Nagaland are hilly, forested and dissected areas of north-east India. These areas suffer

TABLE 10.12. Ranking of States and Union Territories by density : 2011 and 2001

Rank in 2011	State/Union Territory	Density (per sq km) 2011	Density (per sq km) 2001	Rank in 2001
1	2	3	4	5
	India	382	325	
1	NCT of Delhi	11,297	9,340	1
2	Chandigarh	9,252	7,900	2
3	Puducherry	2,598	2,034	3
4	Daman & Diu	2,169	1,413	5
5	Lakshadweep	2,013	1,895	4
6	Bihar	1,102	881	7
7	West Bengal	1,029	903	6
8	Kerala	859	819	8
9	Uttar Pradesh	828	690	9
10	Dadra & N. Haveli	698	449	13
11	Haryana	573	478	12
12	Tamil Nadu	555	480	11
13	Punjab	550	484	10
14	Jharkhand	414	338	16
15	Assam	397	340	15
16	Goa	394	364	14
17	Maharashtra	365	315	17
18	Tripura	350	305	18
19	Karnataka	319	276	20
20	Andhra Pradesh (+ Telangana)	308	277	19
21	Gujarat	308	258	21
22	Odisha	269	236	22
23	Madhya Pradesh	236	196	23
24	Rajasthan	201	165	24
25	Uttarakhand	189	159	25
26	Chhattisgarh	189	154	26
27	Meghalaya	132	103	29
28	Jammu & Kashmir	124	100	31
29	Himachal Pradesh	123	109	28
30	Manipur	122	103	30
31	Nagaland	119	120	27
32	Sikkim	86	76	32
33	Mizoram	52	42	34
34	Andaman & Nicobar Islands	46	43	33
35	Arunachal Pradesh	17	13	35

***Source*:** Census of India, 2011; Provisional Population Totals, Paper 1, p. 140.

from almost the same problems as those of Arunachal Pradesh and Mizoram, although to a lesser extent. Himachal Pradesh and Uttarakhand are parts of the north-western Himalayan region and have very little level land to support high population density. Jammu and Kashmir has vast areas devoid of population. Only some parts of Jammu region and Kashmir valley are thickly populated. Large stretches of Leh (Ladakh) and Kargil have population density less than ten persons per sq km. On the whole Kargil has population density of 10 persons/sq km while Leh (Ladakh) has only 3 persons per sq km. These are dry and cold areas and badly lack the basic amenities of life. Rajasthan is the largest state of India. There are obviously large variations in the density of population in different parts of the state depending upon the local conditions. Most of Rajasthan is a sandy desert lacking in water resources and does not support high population density. Western part of the state is having even less than 50 persons per sq km whereas eastern and north-eastern parts of this state have sufficient resources and have comparatively high density of population. Madhya Pradesh is a part of the Deccan Plateau and is having rugged topography of hard rocks. Like Madhya Pradesh, Chhattisgarh has rugged topography, is thickly forested and is largely inhabited by the tribal people. As such, the population density in this state also is low.

3. Areas of Moderate Density. This class includes those areas which are having 251 to 500 persons per sq km. The average for whole of India (382 persons per sq km) also falls in this class. Odisha (269), Gujarat (308), Andhra Pradesh including Telangana (308), Karnataka (319), Tripura (350), Maharashtra (365), Goa (394), Assam (397), and Jharkhand (414) are included in this category. These areas are wide apart from one another and there are different reasons for moderate density of population in different areas. For example, Assam has tea estates whereas Andhra Pradesh, Telangana, Odisha, Karnataka and Jharkhand have agricultural and mineral resources. Maharashtra is highly urbanised and industrialised state. The neighbouring state of Gujarat also has urban and industrial growth, although at a scale smaller than that of Maharashtra. Among the north-eastern states, Tripura has sufficient level land which supports moderate population density.

4. Areas of High Density. These are areas having population density of 501 to 1000 per sq km. States and union territories included in this category are Punjab (550), Tamil Nadu (555), Haryana (573), Dadra & Nagar Haveli (698), Uttar Pradesh (828) and Kerala (859). Punjab and Haryana have highly developed agriculture based on heavy inputs in the form of high yielding varieties of seeds, chemical

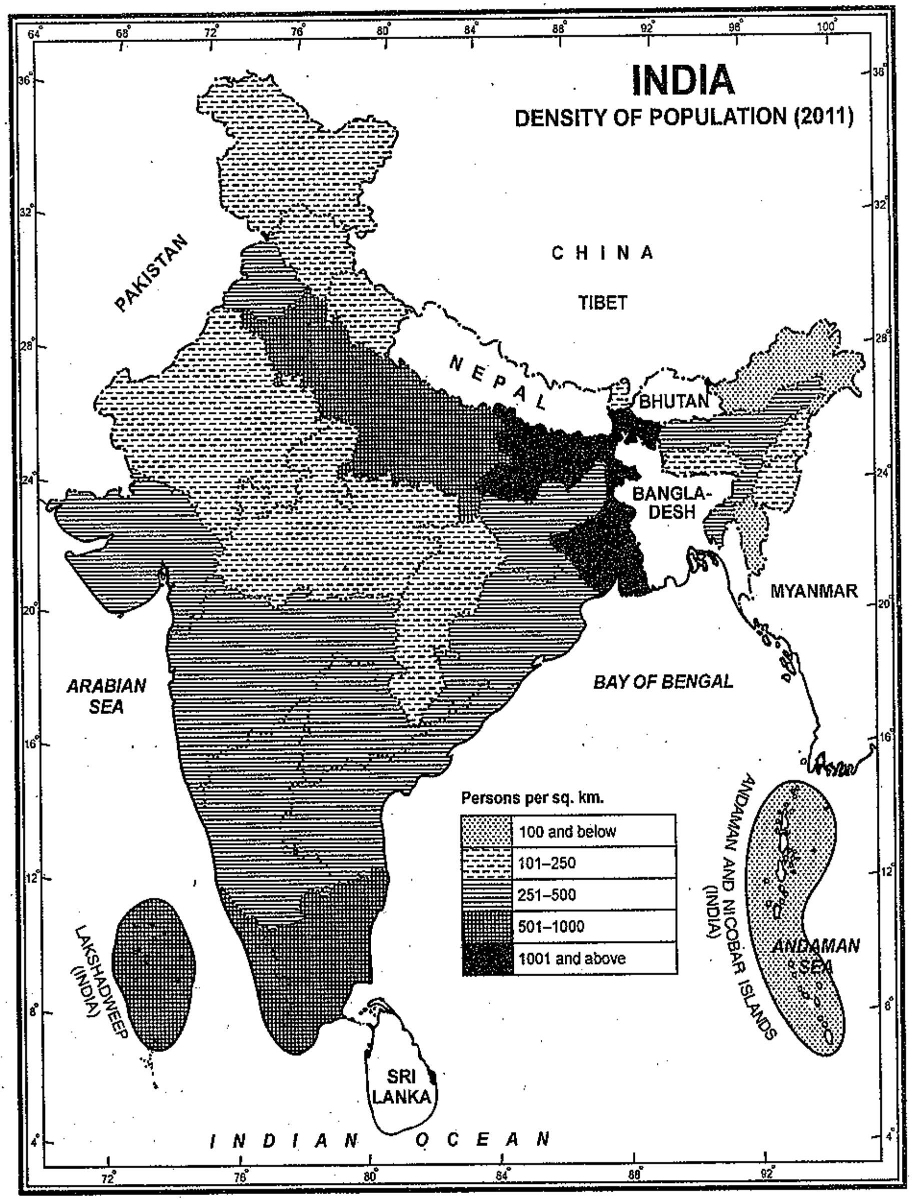

FIG. 10.13. India: Density of Population 2011.

fertilizers and canal and tube-well irrigation. Similarly, Tamil Nadu's population is based on agriculture and industries. The coastal plain of Kerala is also very fertile. However, Kerala has started showing decline in the growth rate of population. Uttar Pradesh is located in the fertile Ganga Plain and supports high population density.

5. Areas of Very High Density. Areas having more than 1000 persons per sq km are termed as areas of very high population density. West Bengal (1029), Bihar (1102), Lakshadweep (2013), Daman & Diu (2169) Puducherry (2548), Chandigarh (9252) and Delhi (11,297) have very high density of population due to different factors operating in different areas. Like Uttar Pradesh, Bihar is located in the fertile plain of Ganga and supports very high population density. It seems that measures to control for population growth have not given the desired results and Bihar has now surpassed West Bengal as the state with highest density of population among the major states. West Bengal is located in the Ganga delta which is one of the most fertile areas of the world, producing 3-4 crops of rice in a year. In addition, India's biggest industrial cluster is located in the Hugli basin. These factors combine together to make West Bengal the second most densely populated state of India. Among the union territories, Delhi has experienced one of the fastest population growths as a result of which its population density has increased considerably. This growth is primarily due to large scale migration of people from the surrounding areas. People migrate to Delhi in large numbers in search of livelihood, and better amenities of life.

District Level Patterns

States are often too large in area to give a realistic picture of population density. Some states with low density of population have very high density districts. The *vice versa* is also true. The range in district level densities is very wide. The highest density of 37,346 persons per sq km is in Northeast Delhi district and lowest is only one person per sq km in Dibang valley of Arunachal Pradesh. **Table 10.13** gives the distribution of density for all the 640 districts in India for 2001 and 2011. This table shows that the number of districts with higher population densities has increased while those with lower densities has decreased. **Table 10.14** gives details of ten districts with highest density and another ten districts with lowest densities.

TABLE 10.13. Distribution of districts according to population density 2001 and 2011

Population density	Number of districts	
	2001	2011
2000 and Above	22	28
1000-1999	38	71
500-999	149	145
250-499	178	186
100-249	183	150
Below 100	70	60
Total	640	640

Source : Census of India 2011, Series 1, India, *Provisional Population Totals*, Paper 1 of 2011. Districtwise density data for 2011 obtained from census website <censusindia.gov.in>.

The belt comprising districts with densities above the national density of 382 persons per sq km starts from the plains of Punjab, runs through the Ganga-Yamuna plains, the middle and lower reaches and delta of the Ganga system, winds through the eastern coast to Kanniyakumari traversing the deltas of Mahanadi, the Godavari, the Krishna, the Kaveri and other rivers and finally turns north along the western coastal districts, especially in Kerala. In contrast, districts in north- east, especially those in Arunachal Pradesh, Manipur, and Mizoram; and a few from Himachal Pradesh, Jammu and Kashmir, Uttarakhand; and arid districts of Rajasthan have recorded very low densities.

Population Problems

As mentioned earlier, India is the second most populous country of the world, next only to China. Obviously India is facing serious problems regarding population and there are spatial and temporal variations in these problems. Perhaps the most serious problems being faced by India today are in connection with her people. Some of the major population problems are briefly described as under :

1. Rapid Growth of Population. In spite of several steps taken by the government, population of India is growing at a rapid pace. India's population was just 36.1 crores at the time of first census (1951)

TABLE 10.14. Ten districts with highest density per sq. km. in 2001 and 2011 respectively and ten districts with lowest density per sq. km. in 2001 and 2011 respectively

State	District	Density	State	District	Density
Ten districts with highest density, 2011			**Ten districts with highest density, 2001**		
Delhi	North East	37,346	Delhi	North East	29,468
Tamil Nadu	Chennai	26,903	Delhi	Central	25,855
Delhi	East	26,683	Tamil Nadu	Chennai	24,963
West Bengal	Kolkata	24,252	West Bengal	Kolkata	24,718
Delhi	Central	23,147	Delhi	East	22,868
Maharashtra	Mumbai (Suburban)	20,925	Maharashtra	Mumbai	21,261
Maharashtra	Mumbai	20,038	Maharashtra	Mumbai (Suburban)	19,373
Delhi	West	19,625	Telangana	Hyderabad	17,649
Telangana	Hyderabad	18,480	Delhi	West	16,503
Delhi	North	14,973	Delhi	North	13,246
Ten districts with lowest density, 2011			**Ten districts with lowest density, 2001**		
Himachal Pradesh	Kinnaur	13	Arunachal Pradesh	West Kameng	10
Arunachal Pradesh	Upper Subansiri	12	Sikkim	North	10
Arunachal Pradesh	West Kameng	12	Jammu & Kashmir	Kargil	9
Sikkim	North	11	Arunachal Pradesh	Upper Subansiri	8
Jammu & Kashmir	Kargil	10	Arunachal Pradesh	Kurung Kumey	7
Arunachal Pradesh	Upper Siang	5	Arunachal Pradesh	Upper Siang	5
Arunachal Pradesh	Anjaw	3	Arunachal Pradesh	Anjaw	3
Jammu & Kashmir	Leh	3	Jammu & Kasahmir	Leh	3
Himachal Pradesh	Lahul & Spiti	2	Himachal Pradesh	Lahul & Spiti	2
Arunachal Pradesh	Dibang Valley	1	Arunachal Pradesh	Dibang Valley	1

Source : Census of India 2011.

after Independence which rose to over 121 crores in 2011. Thus our population has increased more than three fold in a short span of half a century. During the last century, the world population grew by three times while India's population grew by four times. Although the growth rate of our population has come down from 24.8 per cent in 1961-71 to 17.64 per cent in 2001-11, it is still vary high as compared to world average growth rate of 12.3 per cent and is much higher than 5.3 per cent of the most populous country of the world—China. During 2001-11 India's population increased by 181.4 millions against China's 79.7 millions. At this rate our population is likely to exceed the population of China in 2028. The population growth was so high during 1951-81 that it is often referred to as ***'population explosion'***.

2. Uneven distribution of Population. One of the most striking features of India's population is its uneven distribution. On one hand, there are almost empty lands like Arunachal Pradesh where population density is only 17 persons per sq km and large tracts of the Himalayas have less than five persons per sq km. On the other hand Bihar's one sq km has to support as many as 1102 persons per sq km on an economy which is heavily dependent on agriculture. Urbanized union territories like Chandigarh and Delhi have unmanageable densities of 9,252 and 11,297 persons per sq km.

Rapid growth and uneven distribution of population have put enormous pressure on our scarce natural resources to varying degrees in different parts of the country. Main problems arising out of such a situation are unemployment, poverty, hunger, malnutrition, environmental degradation and lower standard of living. These problems will be discussed in the following paragraphs.

3. Unemployment. In view of rapidly growing population and limited resources, the employment seekers far outnumber and outpack the growth of employment opportunities. Indian economy is heavily dependent on agriculture which the largest employment provider in the country. At present 68.84 per cent of India's population is living in rural areas which solely depends on agriculture for its livelihood. More than 58% of the population of the country earns its livelihood from agriculture. But in spite of heavy inputs in agriculture in the form of high yielding variety of seeds, chemical fertilizers and machines, agricultural progress has failed to keep pace with the growing demand for employment due to fast increasing population. Moreover, agriculture is a seasonal activity in which labour is required only during the sowing and harvesting seasons and the agricultural labourers are without employment for about six months in a year. The secondary and tertiary sectors have also not grown in proportion to demand for employment. As such, the employment opportunities for unskilled, semi-skilled, and skilled people are very limited. Even the educated and professional technocrats are finding it difficult to get a suitable jobs and they have a tendency to migrate to developed countries resulting in a serious crisis of **brain drain.** According to official figures there are more than forty million unemployed youths in India and their number is fast growing. This situation of unemployed youth is very dangerous because the younger people are more liable to be involved in anti-social activities like theft, cheating, drugs, murder, rape, etc.

4. Hunger and Malnutrition. Situation of hunger and malnutrition arises when the population growth outpaces the growth of foodgrains and food items become so costly to be out of reach of the common man. The Global Hunger Index (GHI) released in 2012 showed that India's ranking was a miserable 65 out of 79 countries and this is termed as alarming situation. Table 10.15 shows that many of India's neighbours have done better in tackling issues of hunger and malnutrition.

TABLE 10.15. Global Hunger Index (GHI) of India as compared to Pakistan and China

Country	1990	1996	2001	2012
India	30.3	22.6	24.2	22.9
Pakistan	25.5	21.8	21.7	19.7
China	11.8	8.9	6.6	5.1

Note : Higher the Global Hunger Index, more serious is the problem of hunger.

Source **:** International Food Policy Research Institute (2012).

Although India's rating has improved from 30.3 in 1990 to 24.2 in 2001 and 22.9 in 2012, it is still very high as compared to other countries. It is estimated that nearly 870 million people across the globe go hungry each day and a fourth of them—more than 200 million—live in India. With a rank of 66 out of 88 nations on the global hunger index, we were only slightly better than Bangladesh (68) and worse off than Pakistan (57), China (2) and even certain African countries. The report analysed three indices—under nourishment in the population, under five mortality and underweight children under-five. India's record with respect to all three indices is dismal. It has been reported that 19% is the proportion of under-nourished population (2006-08), 6.3% is the under-five mortality rate (2010) and 43.5% is the prevalence of underweight in children under 5 years (2005-10). In 2011 around 50% of global under-5 deaths occurred in just five countries and India held the top position. India reported 16.55 lakh deaths in contrast to Nigeria (7.56 lakh), Democratic Republic of Congo (4.65 lakhs) Pakistan (3.52 lakhs) and China (2.49 lakhs).

Among the Indian states, Madhya Pradesh is the worst sufferer so far as hunger is concerned (**Fig. 10.14**). Many other states of India are as bad as some of the poorest countries of the world (**Table 10.16**).

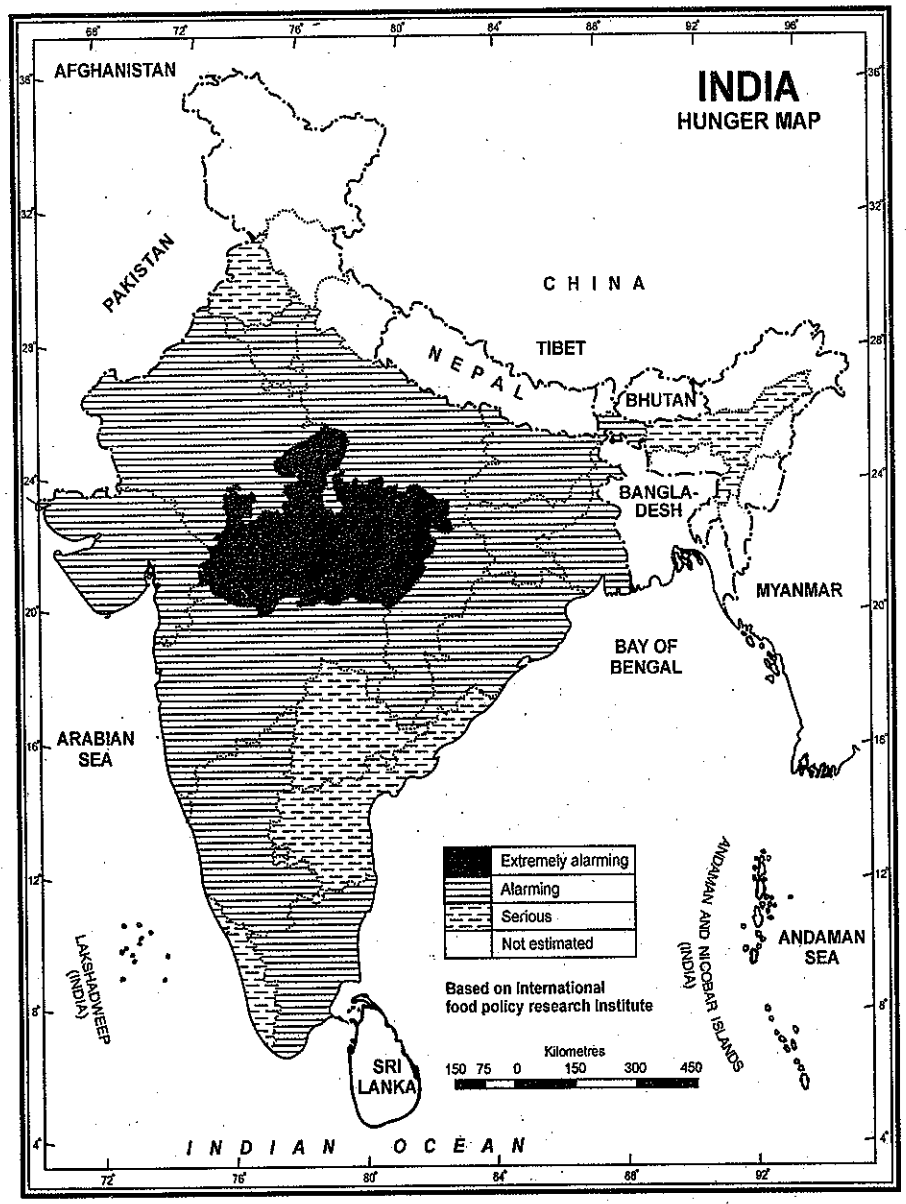

FIG. 10.14 : India : Hunger Map

5. Poverty. Poverty is another serious population problem, but million dollar question is "who is a poor Indian". Different criteria have been followed by different committees and the number of families living below poverty line have varied widely from each other. For example in 2010 Wadhwa Committee

TABLE 10.16. Hunger levels in seven major states of India along with their nearest world equivalents

1.	Madhya Pradesh 30.85 = Ethiopia
2.	Bihar 27.30 = Yemen
3.	Gujarat 24.70 = Bangladesh
4.	Maharashtra 22.80 = Djibouti
5.	Assam 19.83 = Mali
6.	Kerala 17.63 = Senegal
7.	Punjab 13.63 = Philippines

Note : (*i*) Higher score reflects higher hunger levels.
(*ii*) For states versus world, closest approximation is used.

Source : India State Hunger Index 2008 and Global Hunger Index 2008.

Some glaring facts about hunger in India (as per International Food Policy Research Institute)

- 20 per cent is the prevalence of caloric undernourishment in India.
- 25 is the number of Sub-saharan countries better off than India in terms of food security. We are worse off than even Pakistan.
- 4 African nations—Nigeria, Cameroon, Kenya and Sudan—have far lower per capita income than India but manage hunger better.
- 410 million is the number of people who are poor and food insecure in just 8 Indian states—more than many sub-Sarahan countries (according to an Oxford University report).
- There is not even a single state in India with low or even moderate levels of hunger.
- **Punjab** the food bowl of India, India's best performing state, falls in serious category (Fig. 10.14) and ranks behind Vietnam and Saudi Arabia.
- Madhya Pradesh, India's worst state, besides Gujarat, Chhattisgarh and Haryana are worse off than Sudan.
- Bihar and Jharkhand rank lower than Zimbabwe and Haiti.

put BPL (Below Poverty Line) families at 20 crores, while State Government estimated 10.5 crore. Tendulkar Committee at 9.25 crores and World Bank at 7.5 crore BPL families in India. However, general parameters for determining poverty status are agreed upon by majority of investigators (see box below).

STUDY PARAMETERS

Who were automatically counted as poor :

- Households without shelter
- Destitute or beggars
- Manual scavengers
- Primitive tribal groups
- Legally released bonded labour

Depreciation indicators

- Households with one room having kucha walls and roof.
- No adult member between 16 and 59 years of age.
- Female-headed household with no adult male between 16 and 59 years of age.
- No able-bodied adult member and no literate member above 25 years of age.
- Scheduled caste, scheduled tribe and landless households.

The Planning Commission estimates poverty using data collected by National Sample Survey Office (NSSO) every five years and defines poverty line on the bases of monthly per capita consumption expenditure (MPCE). The expert group headed by Prof. Suresh D. Tendulkar submitted its report in December 2009. This report computed the poverty line at all India level as MPCE of ₹ 447 for rural and ₹ 579 for urban areas in 2004-05. This survey was again conducted in 2009-10 and accordingly the poverty lines were decided at all India level as an MPCE of ₹ 673 for rural and ₹ 860 for urban areas in 2009-10. Based on these cut off, the percentage of people living below poverty line in the country has declined from 37.2 per cent in 2004-05 to 29.8 per cent in 2009-10. Even in absolute terms, the number of poor people has fallen by 52.4 million during this period. Of this 48.1 million are rural poor and 4.3 million are urban poor. Thus poverty has declined on an average by 1.5 percentage points per year between 2004-05 and 2009-10. The annual average rate of decline during the period 2004-05 to 2009-10 is thrice the rate of decline during the period 1993-94 to 2004-05. However **table 10.17** shows that even with changes in NSSO surveys and criteria for fixing the level of families below poverty line as many as 269.3 million or 21.9 per cent of India's population is living below poverty line which is unable to have enough food to eat and enjoy even the basic necessities of life. This section of population lives under conditions of serious deprivation.

TABLE 10.17. Number and Percentage of Poor

	Rural	Urban	Total
Poverty ratio (per cent)			
2004-05	41.8	25.7	37.2
2011-12	25.7	13.7	21.9
Number of poor (million)			
2004-05	326.3	80.8	407.1
2011-12	216.5	52.8	269.3
Annual averge decline 2004-05 to 2011-12 (percentage points per annum)	2.32	1.69	2.18

Source : Economic Survey 2013-14, p. 233.

The BJP led government at the centre, in July 2014, declared that those spending ₹ 32 in rural areas and ₹ 47 in urban areas should not be considered poor. This means that 29.5% of the Indian population lives below poverty according to a report by Rangarajan Committee. According to the Millennium Development Goals (MDG) report released in July 2014, about 32.9 per cent of the world's poorest surviving on less than ₹ 80 ($1.25) a day live in India. As against this 12.8% of the world's poorest live in China. That country leads the way in global poverty reduction, with extreme poverty dropping from 60% in 1990 to 16% in 2005 and 12.8% in 2014. Some other countries with a sizeable percentage of poor people are Nigeria (8.9%), Bangladesh (5.3%, and Congo Democratic Republic (4.6%). The remaining 35.5% of the poor people live in the rest of the world.

6. Low Agricultural Productivity. In most parts of India, agriculture is tradition bound and is of subsistence type in which the entire agriculture produce is consumed by the family members of the farmer. A large percentage of farmers are poor and cannot afford costly inputs like agricultural machines, high yielding seeds, and chemical fertilizers etc. Moreover land tenancy, small and fragmented fields also create hindrances in agricultural growth. For the last so many years the annual rate of agricultural growth has been very slow and is not able to meet the growing demand of teeming millions. Further agricultural sector has failed to provide suitable employment opportunities to growing number of rural youth.

7. Slow Growth of Industries. Although industrial sector has grown faster than agricultural sector, yet this sector is unable to provide sufficient employment to our young population, particularly to those who migrate from rural to urban areas. The basic problem is that the labour which migrates from rural to urban areas largely consists of unskilled workers for whom there is little scope in the industrial sector. Financial constraints and lack of proper infrastructure are also great hindrances in industrial growth. A high percentage of Indian population consists of poor people and there is lack of proper market for industrial products.

8. Frequent Strikes and Bandhs. The fast growing population has resulted in underemployment, unemployment, hunger, malnutrition, poverty, deprivation and lack of basic necessities of life and has led to overall frustration, particularly among the youngsters and they become indisciplined. Consequently, there are frequent strikes in different spheres of life and industrial sector is the worst sufferer. This reduces the overall productivity of the people.

9. Religion, Tradition and Orthodoxy. Indian population is primarily religious minded society and followers of almost all religious can be found in this country. Some of the religions do not believe in family planning practice. This leads to unchecked growth of population which has its own implications. Further, Indian society is tradition-bound and this is more true of rural society. Orthodoxy and ignorance are their major social aspects of Indian population. All these traits are major obstacles in the way to adopt new technology and innovative ideas. Hence masses are still in a backward state and lead miserable life. In order to overcome these obstacles, large scale literacy and education campaign is necessary.

10. Terrorism and insurgency. India's socio-economic system has undergone drastic changes during the last few decades and economic disparities have increased tremendously. In the existing socio-economic scenario, a few people have become very rich while a large proportion of population is living a life of misery and deprivation. The youthful section of society becomes frustration in the absence of opportunities to earn a livelihood and the youngsters resort to anti-social activities like thefts, robberies, kidnapping, extortion, murder, etc. Some of them go to the extent of resorting to terrorism and insurgency. There are many terrorist groups operating in different parts of the country and the frequency as well intensity of terrorist attacks is increasing with the passage of time. A lot of insurgency is taking place in the peripheral states, particularly in the north-eastern states.

11. Environmental Degradation. Growing pressure of population on natural resources is leading to depletion of these resources and at the same time it has several problems regarding environment and ecology. Large scale destruction of forests for forest products and for making land available for other uses has resulted in drastic ecological imbalance. Shifting agriculture, known as Jhum culture, in the north-eastern stages is the main cause of forest destruction there, because the duration of completing the Jhum cycle has been reduced due to increase in demand for agricultural crops caused by growth in population. Over irrigation in Punjab, Haryana and western parts of Uttar Pradesh has caused large scale depletion of ground water and increase in salinity and alkalinity in soil over vast areas. Air and water in (both surface and ground) have been polluted over large tracts in different parts of the country. Noise pollution has become a serious problem in large cities of India. Environmental pollution leads to ill health and cause several diseases which put undue pressure on health services.

12. Pressure on infrastructure and low standard of living. Rapidly growing population puts undue pressure an infrastructure,. Educational institutes, hospitals, transport system always remain over crowded and there is acute shortage of housing amenities. Supply of drinking water and electricity is almost invariably erratic and condition of roads and streets is pathetic. Overall deprivation leads to social tensions, and the number of people involved in anti-social activities is increasing with each passing day. Thus the overall standard of living of the masses is very low and people are deprived of even the basic amenities.

Measures to Solve Population Problems

1. Rapid growth of population in India is the main problem concerning population of the country and all other problems are the off-shoots of this basic problem. If population growth is checked, all other problems will be automatically solved. Following few steps are suggested to solve this problem.

(*i*) People should be persuaded to adopt family planning methods and opt for small families.

(*ii*) Incentives should be given to those couples who opt for small families.

(*iii*) There should be a complete ban on child marriage and minimum age for marriage (18 years for girls and 21 years for boys) should be strictly followed and violators should be given severe punishment. System of child marriage is more prevalent in the rural areas and rural masses should be educated about the ill effects of child marriage.

(*iv*) There is close correlation between infant mortality and birth rate. Unfortunately both are high in India which adversely affect the family planning programmes. There is urgent need to bring these rates down considerably.

(*v*) Illiteracy and high birth rate go hand in hand together and high birth rate leads to high growth rate of population. Although literacy rate has increased considerably during the last few decades still more than 35 per cent of India's population is illiterate. This section of society generally fails to understand in significance of population control and the population increases unchecked. It is often said that "*education is the best contraceptive.*" Thus spread of education can be a great instrument in controlling the population growth.

(*vi*) As mentioned earlier, a large section of our population is suffering from hunger and malnutrition. This makes us a nation of unhealthy people who are unable to make much contribution to economic growth. Proper arrangements should be made to feed these teeming millions so that the nation moves faster on the path of economic growth. It is hoped that the food security bill passed by the Parliament in 2013 will go a long way to eradicate hunger and malnutrition from our country.

(*vii*) A section of our population, particularly in the rural areas, sufferer from the sense of social insecurity and a very high percentage of Indian parents cpt for larger number of children who could look after them in their old age. Such a thinking has to be washed away by providing some measure of social security to this section of society.

The other methods to solve our population problems are briefly discussed below.

2. Special attentions should be paid to agriculture for solving the food problem. Incentives should be given for larger used of agricultural inputs like high yielding varieties of seeds, fertilizers and farm mechanisation. From 1960s onwards, Green Revolution has been helping India to solve her food problem. But in the post Green Revolution era, growth of population outpaced the growth of food grains and India is again finding it difficult to provide proper food to her masses. We are looking forward to see the positive results of the Second Green Revolution.

3. Unproductive lands such as waste land, barren lands should be improved by providing proper inputs and should be brought under plough.

4. Different types of natural resources such as minerals, soils, water, natural vegetation, etc. should be judiciously used and wisely conserved so that they are easily available in sufficient quantities for the present and the future generations.

5. Incentives should be given to industrialization and urbanization so that employment and housing facilities could be provided to large number of people.

6. Migration of the people from densely populated areas to sparsely populated areas should be encouraged so that regional imbalances in population distribution are removed or at least reduced. This will help in reducing pressure of population in crowded areas and using the resources of sparsely populated areas.

Population Policies

Rapidly growing population of India has forced our planners to frame a solid population policy to keep the rate of population growth at a reasonable level and the importance of such a policy was raised immediately after independence.

When the population policy was designed in the *First Five Year Plan (1951-56)* the population of India had already crossed 361 million mark. It was realised that this base of population was very large and it was difficult to check the trend of rapidly growing population within a limited time period. According to provision of the First Five Year Plan, the programme for family limitation and population control was design to :

(*i*) present an accurate picture of the factors. responsible for rapid increase in population.

(*ii*) discover suitable techniques of family planning and devise suitable methods by which knowledge of these techniques could be widely disseminated, and

(*iii*) give advice on family planning as an integrated part of the service of government hospitals and public agencies.

However, the financial allocation for family planning programme was only ₹ 0.65 million which was so meager that it could not yield any tangible results.

A voluntary sterilization programme was introduced in the *Second Five Year Plan* (1956-57 to 1960-61) for which provision of ₹ 50 million was made. This account was mainly used to set-up 1650 family planning centres in different parts of the country.

In the *Third Five Year Plan* (1961-62 to 1965-66), logistics were provided for family planning, which motivated about one million people to accept sterilization.

In the *Fourth Five Year Plan* (1969-74), the main emphasis was on family planning programme in which a time bound programme of reducing the birth rate from 3.9 per cent to 2.3 per cent by 1979 was fixed. The outlay for family planning programme in this plan was raised to ₹ 2,860 million. This amount was spent to cover nearly 9 million couples under sterilization and about 6 million couples under other family planning methods. It is estimated that about 7 million births were averted during this period.

Strict population control policy followed by the central government led by Mrs. Indira Gandhi particularly during emergency period was vigorously opposed by the mass and this led to an unprecedented defeat of the government in 1977 elections. Consequently a more pragmatic population policy was adopted in the Seventh (1985-1990) and Eighth Plan (1992-97) periods in which more emphasis was laid on persuation, publicity as well family and individual well-being.

Unfortunately the above mentioned population policies could not give the desired results and India's population kept on growing at a fast rate and almost took the shape of a *population explosion*. Compelled by the prevailing circumstances, the government came out with a solid population policy in 2000, a brief summary of which is given below :

National Population Policy, 2000. It is a very comprehensive policy which spells out 14 demographic goals and 12 strategic themes. The immediate objectives of this policy was to meet all the unmet needs for contraception and health care for women and children. The medium-term objective was to bring the Total Fertility Rate (TFR) to replacement level (TFR of 2.1) by 2010, and the long-term object is to achieve population stabilisation by 2045. However, the subsequent events reveal that the goals set under the policy were rather over-ambitious. For example, National Population Policy (NPP) wanted Infant Mortality Rate (IMR) to be reduced to below 30 per thousand live births. But figures released by Office of Registrar General India in 2008 show that IMR stood at a high of 53 per thousand live births which was nowhere near the desired figures of 30 per thousand. The situation in regard to other goals is also depressing.

Most scholars agree with the concluding paragraph of NPP, 2000 which is reproduced below.

"The vast numbers of the people of India can be its greatest asset if they are provided with the means to lead healthy and economically productive lives. Population stabilisation is a multi-sectoral endeavour requiring constant and effective dialogue among a diversity of stakeholders, and coordination at all levels of the government and society. Spread of literacy and education, increasing availability of affordable reproductive and child health services, convergence of service delivery at village levels, participation of women in the paid workforce, together with a steady, equitable improvement in family incomes, will facilitate early achievement of the socio-demographic goals. Success will be achieved if the Action Plan contained in the NPP 2000 is pursued as a national movement."

EXCERPTS

National Socio-Demographic Goals for 2010

1. Address the unmet needs for basic reproductive and child health services, supplies and infrastructure.
2. Make school education upto age 14 free and compulsory, and reduce dropouts at primary and secondary school levels to below 20 per cent for both boys and girls.
3. Reduce infant mortality rate to below 30 per 1000 live births.
4. Reduce maternal mortality rate to below 100 per 100,000 live births.
5. Achieve universal immunisation of children against all vaccine preventable diseases.
6. Promote delayed marriage for girls, not earlier than age 18 and preferably after 20 years of age.
7. Achieve 80 per cent institutional deliveries and 100 per cent deliveries by trained persons.
8. Achieve universal access to information/ counselling, and services for fertility regulation and contraception with a wide basket of choices.

9. Achieve 100 per cent registration of births, deaths, marriage and pregnancy.
10. Contain the spread of Acquired Immuno Deficiency Syndrome (AIDS), and promote greater integration between the management of reproductive tract infections (RTI) and sexually transmitted infections (STI) and the National AIDS Control Organisation.
11. Prevent and control communicable diseases.
12. Integrate Indian Systems of Medicine (ISM) in the provision of reproductive and child health services, and reaching out to households.
13. Promote vigorously the small family norm to achieve replacement levels of TFR.
14. Bring out convergence in implementation of related social sector programmes so that family welfare becomes a people centred programme.

Strategic Themes

Following 12 strategic themes must be followed to achieve that national socio-demographic goals for 2010.

I. Decentralised Planning and Programme Implementation. The 73rd and 74th Constitutional Amendment Act, 1992 made health, family welfare, and education a responsibility of village panchayats in the context of NPP 2000. As may as 33 per cent of elected panchayat seats were reserved for women to promote a gender sensitive, multi-sectoral agenda for population stabilisation that will "think, plan and act locally and support nationally". Panchayat demonstrating exemplary performance will be nationally recognised and honoured.

II. Convergence of Service Delivery at Village Levels. Efforts at population stabilisation will be effective only if we direct an integrated package of essential services at the village and household levels. A flexible approach has to be promoted by extending basic reproductive and child health care through mobile clinics and counselling services particularly to remote, inaccessible or sparsely populated regions in the country like hilly and forested areas, desert regions and tribal areas.

III. Empowering Women for Improved Health and Nutrition. The complex socio-cultural determinants of women's health and nutrition have cumulative effects over a life time. Discrimination against girl child leads to her malnutrition and impaired physical development. This situation is compounded by early childbearing and consequent risk of serious pregnancy related complications. Women's risk of premature death and disability is the highest during their reproductive years. Shockingly maternal mortality ratio (MMR) in India is among the highest in the world. Programmes for Safe Motherhood, Universal Immunisation, Child Survival and Oral Rehydration have been combined into Integrated Reproductive and Child Health Programme.

IV. Child Health and Survival. India suffers from high rate of mortality and morbidity among infants and children below 5 years of age. For solving this problem, a National Technical Committee consisting of consultants in obstetrics, pediatrics, family health, medical research and statistics from academic, public health professionals, clinical practitioners etc. has to be set-up. The baby friendly hospital initiative (BFHI) should be extended to all hospitals, upto to sub-centre levels. Breast-feeding should be encouraged.

V. Meeting the Unmet Needs for Family Welfare Services. There are unmet needs in both rural and urban areas for contraceptives, supplies and equipment for integrated service delivery, mobility of health providers and patients, and comprehensive information. It is necessary to meet these requirements and strengthen health infrastructure at the village, sub-centre and primary health centre levels.

VI. Under-Served Population Groups. Following groups of population are under-served which need due attention of the government and the concerned organisations :

(*a*) **Urban slums** with little or no access to potable water, sanitation facilities and health care services.

(*b*) **Tribal Communities, Hill Area Populations and Displaced and Migrant Populations** in remote and low density areas.

(*c*) **Adolescents** representing about a fifth of India's population need protection from unwanted pregnancies and sexually transmitted diseases, particularly in rural areas.

(*d*) **Increased Participation of Men in Planned Parenthood.** In the past, population programmes have tended to exclude menfolk but now active participation of men is recognised in all efforts in planning families. Nearly 97 per cent of sterilisations are tubectomics and this gender imbalance needs to be corrected.

VII. Diverse Health Care Providers. Considering the large unmet goals, it is imperative to increase the numbers and diversify of the categories of healthcare providers.

VIII. Collaboration with and commitments from Non-Government Organisations and Private Sector. Government alone cannot reach each and every household and partnership of non-government voluntary organisation and private corporate sector with government must be encouraged.

IX. Mainstreaming Indian Systems of Madicine and Homeopathy. Indian system of medicine has sustained life in the country for centuries with minimal side effects and this branch of medicine will expand the pool of effective health care providers at low cost.

X. Contraceptive Technology and Research on Reproductive and Child Health. The government has to take steps to advance, encourage, and support medical, social science, demographic and behavioural science, research on maternal, child and reproductive health care issues. This will improve medical techniques relevant to country's needs.

XI. Providing for the Older Population. Keeping in view the increasing life expectancy it is estimated that in proportion of population above 60 years and above will increase considerably. Considering the weakening traditional support system, the elderly are becoming increasingly vulnerable, needing protection and care. Promotion of old age health care and support will also serve to reduce incentive for large families. National Policy for Older Persons was adopted by the Ministry of Social Justice and Empowerment in January, 1999.

XII. Information, Education and Communication. Information, education and communication (IEC) of family welfare messages must be clear, focussed and disseminated everywhere, including the remote corners of the country and in local dialects.

National Commission on Population

The Government of India constituted the National Commission on Population on May 11, 2000 with the Prime Minister as the Chairman and the Deputy Chairman of Planning Commission as its vice chairman. The Commission has the mandate to :

- review, monitor and give direction for the implementation of the National Population Policy with the view of achieving the goals it has set;
- promote synergy between health, educational, environmental and developmental programmes so as to hasten population stabilisation;
- promote inter-sectoral coordination in planning and implementation of the programmes through different agencies at the Centre and in the states; and
- develop a vigorous people's programme to support this national effort.

A Strategic Support Group consisting of secretaries of concerned sectoral ministries has been constituted as a standing advisory group to the Commission. Nine working groups were constituted to look into specific aspects of implementation of the programmes aimed at achieving the targets set in the National Population Policy.

Health Indicators

Health is one of the most important constituent of human development. Life free from illness and having reasonably long span is termed as healthy life.

Following are important health indicators :

1. Life expectancy at birth. This is an important health indictor which indicate the number of years a person (male and female) would live after birth. Due to improvement in health and sanitation services, life expectancy at birth in India has improved considerably during the last over four decades (**Table 10.18**).

TABLE 10.18. Life expectancy at birth by sex, India

Year	Males	Females	Difference Female–Male
1970-75	50.5	49.0	–1.5
1981-85	55.4	55.7	+0.3
1991-95	59.7	60.9	+1.2
2001-06	63.8	66.1	+2.3
2006-11	65.8	68.1	+2.3
2011-16	67.3	69.6	+2.3
2016-21	68.8	71.1	+2.3
2021-26	69.8	72.3	+2.5

Source : (*i*) Premi Mahendra K. and Das Dependra Nath (2012) Population of India 2011, p. 47.
(*ii*) Bose Ashish (2010), India's Quest for Population Stabilisatior, p. 89.

Table 10.18 shows that the difference between female-male life expectancy has been in favour of males in 1970-75 whereafter it become in favour of females. It is also worth noting that the gap between female and male life expectancy has gradually increased between 1981-85 and 2001-06. This gap is likely to remain constant upto 2016-21 after which is will increase further.

2. Crude Birth Rate (CBR). Crude birth rate is expressed in terms of number of births in a year per thousand of mid year population. It is worth noting that only live births during the year are to be taken into account. It is calculated as under :

$$CBR = \frac{Bt}{P} \times 1000$$

where Bt = live births during the year

and P = estimated mid-year population

This is the simplest and most widely used measure of human fertility. CBR in India has fallen from 49.2 per thousand in 1901-10 to 23 per thousand in 2001-07 (**Table 10.19**). This is an indication of some success in controlling the birth rate.

3. Total Fertility Rate (TFR). Total Fertility Rate is expressed as the number of children born to a women during her entire reproductive age. TFR in India decreased from 6 in 1960 to less than 3 in 2003. Thus India has crossed two-third of the way towards its goal of replacement level fertility of 2.1. Some states like Kerala, Tamil Nadu, Andhra Pradesh and Karnataka have already achieved this goal.

TABLE 10.19. India : Child Birth Rate and Crude Death Rate

Year	Crude Birth Rate (per thousand)	Crude Death Rate (per thousand)
1901-10	49.2	42.6
1911-20	48.1	48.6
1921-30	46.4	36.3
1931-40	45.2	31.2
1941-50	39.9	27.4
1951-60	41.7	18.0
1961-70	41.2	19.2
1971-80	37.2	15.0
1981-90	29.6	10.8
1991-2000	26.0	8.6
2001-2007	23.0	7.0

Source : (*i*) Registrar General India.
(*ii*) India : A Reference Annual, 2008.

4. Crude Death Rate (CDR). It is the simplest measure of mortality indicating the number of deaths in a particular year per thousand of population. It is expressed as under :

$$CDR = \frac{D}{P} \times 100$$

where D = Number of deaths in a year
P = Estimated mid-year population

Table 10.19 shows that CDR in India declined from 42.6 per thousand in 1901-10 to a mere 7.0 per thousand in 2001-07. This is an indication of improvement in our health services and increased availability of health facilities.

5. Infant Mortality Rate (IMR). Infant Mortality Rate refers to the death rate among infants and is calculated for connoting mortality among children of less than one year of age. It is expressed as under :

$$IMR = \frac{D_o}{B_l} \times 1000$$

where D_o = number of deaths of children under one year of age

and B_l = number of live births.

Thus IMR is the ratio of number of deaths among children under one year of age to the number of live births.

In India, infant mortality rte was 61 per thousand in 2001-06 which decrease to 54 per thousand in 2006-11. It is likely to fall to 49 per thousand in 2011-16, 44 per thousand in 2016-21 and further to 40 per thousand in 2021-25. This is an indication of our concern about the newly born infants because this section of population will decided the future course of population trends in India.

6. Under Five Mortality Rate. This is another health indictor which is concerned with children below the age of 5 years. Drive to care for children especially in the rural areas, has paid rich dividends. It is heartening to note that under five mortality rate decreased considerably in the Post-Independent era, from 326 per thousand in 1951 to 55 per thousand in 2011.

7. Maternal Mortality Rate (MMR) is the indicator of health of women during pregnancy and delivery. MMR declined from 20.2 per cent at the time Independence to at low of less than 4 per cent in 2011. This decline is the result of medical facilities available to prospective mothers. Levels of MMR vary greatly across regions due to variation in access to emergency obstetric care (EOC), parental care, anaemia rates among women, education level of women and other factors.

HUMAN DEVELOPMENT

Growth and Development. Although both growth and development refer to changes over a period of time, yet these terms differ from each other. **Growth** is *quantitative* and value natural which may have a positive or a negative sign. This means that the change may be either positive (increase) or negative (decrease). Development on the other hand is *qualitative* change which is always value positive. This means that development cannot take place unless there is an increment or addition to the existing conditions. Development occurs when positive growth takes place. Yet, positive growth does not always lead to development. Development occurs when there is a positive change in quality. For example, if the population of a city grows from five lakhs to ten lakhs over a period of time, we say the city has grown. But if the basic facilities of life such as housing, water, power, transport, severage etc. remain the same or do not grow in proportion to population growth, then the growth has not been accompanied by development.

Before 1990s, a country's development was gauged as a measure of its economic progress. This implied that countries with better economic conditions were more developed while poor countries were less developed. This however, did not reflect the true nature of development because in many cases the benefit of economic growth did not reach the common man who deserved it the most. Quality of life of the people, the opportunities they have and the freedom they enjoy are important aspects of development.

The above mentioned ideas were clearly spelt out for the first time in the late 1980s and early 1990s by two great economists of Asia. One was **Dr. Mahbub-ul-Haq** of Pakistan and the other was **Nobel Laureate Dr. Amartya Sen** of India. **Dr. Mahbub-ul-Haq** created the Human Development Index (HDI) in 1990. According to him, *development is all about enlarging people's choices in order to lead long, healthy lives with dignity*. Dr. Haq believed that people are central to all development. The choices of the people are not fixed but keep on changing. The chief objective of development is to create conditions in which people can live meaningful lives.

A meaningful life is not just a long one. It must be a life with some purpose. This means that people must be healthy, be able to develop their talents, participate in society and be free to achieve their goals.

Dr. Amartya Sen expressed the opinion that an increase in freedom (or decrease in unfreedom) is the main objective of development. Increasing freedom is one of the most effective ways of bringing about development. He laid much emphasis on the role of social and political institutions and processes of increasing freedom.

Following three are the most important aspects of human development:

(*i*) Leading long and healthy life.

(*ii*) Attaining ability to gain knowledge.

(*iii*) Having enough means to be able to live a decent life.

In view of the above mentioned aspects, it is essential to have access to resources, health and education. But very often, people fail to attain capability and freedom to make even basic choices. This may be due to various reasons of which lack of knowledge, poverty, social discrimination etc. are important. Such a situation prevents people from leading healthy lives, being able to get educated and to lead a decent life. Therefore, in order to enlarge the choices of the people, it is essential to build their capabilities in the areas of health, education and access to resources. The choices become limited in the absence of these capabilities.

Generally speaking "Development is freedom". Development and freedom are often associated with modernisation, leisure, comfort and affluence. In the present day world computerisation, industrialisation, efficient transport and communication network, large education system, advanced and modern medical facilities, safety and security of individuals, etc. are considered as the symbols of development. Level of development is measured with respect to the availability and access to these modern things. But this is only one sided view of development which is often called the ***'western or euro-centric'*** view of development. For a postcolonial country like India, colonisation, marginalisation, social discrimination and regional disparity etc. show the other face of development.

In India, development is a mixture of opportunities as well as neglect and deprivation. A few people in urban areas are enjoying all the facilities of modern life while on the other hand vast humanity living in rural areas and urban slums do not have even the basic amenities of life. People belonging to scheduled castes, scheduled tribes, landless agricultural labourers, poor farmers, slum dwellers etc. are the worst sufferers. The condition of female population is more pathetic.

Lack of development leads to deteriorating human conditions and results in environmental pollution. Air, soil, water and noise pollution are posing a great threat to the very existence of our society. Consequently, the poor are being subjected to three inter-related processes of declining capabilities; *i.e.* (1) social capabilities — due to displacement and weakening social ties (social capital), (2) environmental capabilities—due to pollution and, (3) personal capabilities—due to increasing incidence of diseases and accidents. This, in turn, has adverse effects on their quality of life and human development.

Why Human Development ?

According to **Paul Streeten**, human development is necessary due to following reasons :

1. The main purpose of human development is to improve the human conditions and to enlarge people's choices.
2. It is a major tool of achieving higher level of productivity. A well-nourished, healthy, educated, skilled, alert labour force is the most productive asset. Therefore, investments on these sectors are justified on grounds of productivity too.
3. It helps in reducing the rate of growth of population.
4. Human development is friendly to the physical environment also. Deforestation, desertification and soil erosion decline when poverty declines.
5. Improved living conditions and reduced poverty contribute to a healthy civil society, enhanced democracy and greater social stability.
6. Human development also helps in reducing civil disturbances in the society and in increasing political stability.

The Four Pillars of Human Development

Just as any building is supported by pillars, the idea of human development is supported by the concepts of equity, sustainability, productivity and empowerment.

1. Equity. Equity means making equal access to opportunities available to everybody. The opportunities available to people must be equal irrespective of their gender, race, income and in the Indian case, caste. Yet this is very often not the case and happens in almost every society. Normally, the poor and persons belonging to socially and economically backward groups fail to have access to equity.

2. Sustainability. Sustainability refers to continuity in the availability of opportunities. This means that each generation must have the same opportunities. Therefore, we must use our environmental, financial and human resources in such a way that our future generations are not deprived of these opportunities.

3. Productivity. Productivity means human labour productivity or productivity in terms of human work. It must be enriched by building capabilities in people. In fact, people of a country are its real wealth. As such sincere effort should be made to increase their knowledge and provide better facilities of health and education so that they can attain better work efficiency.

4. Empowerment. It refers to have power to make choices. Such power comes from increasing freedom and capability. Good governance and people-oriented policies are required to empower people. The empowerment of socially and economically disadvantaged groups is of special importance.

Indicators of Human Development

Although it is not possible to have a flawless quantitative measure of human development, the United Nations Development Programme (UNDP) has developed a composite index, now known as the Human Development Index (HDI). It includes (*i*) longevity of life, (*ii*) knowledge base, and (*iii*) a decent material standard of living. To keep the index simple, only a limited number of variables are included. Initially, life expectancy was chosen as an index of longevity, adult literacy as an index of knowledge and per capita Gross National Product adjusted for **Purchasing Power Parity (PPP)** as an index of decent life. These variables are expressed in different units. Therefore, a methodology was evolved to construct a composite index rather than several indices.

In India, three sets of indicators have been selected for preparing the Human Development Report. Among them, a core set of composite indices presents the state of human development for the society as a whole. Besides, Gender Equality Index has been estimated to reflect the relative attainments of women, and the Human Poverty Index to evaluate the state of deprivation in the society.

Several other variables have gradually been added to the above sets of indicators. Among them, *health indicators* related to longevity are birth rate, death rate with special reference to infant mortality, nutrition, and life expectancy at birth. *Social indicators* include literacy particularly female literacy, enrollment of school-going children, drop out ratio, and pupil-teacher ratio. *Economic indicators* are related to wages, income, and employment. Per Capita Gross Domestic Product, incidences of poverty and employment opportunity are also favoured indicators in this group. They are converted into a composite index to present the holistic picture of the Human Development.

WHAT IS HUMAN DEVELOPMENT?

"Human development is a process of enlarging the range of people's choices, increasing their opportunities for education, health care, income and empowerment and covering the full range of human choices from a sound physical environment to economic, social and political freedom."

Thus, enlarging the range of people's choices is the most significant aspect of human development. People's choices may involve a host of other issues, but, living a long and healthy life, to be educated and have access to resources needed for a decent standard of living including political freedom, guaranteed human rights and personal self-respect, etc. are considered some of the non-negotiable aspects of the human development.

Approaches to human development

Four important approaches to human development are :

1. The income approach;
2. The welfare approach;
3. Minimum needs approach;
4. Capabilities approach.

Measuring Human Development

Human Development is measured in terms of Human Development Index (HDI). It measures average achievements in basic human development in one simple composite index and produces a ranking of countries on the basis of their performance in key areas of health, education and access to resources. These rankings are based on a score between 0 & 1 that a country earn from its record in key areas of health, education and access to resources.

TABLE 10.20. Approaches to Human Development

1. Income Approach	This is one of the oldest approaches to human development. Human development is seen as being linked to income. The idea is that the level of income reflects the level of freedom an individual enjoys. Higher the level of income, the higher is the level of human development.
2. Welfare Approach	This approach looks at human beings as beneficiaries or targets of all development activities. The approach argues for higher government expenditure on education, health, social secondary and amenities. People are not participants in development but only passive recipients. The government is responsible for increasing levels of human development by maximising expenditure on welfare.
3. Basic Needs Approach	This approach was initially proposed by the International Labour Organisation (ILO). Six basic needs i.e., health, education, food, water supply, sanitation and housing were identified. The question of human choices is ignored and the emphasis is on the provision of basic needs of defined sections.
4. Capability Approach	This approach is associated with Prof. Amartya Sen. Building human capabilities in the areas of health, education and access to resources is the key to increasing human development.

1. Health. The indicator chosen to assess health is *life expectancy at birth*. It means that people have a better choice to lead longer and healthier life. Higher the life expectancy at birth, higher is the human development index.

2. Education. Education here involves adult literacy rate and gross enrolment ratio. It means that a country should have larger number of adults who are able to read and write and larger number of children enrolled in schools to be placed higher in human development index.

3. Access to resources. Access to resources is measured in terms of purchasing power (in U.S. dollars).

The Human Development Report was first published in 1990 by the United Nations Development Programme (UNDP). Since then it is published every year. This report gives an interesting rank wise list of the member countries according to the level of human development. The Human Development index and the Human Poverty index are two important indices to measure human development used by the UNDP.

International Comparisons

Human Development is not necessarily related to size or per capita income of a country. It has been found that smaller and economically poorer countries are often ranked higher in terms of human development than the bigger and richer countries. For example Norway and Iceland are much smaller and poorer countries in terms of GDP than the U.S.A. But these two small countries rank much higher than the U.S.A. with respect to HDI value. Similarly Sri Lanka, Trinidad and Tobago have smaller economies than that of India but have higher rank than India in terms of human development index (HDI). In India, Kerala has higher rank than Panjab and Gujarat despite having lower per capita income than these states.

Member countries have been divided into three broad groups on the basis of the human development scores earned by them. Countries with a score of above 0.8 are termed as having high index value. Countries with score of between 0.5 and 0.799 are placed in medium level of development. Countries having development index below 0.5 are said to have low level of human development. (*see* **Table 10.21**)

TABLE 10.21. Human Development Categories, Criteria and Countries

Level of Human Development	Score in Development Index	Number of Countries
High	above 0.8	57
Medium	between 0.5 up to 0.799	88
Low	below 0.5	32

Source : Human Development Report, 2011.

Computing the HDI

To construct the Index, fixed minimum and maximum values have been established for each of the indicators :

- Life expectancy at birth : 25 years and 85 years;
- General literacy rate : 0 per cent and 100 per cent;
- Real GDP per capita (PPP$) ; PPP$ 100 and PPP$ 40,000.
- Purchasing power party.

Individual Indices are computed first on the basis of a given formula. HDI is a simple average of these three indices and is derived by dividing the sum of these three indices by 3.

With normalisation of the values of the variables that make up the HDI, its value ranges from 0 to 1. The HDI value for a country or a region shows the distance that it has to travel to reach the maximum possible value of 1 and also allows intercountry comparisons.

The closer a score is to one, the greater is the level of human development. Therefore, a score of 0.983 would be considered very high while 0.268 would mean a very low level of human development.

TABLE 10.22. Human Development, International Comparison

HDI Rank	Country	1980	1990	2000	2005	2009	2010	2011	Average annual HDI Growth Rate (per cent)		
									1980–2011	1990–2011	2000–2011
1	Norway	0.796	0.844	0.913	0.938	0.941	0.941	0.943	0.55	0.53	0.29
2	Australia	0.850	0.873	0.906	0.918	0.926	0.927	0.929	0.29	0.30	0.23
39	Poland	—	—	0.770	0.791	0.807	0.811	0.813	—	—	0.50
61	Malaysia	0.559	0.631	0.705	0.738	0.752	0.758	0.761	1.00	0.90	0.69
66	Russian Fed.	—	—	0.691	0.725	0.747	0.751	0.755	—	—	0.81
84	Brazil	0.549	0.600	0.665	0.692	0.708	0.715	0.718	0.87	0.86	0.69
92	Turkey	0.463	0.558	0.634	0.671	0.690	0.696	0.699	1.34	1.08	0.90
101	China	0.404	0.490	0.588	0.633	0.674	0.682	0.687	1.73	1.62	1.43
97	Sri Lanka	0.539	0.583	0.633	0.662	0.680	0.686	0.691	0.80	0.81	0.80
103	Thailand	0.486	0.566	0.626	0.656	0.673	0.680	0.682	1.10	0.89	0.78
112	Philippines	0.550	0.571	0.602	0.622	0.636	0.641	0.644	0.51	0.58	0.62
113	Egypt	0.406	0.497	0.585	0.611	0.638	0.644	0.644	1.50	1.24	0.88
124	Indonesia	0.423	0.481	0.543	0.572	0.607	0.613	0.617	1.23	1.19	1.17
123	South Africa	0.564	0.615	0.616	0.599	0.610	0.615	0.619	0.30	0.03	0.05
128	Vietnam	—	0.435	0.528	0.561	0.584	0.590	0.593	—	1.50	1.06
134	**India**	**0.344**	**0.410**	**0.461**	**0.504**	**0.535**	**0.542**	**0.547**	**1.51**	**1.38**	**1.56**
145	Pakistan	0.359	0.399	0.436	0.48	0.499	0.503	0.504	1.10	1.12	1.33
143	Kenya	0.420	0.456	0.443	0.467	0.499	0.505	0.509	0.62	0.52	1.27
146	Bangladesh	0.303	0.352	0.422	0.462	0.491	0.496	0.500	1.63	1.69	1.55
	World	0.558	0.594	0.634	0.66	0.676	0.679	0.682	0.65	0.66	0.66

Source : HDR 2011.

HDI of India

As compared to the pre-independence days, India has done well in development in general. As per Human Development Reports (HDRs) published annually by the UNDP, India has consistently improved on human development front and is grouped among the countries with '*medium human development*'. According to Human Development Report 2011 published by the United Nations Development Programme (UNDP) [which estimates the Human Development Index (HDI) in terms of three basic capabilities to live a long and healthy life, to be educated and knowledgeable and to enjoy a descent economic standard of living] the HDI of India was 0.547 in 2011 with an overall global ranking of 134 (out of 187 countries) compared to 119 (out of 169 countries HDR 2010).

However, a comparable analysis of the trends during 1980-2011 (**Table 10.22**) shows that although lower in HDI ranking, India has performed better than

TABLE 10.23. India's Global Position in Human Development 2011

Country	HDI 2011	HDI rank 2011	Gross national income (GNI) per capita (constant 2005 PPP $) 2011	Life expectancy at birth (years) 2011	Mean years of schooling (years) 2011[a]	Expected years of schooling (years) 2011[a]
Norway	0.943	1	47,557	81.1	12.6	17.3
Australia	0.929	2	34,431	81.9	12.0	18
Poland	0.813	39	17,451	76.1	10.0	15.3
Malaysia	0.761	61	13,685	74.2	9.5	12.6
Russian Fed.	0.755	66	14,561	68.8	9.8	14.1
Brazil	0.718	84	10,162	73.5	7.2	13.8
Turkey	0.699	92	12,246	74.0	6.5	11.8
China	0.687	101	7,476	73.5	7.5	116
Sri Lanka	0.691	97	4,943	74.9	8.2	12.7
Thailand	0.682	103	7,694	74.1	6.6	12.3
Philippines	0.644	112	3,478	68.7	8.9	11.9
Egypt	0.644	113	5,269	73.2	6.4	11.0
Indonesia	0.617	124	3,716	69.4	5.8	13.2
South Africa	0.619	123	9,469	52.8	8.5	13.1
Vietnam	0.593	128	2,805	75.2	5.5	10.4
India	**0.547**	**134**	**3,468**	**65.4**	**4.4**	**10.3**
Pakistan	0.504	145	2,550	65.4	4.9	6.9
Kenya	0.509	143	1,492	57.1	7.0	11.0
Bangladesh	0.5	146	1,529	68.9	4.8	8.1
World	**0.682**		**10,082**	**69.8**	**7.4**	**11.3**

Source : HDR 2011.

Note : a—Data refer to 2011 or the most recent year available; PPP is purchasing power parity.

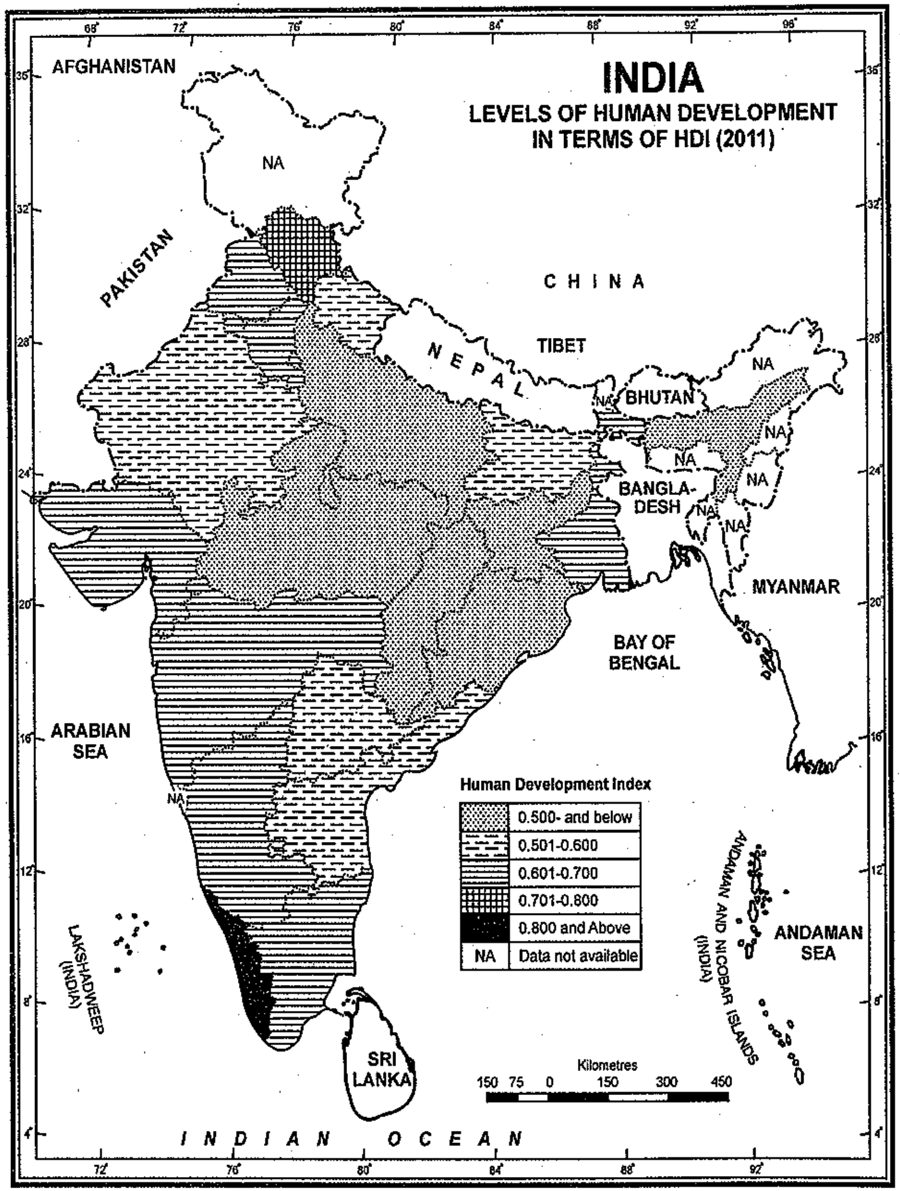

FIG. 10.15. India : Levels of Human Development in terms of HDI (2011)

most (including high and very high human development) countries in terms of average annual HDI growth rate. India is behind only China and Bangladesh in this regard. If average annual HDI growth of 2000-11 is viewed, India (1.56 per cent) is even ahead of China (1.43 per cent) (**Table 10.22**). While China performed very well in terms of growth of HDI in the 1980s, there was a deceleration in the

1990s and 2000s. On the other hand India, which seems to have faltered in the 1990s, has picked up again with its growth rates during 2000-11 surpassing even those of the 1980s.

However, there should be no room for complacency as India is still in the medium human development category with countries like China, Sri Lanka, Thailand, Philippines, Egypt, Indonesia, South Africa, and even Vietnam having better overall HDI ranking within the same category. The existing gap in health and education indicators as compared to developed countries and also many of the developing countries indicates the need for much faster and wider spread of basic health and education. Life expectancy at birth in India was 65.4 years in 2011 as against 81.1 years in Norway, 81.9 years in Australia, 74,9 years in Sri Lanka, 73.5 years in China, and the global average of 69.8 years. However, it has increased by one percentage points from 64.4 in 2010 to 65.4 in 2011. The other countries referred to were almost stagnant during this period. Similarly, the performance of India in terms of mean years of schooling is not only much below that of countries like Sri Lanka, China, and Egypt which have higher per capita incomes but also below that of Pakistan, Bangladesh, and Vietnam which have lower per capita incomes. It is also much lower than the global average (**Table 10.23**). The National Human Development Report (NHDR) 2011 of the Institute of Applied Manpower Research and Planning Commission states that India's HDI between 1999-2000 and 2007-08 has increased by 21 per cent, with an improvement of over 28 per cent in education being the main driver. The increase in HDI in the poorest states of India has been much sharper than the national average and hence the convergence in HDI across states.

In terms of the gender inequality index (GII), India with a value of 0.617 ranks 129 out of a total of 187 countries as per HDR 2011. The GII captures the loss in achievement due to gender disparities in the areas of reproductive health, empowerment, and labour force participation with values *ranging from 0* (perfect equality) to 1 (total inequality). The GII value of 0.617 indicates a higher degree of gender discrimination in India compared to countries like China (0.209), Pakistan (0.573), Bangladesh (0.550), Bhutan (0.495), and Sri Lanka (0.419). It is even higher than the global average 0.492.

TABLE 10.24. State level patterns of Human Development Index (HDI) in 2011

Name of State	Human Development Index (HDI)	HDI Ranking
1. Andhra Pradesh	0.580	15
2. Assam	0.407	16
3. Bihar	0.563	21
4. Chhattisgarh	0.417	23
5. Gujarat	0.633	11
6. Haryana	0.627	9
7. Himachal Pradesh	0.717	3
8. Jharkhand	0.500	19
9. Karnataka	0.627	12
10. Kerala	0.817	1
11. Madhya Pradesh	0.430	20
12. Maharashtra	0.650	7
13. Odisha	0.450	22
14. Punjab	0.667	5
15. Rajasthan	0.587	17
16. Tamil Nadu	0.637	8
17. Uttar Pradesh	0.473	18
18. Uttarakhand	0.530	14
19. West Bengal	0.650	13

Source : India HDR 2011 Quoted in Economic Survey 2011-12, p. 310.

Table 10.24 shows that Kerala is the most prospectus state of India with respect to human development index. This state can easily match with some of the advanced countries of the world so far as human development is concerned. Surprisingly Himachal Pradesh also has high human development which is higher than the so called advanced states of Punjab, Haryana and Gujarat. This shows that human development does not always correspond with economic growth and so many other factors are also considered while computing human development index. States with lower human development index are Assam, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha and Uttar Pradesh. Again this is surprising that the mineral rich state of Jharkhand is having low HDI while states with meager minerals have sufficiently high HDI.

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CHAPTER 11

Population Composition

Population composition is a vast field which refers to the physical, socio-cultural and economic attributes of population, such as ethnicity, tribes, language, religion, literacy and education, age, sex, economically active population and many more traits. The study of composition of population helps us in understanding the social, economic and demographic structure of population.

ETHNIC COMPOSITION

Our present day population is a conglomeration of people belonging to different racial groups with different ethnic backgrounds. These people entered India from different parts of the world at different points of time adopting different land and water routes. In fact India has been a meeting pot of various races and tribes from times immemorial. Almost all the major races of the world are visible in India as a result of which the country is said to have a varied and diverse ethnic composition. The present day population of the country has been derived mainly from the following racial groups :

1. The Negritos

According to Hutton, the earliest occupants of India were the people of Negrito race. S.K. Chatterjee and S.M. Katre have expressed the view that Negroid people migrated to India from Africa and established their language on the soil of India. **A.C. Haddon** opines that Negrito features are met with particularly amongst the Andaman islanders and most probably the Uralis of Nilgiri hills, Kadors of Kochi, Pullayans of Palni hills, etc. Besides some tribes like the Angami Nagas in the north-east and the Badgis in the Rajmahal hills in Jharkhand, etc. possessing some physical traits reminiscent of the Negrito are seen. The Negrito race is characterised by short stature, dark chocolate brown skin, woolly hair, bulbous forehead, broad flat nose and slightly protruding jaws.

2. The Proto-Australoids

Hutton is of the opinion that the Proto-Australoids came to India from the East Mediterranean area (Palestine). They came soon after the Negritos. Today they constitute the bulk of population in many isolated and semi-isolated parts of central and southern India. The Veddahs, Malavedahs, Irulas and Sholagas are the true representatives of Proto-Australoids. The Bhils, Kols, Badagas, Korwas, Kharwars, Mundas, Bhumjis and Malpaharis of the highlands of Central India and the

Chenchus, Kurumbas, Malayans and Yeruvas of South India may all be treated as Proto-Australoids. Some anthropologists believe that the Proto-Australoids supported the Mediterraneans in building the Indus Valley Civilization. On their arrival in India, the Proto-Australoids pushed, pressed, displaced and supplanted the Negritos and forced them to shift to more inaccessible, remote and less hospitable areas, where they are found even today. In the process, there was some admixture of the two races, perhaps more so in the south than in the north. In physical appearance the Proto-Australoids more or less resemble the Negritos with the main exception that they do not have wooly hair like the Negritos. Their other physical characteristics are bulbous forehead, broad flat nose and slightly protruding jaws.

3. The Mongoloid

According to **Risley**, "On its northern and eastern frontier, India marches with the great Mongoloid region of the earth". Most of the anthropologists believe China to be the homeland of the Mongoloid race from where they were pushed southward into the Malaya peninsula and Indonesia. They entered India through the passes in the northern or eastern mountains. Hutton is of the opinion that the bulk of Burma (Myanmar) in any case is primarily Mongoloid, and any non-Mongoloid streams of migration that may have reached India through Myanmar have absorbed a vast quantity of Mongolian blood. There is also some evidence of a Mongoloid Melanesian intrusion from Oceania to Tamil Nadu and Kerala and probably that accounts for the occasional Mongoloid element noticed among the people of these states. Presently, they occupy large areas in Ladakh, Sikkim, Arunachal Pradesh and some other parts of east India. Some of the basic physical characteristics of the Mongoloid race include a round and broad head, face with very high cheek bones and a long flat nose, with little or no hair on the face and the body. The tribes of Garo, Khasi, Jaintia, Lipchas, Chakmas, Murmis, Naga and Daffla belong to the Mongoloid race.

The Mongoloid racial stock of India can be divided into two sub-groups as follows :

(*i*) Palaeo-Mongoloids
(*ii*) Tibeto-Mongoloids.

(*i*) ***Palaeo-Mongoloids*** are further divided into ***broad headed*** and ***long headed*** sub-types. They settled mainly along the fringes of the Himalayas in Assam and the Myanmar border.

(*ii*) ***Tibeto-Mongoloids*** have come from Tibet as their name suggests. They are mostly living in Bhutan and Sikkim, as well as in the north-western Himalayas and Trans Himalayan regions.

4. The Mediterraneans

The Mediterranean racial stock came to India from eastern Mediterranean region or South West Asia. They are believed to have migrated during the third and the second millennium B.C. This race has contributed much to the physical composition of peoples of India and also to its culture. They brought earlier forms of Austro-Asiatic languages and are believed to be the bearers of the earliest form of Hinduism in India. *Palaeo-Mediterrraneans* are considered to be the first and the most ancient of all the Mediterranean races to enter India. Their physical characteristics include medium stature, dark skin and long head. In all probability, they first settled in north-west India and started practising agriculture there. However, they were pushed into central and southern India by subsequent immigrants. Today the Palaeo-Mediterranean stock forms the bulk of population of south India and a considerable proportion of population in northern India. The Mediterraneans were the chief architects of the Indus Valley Civilization as is evident from the excavations of Mohanjo Daro and Harappa.

The Dravidians. To quote **Risley**, "The Dravidian race, the most primitive of the Indian types, occupies the oldest geological formation in India, the medley of forestclad ranges, terraced plateaus, and undulating plains which stretches, roughly speaking, from the Vindhyas to Cape Comorin (Kanniyakumari). On the east and west of the peninsular area the domain of the Dravidian is coterminous with the Ghats; while further north it reaches on one side to the Aravalis and on the other to the Rajmahal hills. Where the original characteristics have been unchanged by contact with Indo-Aryan or Mongoloid people, the type is remarkably uniform and distinctive."

5. Brachycephals

Brachycephal groups of races of India are characterised by broad heads. Coorgis and Parsis are representatives of the Brachycephals in India. These races are sub-divided into three major groups. They followed three different routes to enter India.

(*i*) Alpinoids,
(*ii*) Dinarics and
(*iii*) Armenoids.

(*i*) ***Alpinoids.*** Alpinoids came to India along the route passing through Baluchistan, Sind, Kathiawar, Gujarat, Maharashtra, Karnataka and Tamil Nadu.

(*ii*) ***Dinarics.*** Dinarics followed the Ganga valley and its delta as their route to enter India.

(*iii*) ***Armenoids.*** Chitral, Gilgit, Kashmir and Nepal formed the third route for the Armenoids of the Brachycephal group of races to enter India.

6. The Nordics

The Nordics constitute the last wave of migration into India. They spoke Aryan language and migrated to India sometime during the second millennium B.C. The main concentration of these people is in the north-western part of the country. They are a predominant type in Punjab, Haryana and Rajasthan. They are mostly represented among the upper castes of North India particularly in Punjab. The main characteristics of this race are long head, fair complexion, well developed nose and a well built, strong body.

CASTE GROUPS

India's present caste system owes its origin to the ***chatur varna*** which divided the population into four classes, viz. Brahmins, Kshatriyas, Vaishyas, and Shudras. This division was based on the occupation of the people and the complexion of the skin. In due course of time, the caste system in India became extremely hierarchical and rigid encouraging high caste people to exploit the low cast people. Unfortunately, even today, the Indian cast system is intensely hierarchical resulting in several social and economic problems. Today India has more than 3,000 castes.

For the sake of convenience, the castes of the country are divided into three groups. **Table 11.1** indicates that various castes are concentrated in various regions. In other words, their distribution is mainly regional. The regional dimensions of the caste system has led to regional differentiation in social geography of India.

Four major castes according to *varna* (literally colour) are briefly described as under :

1. Brahmans. Brahmans are at the top in *varna* hierarchy. Main castes of this *varna* are those of priests, teachers, custodians of social ritual practices and arbiter of correct social and moral behaviour. Geographically, they are the most ubiquitous because they officiate in a variety of rituals. Although ritually barred from cultivation, they have gathered large stretches of land through grants by local rulers and patrons by virtue of their traditional prestige. Thus they constitute a prominent land owning and money lending class. The services of Brahmans is constantly in demand by other castes for major ritual functions such as births, marriages, deaths, etc. Although Brahman households are a few in a typical village, yet they command a wide variety of services from other castes because they own a large part of agricultural

TABLE 11.1. Caste Groups

Caste

High (Brahmans, Kshatriyas and Vaishyas)	Middle (Cultivating Castes)	Low (Harijans or Scheduled Castes)
1. Saryupanes of Awadh	1. Jats of Haryana and Punjab	1. Chamars of U. P.
2. Namboodris of Kerala	2. Bhumihars of Bihar	2. Balais of W. Bengal
3. Chitpowans of Maharashtra	3. Reddys of Andhra Pradesh	3. Megh of Gujarat
4. Chattopadhyayas of West Bengal	4. Vellalas of Karnataka	4. Mahars of Maharashtra
5. Iyengars of Tamil Nadu		5. Malls of Andhra Pradesh
		6. Adi-Dravidas of Tamil Nadu

land in the village. By and large Brahmans are better educated than other caste groups.

2. Kshatriyas. Next to Brahmans are the Kshatriyas in *varna* ranking. They comprise very powerful castes as they are traditionally warriors and play a major role in defence. However, the role of defence is now largely submerged under the rule of land ownership. When castes form large majorities in a village, the village is generally known by the *jati* name of the Kshatriyas. There are several examples of *Rajput* villages (Rajasthan), *Jat* villages (Haryana, Uttar Pradesh), *Thakur* villages (Himalayan region) and *Nair villages* (Kerala).

3. Vaishyas. Vaishyas rank below Kshatriyas, but fall within the ambit of ritually high *varna*. Vaishyas are primarily engaged in farming and retail trade. Several prominent vaishya groups have established successful monolithic business all over the country.

4. Shudras. These belong to the lowermost class in *varna* ranking. They are mostly engaged in cultivation, and in a wide variety of artisan services such as carpentry, metal work, and basket weaving. However, they are debarred from several ritual privileges. Currently they form the bulk of the country's population.

SCHEDULED CASTES

At the bottom of the social ladder are the *niravasita* meaning "excluded" or the "exterior" castes, so called "*casteless*", officially "scheduled castes". Since the Government of India Act of 1935, they have been listed in special official schedules for administrative and representational purposes. Article 341 of the Constitution provides that the President may, with respect to any State or Union territory, specify the castes, races or tribes or parts of groups within castes, races or tribes which shall for the purposes of the Constitution be deemed to be Scheduled Castes in relation to that State/Union territory. In pursuance of these provisions, the lists of Scheduled Castes are notified for each State and Union territory and are valid only within the jurisdiction of that State or Union territory and not outside.

It is important to mention here that under the Constitution (Scheduled Castes) Order, 1950, no person who professed a religion different from Hinduism was deemed to be a member of a Schedule Caste in addition to every member of the Ramdasi, Kabirpanthi, Majhabi or Siraligar caste resident in Punjab or Patiala and East Punjab States Union (PEPSU) were in relation to that State whether they professed the Hindu or Sikh religion. Subsequently in September, 1956, by an amendment, the Presidential Order of 1950 and all subsequent Presidential Orders relating Scheduled Castes, the population professing the Hindu and the Sikh religions were placed on the same footing with regard to their inclusion as Scheduled Castes. Later on as per amendment made in the Constitution (Schedule Castes) Order 1990, the Hindu, the Sikh and the Buddhist professing population were placed on the same footing with regard to recognition of the Scheduled Castes. Their occupations are unclean (with respect to upper castes) which include disposal of the dead, flaying of dead animals, menial work, cleaning, etc. Many of them are agricultural labourers, cultivators of small land holdings, petty labourers and industrial workers. To the upper castes, they are "untouchables". The practice of untouchability started with their original "unclean" occupations, and physical contact with upper castes was prohibited. They are forced to live in segregation particularly in rural India.

It is clear from the above description that Scheduled castes have been a deprived, neglected and exploited lot in Indian society since the introduction of caste system in the country. It is, therefore, necessary to make a thorough study of these castes. Scheduled Caste is a heterogeneous group consisting of 542 castes. As regards their social and economic status *vis-à-vis* the rest of the population, they are homogeneous to some extent. Majority of them are poor, live in rural areas and are engaged in agriculture. They provide substantial support to agriculture which is the backbone of Indian economy.

Scheduled castes constitute an important segment of Indian population. The Scheduled Caste population has been increasing steadily since 1951, not only in absolute numbers but also in proportion to the total population. Scheduled Castes population was 64 million in 1961 which rose to 80 million in 1971, 105 million in 1981, 138.2 in 1991 (excluding Jammu and Kashmir where 1991 census could not be held), 166.6

million in 2001 and 201.4 million in 2011. The share of Scheduled Castes population has been growing almost consistently since 1951 at the rate of 1.1 per cent to reach 16.63 per cent of the total population in India in 2011.

Distributional Pattern of Schedules Castes

A reference to **Table 11.2** shows that Scheduled Castes are not confined to specific areas; rather they are distributed all over the country. Uttar Pradesh had the largest number of 41.35 million Scheduled Caste people in 2011. This was followed by West Bengal where 21.46 million Scheduled Caste population. These two states account for nearly one-third (31.3 per cent) of the Schedules Caste population of the country. Other states with large size of the Scheduled Caste population are Bihar (16.5 million), Tamil Nadu (14.4 million), Andhra Pradesh and Telangana (13.8 million), Maharashtra (13.2 million), Rajasthan (12.2 million), Madhya Pradesh (11.3 million), Karnataka (10.4 million), Punjab (8.8 million) and Odisha (7.2 million). States with low concentration of scheduled castes population are Sikkim, Manipur, Meghalaya and Goa. Union territories of Daman and Diu and Dadra and Nagar Haveli also have low concentration of Scheduled Castes. No Scheduled Castes have been reported in the states of Arunachal Pradesh, Nagaland and Union Territories of Lakshadweep and Andaman and Nicobar Islands.

It is clear from the above description that the highest concentration of Scheduled Caste is found in the alluvial plains of north India because they find ready employment as agricultural labourers. They are also found in large numbers in the delta plains of South India. In contrast, most of the north-eastern states and largest parts of Jammu and Kashmir have very low concentration of Scheduled Castes.

In terms of the percentage of Scheduled Caste population to the total population, Punjab with 31.94 per cent tops the list. Other states with more than one-fifth of population being Scheduled Caste are Himachal Pradesh (25.19%), West Bengal (23.51%) and Uttar Pradesh (20.69%). As many as 10 states and union territories have 15 to 20 per cent of their population termed as Scheduled Castes. These are in descending order, Uttarakhand, Chandigarh, Rajasthan, Tripura, Karnataka, Odisha, NCT of Delhi, Andhra Pradesh (including Telangana), Tamil Nadu and Madhya Pradesh. In Jharkhand, Chhattisgarh and Maharashtra, the proportion of Scheduled Caste population to total population varies from 10 to 15 per cent. Kerala, Jammu and Kashmir, Gujarat, Assam and Sikkim have 5 to 10 per cent of the population as Scheduled Castes. Daman and Diu, Manipur, Dadra and Nagar Haveli, Goa, Arunachal Pradesh, and Meghalaya have less than five per cent Scheduled Caste population. Scheduled Castes are negligibly small in Mizoram, no castes have been scheduled for Arunachal Pradesh, Nagaland, Lakshadweep and Andaman and Nicobar Islands (**Fig. 11.1**).

Keeping in view the above description regarding the distribution of Scheduled Caste population, following two zones of high concentration are recognised :

(*a*) The Indo-Gangetic Plains. The Indo-Gangetic Plains are composed of rich alluvial soils. Water supply, suitable climate and weather provide opportunities for agricultural labourers to settle in the alluvial plains. Consequently, the Indo-Gangetic Plains are the zones of high concentration of scheduled castes who are primarily agricultural labourers.

(*b*) The East Coastal Plains. The East Coastal plains provide identical opportunities for the settlement of agricultural communities as they are available in the Indo-Gangetic Plains of the north. Hence, the scheduled castes are found concentrated on eastern coasts particularly in coastal areas of Tamil Nadu, Andhra Pradesh, and Odisha.

The Changing Caste System. The origin of caste system in India may be traced in the Aryan settlement and expansion sometime in the second millennium. Ever since its introduction, caste system has persisted and expanded, with assimilation of new elements, to form new castes. This system has worked very well in the rural, self-contained, conservative society of India in which each social stratum performs its assigned functional role. But this system is based on social inequalities and is surely undemocratic in its fundamental nature. Moreover, it presupposes a fiscal environment of unchanging social norms and needs.

Keeping above facts in mind, there is an urgent need to demolish this unethical, unreasonable, and undemocratic caste system. Fortunately, there are great forces like literacy and constitutional democracy

TABLE 11.2. Total Population and Percentage of Scheduled Caste and Scheduled Tribe : 2011 Census

Sl. No.	India / State/ Union Territory	Total Population ('000)	Scheduled Caste Total Population ('000)	Scheduled Caste Percentage of total population	Scheduled Tribe Total Population ('000)	Scheduled Tribe Percentage of total population
	INDIA	**1,21,05,69,573**	**20,13,78,086**	**16.63**	**10,42,81,034**	**8.61**
1.	Jammu and Kashmir	1,25,41,302	9,24,991	7.37	14,93,299	11.91
2.	Himachal Pradesh	68,64,602	17,29,252	25.19	3,92,126	5.71
3.	Punjab	2,77,43,338	88,60,179	31.94	0	0.00
4.	Chandigarh*	10,55,450	1,99,086	18.86	0	0.00
5.	Uttarakhand	1,00,86,292	18,92,516	18.76	2,91,903	2.89
6.	Haryana	2,53,51,462	51,13,615	20.17	0	0.00
7.	NCT of Delhi*	1,67,87,941	28,12,309	16.75	0	0.00
8.	Rajasthan	6,85,48,437	1,22,21,593	17.83	92,38,534	13.48
9.	Uttar Pradesh	19,98,12,341	4,13,57,608	20.69	11,34,273	0.57
10.	Bihar	10,40,99,452	1,65,67,325	15.91	13,36,573	1.28
11.	Sikkim	6,10,577	28,275	4.63	2,06,360	33.79
12.	Arunachal Pradesh	13,83,727	0	0.00	9,51,821	68.79
13.	Nagaland	19,78,502	0	0.00	17,10,973	86.48
14.	Manipur	25,70,390	97,042	3.78	9,02,740	35.12
15.	Mizoram	10,97,206	1,218	0.11	10,36,115	94.43
16.	Tripura	36,73,917	6,54,918	17.83	11,66,813	31.76
17.	Meghalaya	29,66,889	17,355	0.58	25,55,861	86.15
18.	Assam	3,12,05,576	22,31,321	7.15	38,84,371	12.45
19.	West Bengal	9,12,76,115	2,14,63,270	23.51	52,96,953	5.80
20.	Jharkhand	3,29,88,134	39,85,644	12.08	86,45,042	26.21
21.	Odisha	4,19,74,218	71,88,463	17.13	95,90,756	23.85
22.	Chhattisgarh	2,55,45,198	32,74,269	12.18	78,22,902	30.62
23.	Madhya Pradesh	7,26,26,809	1,13,42,320	15.62	1,53,16,784	21.09
24.	Gujarat	6,04,39,692	40,74,447	6.74	89,17,174	14.75
25.	Daman and Diu*	2,43,247	6,124	2.52	15,365	6.32
26.	Dadra and Nagar Haveli*	34,33,309	6,186	1.79	1,78,564	51.95
27.	Maharashtra	11,23,74,333	1,32,75,898	11.81	1,05,10,213	9.35
28.	Andhra Pradesh and Telangana	8,45,80,777	1,38,78,078	16.41	59,18,073	6.99
29.	Karnataka	6,10,95,297	1,04,74,992	17.15	42,48,987	6.95
30.	Goa	14,58,545	25,449	1.74	1,49,274	10.23
31.	Lakshadweep*	64,473	0	0.00	61,120	94.79
32.	Kerala	3,34,06,061	30,39,573	9.09	4,84,839	1.45
33.	Tamil Nadu	7,21,47,030	1,44,38,445	20.01	7,94,697	1.10
34.	Puducherry*	12,47,953	1,96,325	15.73	0	0.00
35.	Andaman and Nicobar Islands*	3,80,581	0	0.00	28,530	7.49

*Union territory

Source **:** Computed from Census of India 2011 Report on revised data issue on C.D. in 2014.

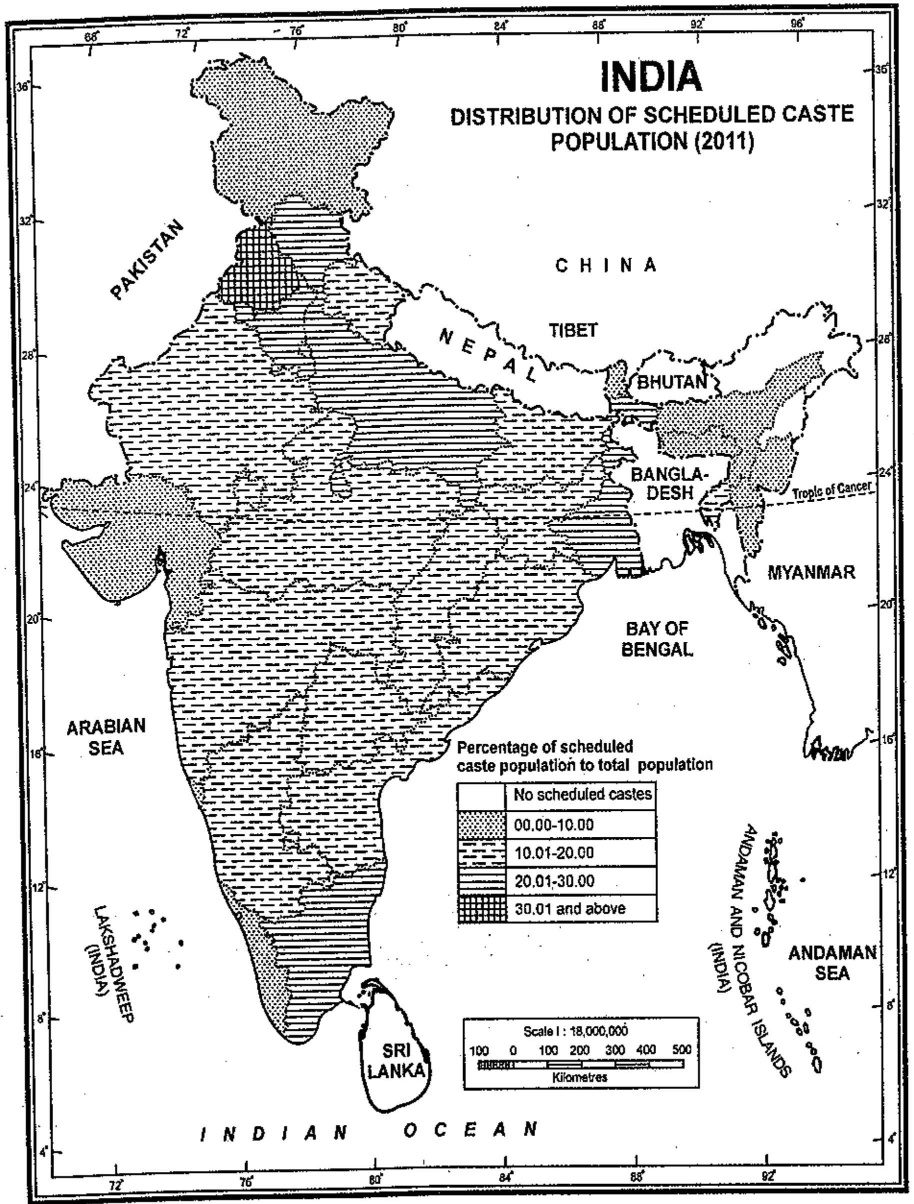

FIG. 11.1. India : Distribution of Scheduled Caste Population (2011)

working with increasing strength against it as the society becomes more urbanised and modernised. Traditional restrictions are slowly being sloughed off in the cities and caste inequalities are being eroded perceptibly. City life inhibits the observance of caste rituals in the matter of interlining and polluting physical contact in public places like cinema houses, shopping areas, city transport, restaurants, etc. Spatial diffusion of these social amenities to rural areas is still limited, but it is on the increase. Transport facilities have penetrated in the rural landscape of India making significant changes in the economic and social life of the rural masses. The traditional self-sufficiency of the villages has been reduced drastically as the money economy becomes more popular. The handicrafts and the caste-related *jajmani* are also disappearing slowly but gradually.

TRIBAL POPULATION

The tribes are the autochthonous or native people of the land who are believed to be the earliest settlers in the Indian Peninsula. They are generally called *adivasis*, implying original inhabitants. The ancient and medieval literature mention a large number of tribes living in India. Before the introduction of the caste system during the Brahminic Age, people were divided into various tribes. A tribe was a homogeneous and self contained unit without any hierarchical discrimination.

The study of tribal population suffers from serious anomalies as there is no clear cut and scientific criteria for this purpose. For example, the Gonds are a Scheduled Tribe in Madhya Pradesh, but a Scheduled Caste in Uttar Pradesh. This problem of anomalies is further aggravated in the case of transhumant groups like the Gujjars of north-western India. A Gujjar Bakarwal Kafila when pasturing in Himachal Pradesh during summer belongs to the scheduled category and the same group loses this status in its winter pastures on the Jammu plains. However, under Article 342 of the Constitution of India, certain tribes have been specified as Scheduled Tribes. Article 342 provides for specification of tribes or tribal communities which are deemed to be for the purposes of the Constitution the Scheduled Tribes and relation to that State or Union territory. In pursuance of these provisions the lists of Scheduled Tribes are notified for each State or Union territory and are valid only within the jurisdiction of the State or Union territory and not outside.

Growth of Tribal Population

The demographic study of tribal population has suffered seriously due to the adoption of arbitrary criteria for 'scheduling' the tribes. After the partition of the country in 1947, the tribal population, as determined by the Constitutional (Determination of Population) Order 1950 was reduced from 24.7 million in 1941 to about 17.9 million. The 1951 census, which was the first census after Independence, recorded a total tribal population of 1,91,19,054. This number of tribal population was according to the terms of the *Scheduled Tribes Order* of 1950. This led to strong resentment among certain tribes resulting in stresses and strains in the Indian polity. In pursuance of the 'Modification Order' of 1956, another 34,00,000 persons, belonging to tribal groups and left out earlier, were added and the number rose to 2,25,19,054. This accounted for 6.23 per cent of the total population of the country at that time. According to 1961 census, there were 3,01,73,998 persons belonging to Scheduled Tribes accounting for 6.87 per cent of the total population of the country. The situation further changed during the 1961-71 inter censal period. Several communities of Uttar Pradesh, *viz*. Jaunsari, Tharus, Buxas, Bhutias and Rajis were included in the 'Schedule' in terms of Presidential Order of June 1967. Thus at the time of 1971 census, the number of Scheduled Tribes had risen to 3,80,15,162 accounting for 6.94 per cent of India's total population. In 1981, the total tribal population (excluding Assam where 1981 census was not held) was 5.38 crore which worked out to 7.58 per cent of the total population. The decennial growth rate during 1971-81 was abnormally high at 41.56 per cent. This was caused by the amendment in the lists of Scheduled Tribes in 1976 removing area restrictions. During this decade, the list of Scheduled Tribes was promulgated by the President in respect of Sikkim (22-6-1978). As per 1991 census, Scheduled Tribes population was 6,77,58,380 (excluding Jammu and Kashmir) and its share in the total population worked out to be 8.08 per cent. The decennial growth during 1981-91 was 25.91 per cent. The rate of growth of the tribal population during 1991-2001 had been recorded at 24.34 per cent, which was higher than the general population growth rate of 21.54 per cent. The tribal population of India increased from 8.43 crore in 2001 to 10.43 crore in 2011 registering a growth rate of 23.72 per cent during the decade. Table 11.3 shows the growth of tribal population as well as its share in the total population.

It is obvious from the above discussion that the growth of Scheduled Tribes population was due to following two reasons :

(*i*) There has been a rapid natural growth of tribal population and

(*ii*) Additions have been made to the list of Scheduled Tribes time and again.

TABLE 11.3. Growth of Scheduled Tribes in India

Census Year	Total Population of Scheduled Tribes in lakhs	Percentage of Scheduled Tribes to Total Population
1951	225	6.23
1961	302	6.87
1971	380	6.94
1981*	538	7.58
1991**	678	8.08
2001	843	8.20
2011	1,043	8.61

*Excluding Assam

**Excluding Jammu and Kashmir

Source **:** (*i*) Census of India 2001

(*ii*) Census of India 2011 Report released on C.D. in 2014.

There are divergent opinions regarding the actual number of tribal communities living in different parts of India. The 1961 census recorded 354 communities based on the scheduled castes and scheduled tribes lists (Modification Order, 1956), **N.K. Bose** (1971) and B.K. Roy Burman (1972) had put the number of Scheduled Tribes at 427 and 450 respectively. The Census of India had given the number of scheduled tribes as 573 in its paper-2 of 1992 of series 1. But a caution has been given that it should not be taken as the total number of tribes, as a tribe might have been notified in different states and union territories and counted as tribe more than once. For example, Bhil has been notified as a scheduled tribe in Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Tripura. Thus in the total of 573, Bhil has been added seven times, once in each of the seven states. Hence, this total does not reflect the actual number of tribes in the country. A fairly accurate estimate puts the number of tribes in India at 365.

Distribution of Scheduled Tribes

An appraisal of the distribution pattern of the tribal communities shows that their spatial distribution is characterised by a striking tendency of clustering and concentrating in pockets, which have suffered from isolation and are situated in areas where environmental setting is, by and large, not suitable for settled agriculture. Thus, most of the tribal communities live in hilly and forested tracts and other remote areas of the country. Constrained by the rigors of environment, which fostered physical and social isolation for ages, the tribal communities have developed their own traditional mode of living. However, the interaction between tribal and non-tribal people after Independence has changed the scenario to some extent.

The distribution of Scheduled Tribes is markedly different from that of Scheduled Castes. For example, Scheduled Tribes have a tendency to concentrate in remote and less hospitable areas, whereas Scheduled Castes show a very high concentration in the fertile Indo-Gangetic Plain and the Coastal Plains where they work as agricultural labourers. Further, it is interesting to note that while no caste has been scheduled in Arunachal Pradesh, Nagaland, Andaman and Nicobar Islands and Lakshadweep, no tribe has been scheduled in the states of Haryana and Punjab and the Union Territories of Chandigarh, Delhi and Puducherry.

State Level Patterns

There are wide variations in the state level distribution of tribal population. While, on one hand, no tribes have been scheduled in Punjab and Haryana, and the union territories of Delhi, Chandigarh and Puducherry, as much as 94.43 per cent of the total population in Mizoram and 94.79 per cent in Lakshadweep belongs to Scheduled Tribes. The other States/Union Territories with predominantly Scheduled Tribes population are : Nagaland (86.48), Meghalaya, (86.15), Arunachal Pradesh (68.79). Manipur, Chhattisgarh and Tripura also have substantial proportion of population as Scheduled Tribes. Among the 15 major states, Chhattisgarh has the largest proportion of Scheduled Tribe population of 30.62 per cent followed by Jharkhand 26.21 per cent. Gujarat, Assam, Rajasthan and Jammu and Kashmir and Goa are the other four major States in

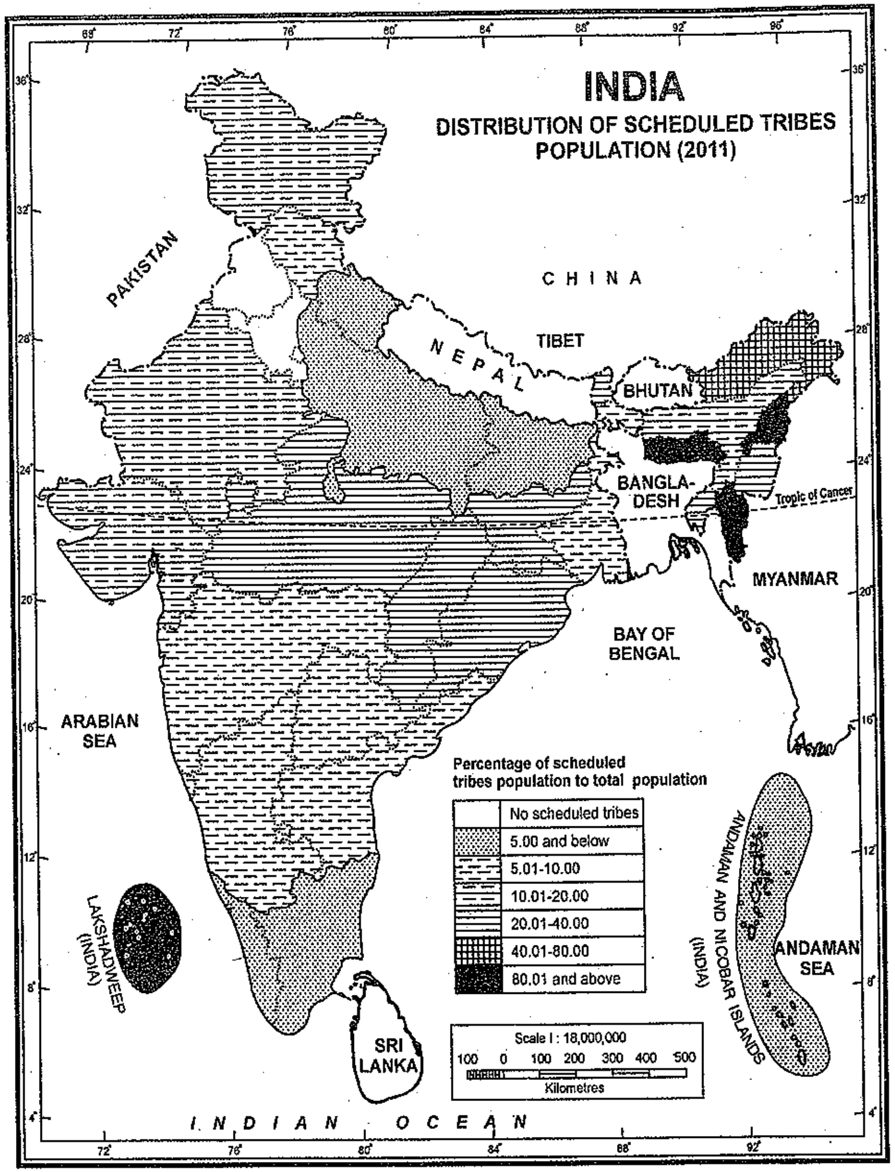

FIG. 11.2. India : Distribution of Schedule Tribes

which more than 10 per cent of the population belong to Scheduled Tribes.

Of the total Scheduled Tribes population of about 10.43 crores counted in different States/UTs in India, 14.68 per cent are in Madhya Pradesh, 10.08 per cent in Maharashtra and 9.12 per cent in Odisha. Thus, roughly one-third of the Scheduled Tribes population of India lives in these three states only. Going a little

further, 71 per cent of the Scheduled Tribes population of India lives in six states, viz. Madhya Pradesh, Maharashtra, Odisha, Gujarat, Rajasthan and Jharkhand. In terms of absolute numbers, the Scheduled Tribes population was 153.17 lakhs in Madhya Pradesh, 105.1 lakhs in Maharashtra, 95.9 lakhs in Odisha, 92.38 lakhs in Rajasthan, 89.17 lakhs in Gujarat, 86.46 lakhs in Jharkhand 54.18 lakhs in Andhra Pradesh (including Telangana), 52.96 lakhs in West Bengal, 42.49 lakhs in Karnataka, 38.84 lakhs in Assam, 25.56 lakhs in Meghalaya and 17.11 lakhs in Nagaland. All other states and Union territories together have about 45 lakhs Scheduled Tribe population; there being absolutely no scheduled tribe population recognised in Haryana, Punjab, Chandigarh, Delhi and Puducherry.

Tribal Economy

Tribal economy forms an important criterion for classifying Scheduled Tribes in India. The dominant economies of the tribes are : (1) Hunting, fishing and food gathering, (2) Shifting cultivation and lumbering, and (3) Sedentary cultivation and animal husbandry. A brief account of tribes practising these economies is given as under :

(1) Hunting, Fishing and Gathering. A large number of tribes live in isolation in forests and depend upon hunting, fishing and food gathering. Some of the tribes depend exclusively on these occupations. The main tribes which practise these professions are the Raji in Uttar Pradesh; Kharia, Birhor, Korwa, Pariha and Birgias in Jharkhand; Kuki in West Bengal; Hill-Maria in Chhattisgarh, Juang in Odisha, Chenchu and Yanadi in Andhra Pradesh and Telangana; Koya, Reddi, Kadar and Paliyan in Tamil Nadu, Bhil, Garasia in Maharashtra and Gujarat; Bhil, Garasia and Sahariya in Rajasthan and Kuki, Konyak and Naga in Assam, Meghalaya, Nagaland and Arunachal Pradesh.

(2) Shifting Cultivation and Lumbering. Shifting cultivation is said to be as old as history of agriculture itself. In this type of cultivation, a piece of forest land is cleared by slash-and-burn technique and crops are grown. After 2-3 years, the fertility of the soil is reduced and the farmer shifts to another piece of land. This is the reason that it is called shifting agriculture. It is known by different names in different parts of the country. It is called *Jhum* or *jum* in north-east India, *kumari* in Western Ghats, *watra* in south-east Rajasthan and *penda, bewar* or *dahia* and *deppa* in different parts of Chhattisgarh and Madhya Pradesh. **Lumbering** involves obtaining wood from the forests. The main tribes practising shifting cultivation and lumbering are Koria, Saharia, Bhutias and Kharwar in Uttar Pradesh, Korwa and Asur in Jharkhand; Garo, Mal-Paharia in West Bengal; Maria, Gonda, Baiga and Dhora in Chhattisgarh and Madhya Pradesh; Saora, Khond, Kurumba and Bagola in Andhra Pradesh; Saora, Keria and Khond in Odisha; Khond, Gond, Kurumba and Muduwan in Tamil Nadu; Bhil and Garasia in Maharashtra and Gujarat; Kathodia in Rajasthan, Naga, Lakher, Chakmas, Garo, Riang, Notia, etc., in the north eastern states.

(3) Sedentary Cultivation and Animal Husbandry. Sedentary cultivation is a type of agriculture in which the farmer grows crops to meet his own requirements and not much is left for sale in the market. This is not an advanced type of cultivation and is generally practised by the tribal people along with animal husbandry. The main tribes adopting these professions are the Tharu, Maghi Khasa, Bhoksa, Kol and Bhotias in Uttar Pradesh; Munda, Ho, Oraon, Tamaria, Korwa and Santhal in Jharkhand; Santhal, Polia, and Bhumji in West Bengal; Parja, Bhatra, Baija and Gond in Chhattisgarh and Madhya Pradesh, Badaga, Irula, Parga and Malydi in Tamil Nadu, Badaga, Koya, Irula and Kota in Andhra Pradesh and Telangana; Bhil, Dubla, Raiwari, Barali, Koli, Dhamalia, etc. in Maharashtra and Gujarat, and Bhil, Garasiya and Meena in Rajasthan.

LANGUAGE AND DIALECT GROUPS

India is a land of vastness and continuity. It is now certain that the inhabitants of the country are not her original people. They entered India in different spans of time and got settled here. Most of them belong to the Asian parts—Central, Eastern and Western. It is natural that differences and variations exist in their languages and dialects owing to their coming into India from different parts of Asia. After coming into India, cultural mixing has taken place among various races and it led to the mixing of their languages and dialects to a great extent. Despite all this, people of different races and classes live in different parts of the country and they speak different languages and dialects.

Classification of Indian Languages

People of India speak a large number of languages which are broadly divided into the following four families :

1. Indo-European Family (Arya),
2. Dravidian Family (Dravida),
3. Austric Family (Nishada), and
4. Sino Tibetan Family (Kirata).

The above classification is based upon the number of people speaking each family of languages. The first is the Aryan family which is numerically and also culturally, the most important in India. About 73% of the Indian population speaks different languages of the Aryan family. Next comes the Dravidian family which is spoken by about 20 per cent of the Indian population. The Austric and the Sino-Tibetan languages are spoken by small percentage of people.

1. The Aryan Languages

This is the most important of all the families of languages and spoken by a little less than three fourths of the Indian population. The Aryan languages are divided into following two main branches :

(*i*) The Dardic Aryan Languages and

(*ii*) The Indo Aryan Languages

(*i*) **The Dardic Aryan Languages.** This group comprises a number of languages which are current among very small mountain communities in Kashmir. Out of India, it is spoken by small communities living on the frontier between Pakistan and Afghanistan. The Dardic languages fall into three branches : (*a*) Shina including Kashmiri, Shina proper and Kohistani; (*b*) Khowar or Chatrari or Chitrali and (*c*) Kafiristan (or Nuristani) dialects.

In Kashmir, there is Shina and Kashmiri, and some dialects allied to Kashmiri. Kashmiri appears to be in its bases a Dardic Aryan dialect. But it has been profoundly influenced by Sanskrit and the Prakrits from the very early times. Many scholars are of the opinion that Kashmiri is Indo-Aryan rather than Dardic. Most scholars consider Dardic to be just a branch of Indo-Aryan. These Dardic dialects are largely on the way to extinct. Kashmiri, however, is one of the recognised national languages of the Indian Union. Except Kashmiri, which is spoken by more than 20 lakh people, no other language of the Dardic Aryan languages is spoken by more than 7 thousand people.

(*ii*) **The Indo-Aryan Languages.** This is the second sub-group of the Aryan languages in which Hindi, Bengali, Punjabi, Rajasthani, Gujarati, Sindhi, Kachchi, Marathi, Oriya, Sanskrit, Assamese and Urdu are included. Based upon the regional distribution of the people speaking these languages, they are further grouped as under :

(*a*) ***Northern Aryan Languages.*** Languages of this group belong to the dialects spoken by the hilly people in North India. They include Nepali, Central Pahari and Western Pahari Aryan languages.

(*b*) ***North-Western Aryan Languages.*** Khanda, Kachchi and Sindhi are the well-known Aryan languages which are spoken by the people living in the north-western part of the country.

(*c*) ***Southern Aryan Languages.*** Marathi and Konkani are the languages included in the Southern group of Aryan languages.

(*d*) ***Eastern Aryan Languages.*** The region of these languages lies in the eastern parts of the country. Bihari, Oriya, Bengali and Assamese languages constitute this group of Aryan languages.

(*e*) ***East Central Aryan Languages.*** Avadh, Bundelkhand and Chhattisgarh regions include these languages as the languages of the people living there. Avadhi, Bugheli and Chhattisgarhi are their languages.

(*f*) ***Central Aryan Languages.*** The central region of India is the region of Central Aryan languages. The major languages of this region are Hindi, Punjabi, Rajasthani and Alawari.

Among the Aryan languages, Hindi is the most important language, spoken by a large percentage people of the country. In every Indian state, Hindi-speaking people are commonly found. Even the illiterate people can speak and understand Hindi. It would, therefore, be in the interest of one and all to give Hindi the status of a national language.

2. Dravidian Languages

Dravidian languages are older than the Aryan languages. According to an estimate, Dravidians entered India much before the Aryans. Other estimates indicate that they are the original inhabitants of the country, who were driven away towards south by the Aryans at a later stage. Today, the Dravidian languages form a well knit family by themselves and unlike the Aryan, the Austric and the Sino-Tibetan speeches, they have no relations outside the Indian subcontinent. The Dravidian languages fall into several groups. Two major groups are as under :

(*i*) **The North Dravidian Languages.** Telugu and a number of other languages such as various Gondi dialects, Kuruth or Oraon, Maler or Malpahariya, Kui or Kandh, Parji, Kolami and a few others are included in this group. Telugu is numerically the most important of all the Dravidian languages and has a very rich literature. This language has spread outside India also—in Myanmar, Indo-China and South Africa. It is usually called the *Italian of the East* by its admirers. Its vocabulary is much influenced by Sanskrit.

(*ii*) **South Dravidian Languages.** This group of languages includes Tamil, Kannada and Malayalam. A number of speeches like Tulu, Kota, Kurgi (or Kedagu) and Toda are also included in this group. Tamil is spoken in large parts of Tamil Nadu. Outside India, it is spoken by a large number of people in Sri Lanka. This language has preserved the old Dravidian spirit in its original form to a great extent. Tamil literature goes back to many centuries before Christ. Tamil presents certain new literary types which are not found in Sanskrit and other Aryan languages. While it includes extensive Sanskrit element, this language has retained the purity of its Dravidian vocabulary to a much greater extent than any other cultivated Dravidian language.

Malyalam is currently the language of Kerala and Lakshadweep. It had its origin in the old Tamil about 1,500 years ago. The Old Tamil speech, started showing simplifications as early as 10th century A.D. Then it followed its own path away from its sister dialects. The speech of Kerala developed independently and became transformed into Malyalam. The first Malayalam writings are said to go back into the period from 13th century to 15th century, when it was established as an independent language. Malayalam has been influenced by Sanskrit more than any other language of India.

Kannada is the main language of the present Karnataka state. The literary cultivation of this language began from the middle of the first millennium A.D. Kannada has passed through three stages : (*a*) Old Kannada upto 13th century (*b*) Medieval Kannada upto 16th century and (*c*) Hosa Kannada which is the language of the present day.

3. Austric Languages

The Austric languages of India belong to the Austro-Asiatic sub-family. This category is further sub-divided into Munda and Mon-Khmer.

(*i*) **Munda or Kol Languages.** Munda languages are the largest of the Austric group of languages. They consist of fourteen tribal languages. The Kherwari is the major group, which is current in Eastern India (Chota Nagpur, Odisha, Chhattisgarh and West Bengal) and includes Santhali, Mundari, Ho, Birhor, Bhumiej, Korwa and Korku (or Kurku). Santhali, Mundari, and Ho languages have a noteworthy literature preserved orally, consisting of songs and mythological romantic stories.

(*ii*) **Mon-Khmer Languages.** Mon-Khmer group of Austric languages has two sub-groups—Khasi and Nicobari. Khasi languages are spoken by Khasi tribal people of Meghalaya, while Nicobari languages are the languages of the tribal people of the Nicobar islands. Khasi used to be written in Bengali-Assamese script about a century ago. Through the influence of Welsh Methodist missionaries, the Roman alphabet has been adopted for Khasi and some literature has been produced.

4. Sino-Tibetan Languages

The Sino-Tibetan languages are spoken by a variety of people. Depending upon the region of settlement, these languages are put into several groups and sub-groups. Sino-Tibetan languages have three major sub-divisions :

(*i*) The Tibeto-Himalayan.

(*ii*) The North-Assamese

(*iii*) The Assam-Myanmari (Burmese)

(*i*) **The Tibeto-Himalayan Languages.** This sub-division of the Sino-Tibetan group of languages is further sub-divided as the Himalayan group and the Bhutia group.

(*a*) ***The Himalayan Group.*** The Himalayan group consists of 4 languages. They are Chamba, Lahauli, Kannauri and Lepcha. Kannauri is the most widely spoken language of the Himalayan group.

(*b*) ***The Bhutia Group.*** Tibetan, Balti, Ladakhi, Lahauli, Sherpa and Sikkim Bhutia are included in the Bhutia group of Sino-Tibetan languages. Ladakhi has largest number of Bhutia speakers. It is followed by Sikkim Bhutia and the Tibetan languages in that order.

(*ii*) **North Assam Languages.** The North Assam branch of languages of the Sino-Tibetan group is also called the *Arunachal* branch. It consists of six languages, such as Aka, Daflta, Abor, Miri, Mishnil and Mishing. Largest number of people speak Miri language.

(*iii*) **The Assam Myanmari Languages.** This group of languages include Boro or Bodo, Naga, Cochin, Kukichin and Myanmar groups. Naga is the largest speaking language of this group.

Besides these, the Sino-Tibetan group of languages has some other important languages. They are Manipuri, Garo, Tripuri, Mikir and Lusai. Lusai is also termed as Mizo.

Linguistic Regions. It is said that India is a (veritable) forest of languages. In the Linguistic Survey conducted during the British period it was concluded that there were 179 languages and 544 dialects in this region (Linguistic Survey of India, 1903-1928). The principal credit for this significant piece of work is given to its editor-in-chief Sir George A. Grierson. In this survey of modern Indian languages, he classified them into language families along historical (comparative) lines. Out of a total of 179 languages mentioned in the Linguistic Survey, 116 are small tribal speeches. They are spoken only on the northern and north-eastern fringes of India and are current among less than one per cent of the total population of the country. Nearly two dozen more are, likewise, insignificant speeches of other language groups; or they are languages not truly belonging to India.

The most comprehensive data on languages was collected at the time of 1961 Census. According to these census figures, there were 187 languages spoken in India. Out of these, as many as 94 languages are spoken by less than 10,000 persons each and 23 languages together account for 77 per cent of the total population of the country. Of these 23 languages, 15 languages in addition to English have been specified in the Eighth Schedule of the Constitution of India. Three more languages have been added to Eighth Schedule by a Parliamentary Act on 20th August, 1992. These languages are Nepali, Konkani and Manipuri. Later on, Maithili, Santali, Dogri and Bodo were also included in the Schedule, making a total of 22 languages. The number of people and their percentage to the total population speaking these languages is given in **table 11.4.**

TABLE 11.4. Schedule Languages in Descending Order of Speakers' Strength-2001

Language	Persons who returned the language as their mother tongue 2001	Percentage to total population 2001
INDIA	1,02,86,10,328	96.56
1. Hindi	42,20,48,642	41.03
2. Bengali	8,33,69,769	8.11
3. Telugu	7,40,02,856	7.19
4. Marathi	7,19,36,894	6.99
5. Tamil	6,07,93,814	5.91
6. Urdu	5,15,36,111	5.01
7. Gujarati	4,60,91,617	4.48
8. Kannada	3,79,24,011	3.69
9. Malayalam	3,30,66,392	3.21
10. Oriya	3,30,17,466	3.21
11. Punjabi	2,91,02,477	2.83
12. Assamese	1,31,68,484	1.28
13. Maithili	1,21,79,122	1.18
14. Santali	64,69,600	0.63
15. Kashmiri	55,27,698	0.54
16. Nepali	28,71,749	028
17. Sindhi	25,35,485	0.25
18. Konkani	24,89,015	0.24
19. Dogri	22,82,589	0.22
20. Manipuri	14,66,705	0.14
21. Bodo	13,50,478	0.13
22. Sanskrit	14,135	N

Speakers of certain other languages left out of the Eighth schedule are demanding the inclusion of their languages in the list of the languages. Some of the important languages of this category are Sindhi, Rajasthani, Khasi and Gondi.

Language became a very important basis for the formation of states in India after Independence, thereby adding a new political meaning to the geographical distribution of languages. Today, most of the states of the Indian Union have been delimited on the basis of linguistic pattern of languages. However, the languages and dialects of the tribal people living in the north-eastern, eastern and central parts of the country do not fit in any linguistic pattern, as they are varying in number and their speakers live in unspecified areas or regions. In all, there are 12 languages in India, which are widely spoken.

Based on these languages, there are twelve linguistic states, of which states delimited from the political point of view are depicted in **Table 11.5** and **Fig. 11.3**.

The relative importance of different languages had undergone drastic change in the historical time. Until the ninth century, Sanskrit was the language for administration and of the cultural elite. Today, Sanskrit is no longer a spoken language, although it is mother of any Indian language. Persian and later Urdu became the court and the administrative language of the Mughal and other Muslim rulers. In the eighteenth century when the Britishers established their supremacy and became the rulers of India, English replaced Persian as the language of courts, administration and higher learning. In the post-independence period, Hindi has emerged as the most popular language and is spoken by majority of people living particularly in north India. This is the official language of several Hindi speaking states like Uttar Pradesh, Uttarakhand, Bihar, Jharkhand, Madhya Pradesh, Chhattisgarh, Haryana, Rajasthan, and Himachal Pradesh. Including its variants like the Bihari, Rajasthani, Marwari, Magadhi, Chhattisgarhi, Maithili, Pahari, Bhojpuri, etc. Hindi ranks numerically third most widely spoken language of the world after Mandarin Chinese and English. As per 2001 Census figures, Hindi along with its recognised regional variants is spoken by 422 million Indians which is about 41% of the total population. The other major languages are Bengali (8.1%), Telugu (7.2%), Marathi (6.9%), Tamil (5.9%) and Urdu (5.0%). Gujarati, Kannada, Malayalam, Oriya, Punjabi and Assamese are spoken by less than 5 per cent but more than one per cent of total population. Kashmiri, Nepali, Sindhi, Konkani, Dogri, Manipuri, Bodo and Sanskrit are spoken by less than one per cent population each.

TABLE 11.5. Linguistic Regions and Languages

Linguistic Region	State/U.T.
1. Kashmiri	Valley of Kashmir
2. Punjabi	Punjab and adjoining parts of Haryana
3. Hindi	U.P., Haryana, H.P., M.P., Chhattisgarh, Jharkhand, Uttarakhand, Delhi, Bihar and Rajasthan
4. Bengali	W. Bengal and Parts of Tripura
5. Assamese	Assam and other northeastern states
6. Oriya	Odisha
7. Gujarati	Gujarat
8. Marathi	Maharashtra, Goa
9. Kannada	Karnataka
10. Telugu	Andhra Pradesh and Telangana
11. Tamil	Tamil Nadu, Puducherry
12. Malayalam	Kerala, Lakshadweep

It is worth mentioning here that although, the present political map of India represents more or less the language map of the country, the state boundaries do not always correspond to linguistic boundaries. The example of Hindi belt may be cited here. This belt covers major states of Uttar Pradesh, Bihar, Jharkhand, Rajasthan, Madhya Pradesh, Chhattisgarh, Haryana, Himachal Pradesh and Uttarakhand including the union territories of Delhi and Chandigarh. In these areas, various languages and dialects have all been brought under the aegis of Hindi and without considering the spoken languages in Garhwal or Kumaon, Magadha or South Bihar, Rajasthan and Bastar district of Chhattisgarh the entire region has been labelled as the Hindi area. As a matter of fact, the linguistic boundary itself is not well defined. Instead of being a sharp line, it is a transitional zone over which one language gradually loses its dominance and gives way to the other.

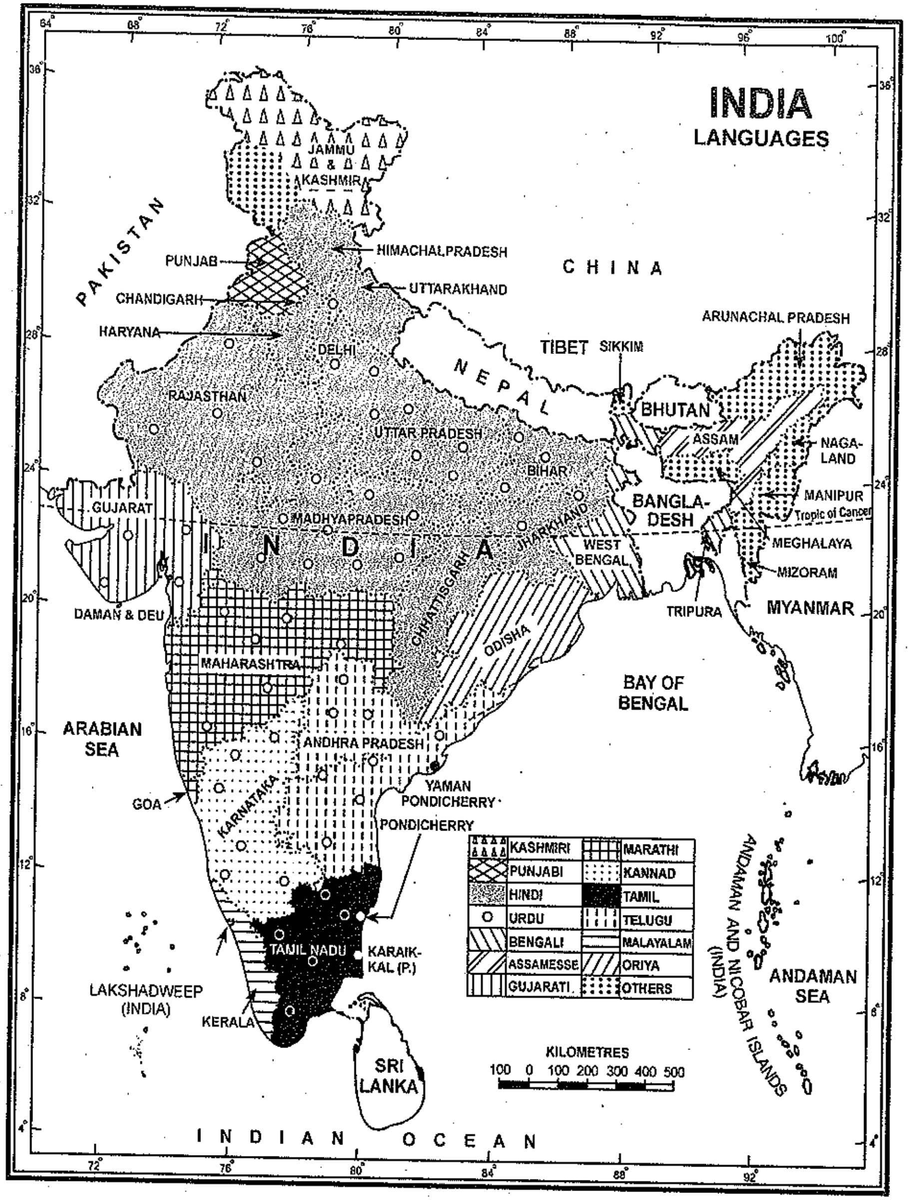

Fig. 11.3. Linguistic Regions

The complexity and diversity of India's linguistic landscape is further compounded by the prevalence of considerable bilingualism or multilingualism along the inter-state boundaries where two or three languages merge into each other. It is estimated that about 10 per cent of India's population is bilingual or trilingual. In several states, the major language of one adjacent state is the second largest language of the

state. For example Tamil is the second most important language in Kerala; in Tamil Nadu it is Telugu; in Telangana it is Urdu. As a matter of fact, Urdu is the "second language" of over 43 million speakers in several states (**Fig. 11.3**). Hindi is claimed to be the "second language" by about 30 million speakers living out of the "Hindi belt". States of Uttar Pradesh, Uttarakhand, Madhya Pradesh, Bihar, Jharkhand, Chhattisgarh, Haryana, Himachal Pradesh and Rajasthan are included in the "Hindi belt". Further, nearly 10 per cent of the Telugu-speakers live outside the Telugu-speaking states of Andhra Pradesh and Telangana. Cosmopolitan cities like Delhi, Mumbai, Kolkata and Chennai contain significant number of speakers of several languages.

National Language and National Unity

Talking of a national language for people living in a polyglot country like India is a complicated matter and poses a serious problem. Hindi is spoken by the largest number of people living in large states. As such Hindi has been championed as the national language since India got independence. The Indian Constitution bestows upon 22 of the country's major languages status of official languages (**Table 11.4**) with pride place for Hindi (in Devanagari script) which is recognised as the "official language" for all India communication at the central level. The Constitution of India also provided that English would continue to be used for all purposes at the central level for a period of 15 years from 1950 to 1965. This language was assigned a special role in central government's transactions, in parliamentary debate, in courts and as a medium of instruction for specialised subjects for higher and technical education, and also a **'link'** language between various states. At the state level, regional languages are the official languages.

Making Hindi the central language by 1965 met with great resistance from the non-Hindi speaking states, particularly the Dravidian language states in south India. It was argued that literary tradition in Hindi was less developed as compared to that of several regional languages such as Bengali, Tamil, Telugu, Marathi, etc. To make things more complicated Hindi was infused with Sanskrit based vocabulary. As such Hindi went beyond the comprehension of non-Hindi speaking people and hence unacceptable to them. The problem became further complicated when Hindi was accorded the status of optional administrative language at the level of central government and the Public Service Commission examinations. This was treated as a discriminatory imposition of Hindi imperialism by several non-Hindi speaking states. To allay the fears of non-Hindi speaking states, the parliament passed the language bill 1963 according to which English was to continue to be used even after 1965, in addition to Hindi. Thus, English was allowed to be used "as an associate official language" until all non-Hindi speaking states had consented to the use of Hindi, thereby retaining English almost indefinitely. Thus, English remains an official language of the central government along with Hindi, and is *serving as a link between the different states*.

Since independence, English has been loosing its importance as medium of instruction and as official language. Several non-Hindi speaking states have been advancing their regional languages as the primary media of instruction at school, college and university level as well as for public service examinations. This has dealt a severe blow to English in these states. Circulation of regional language newspapers and films have tended further to weaken the usage of English as a *lingua franca*. However, English still continues to enjoy the status of an associate official language and an important link between different linguistic regions. The language problem still does not show any sign of abatement and is putting India's overall structure of national unity to a severe test.

RELIGIOUS COMPOSITION

Religion is a very important characteristic of the Indian population and Indian masses are *religious par excellence*. Religion is a way of life in India and it affects the social, economic and political structure of society. Different religions followed by different people living in different parts of the country, have created diversity of culture and brought about changes in life style of the masses.

India is the birth place of four major religions—*Hinduism, Buddhism, Jainism* and *Sikhism*. The most dominant religion, however, is Hinduism. *Hindustan*, the land of the Hindus, is one of the names by which

TABLE 11.6. Population by Religious Communities and Sex, India, 1961-2001

Religious Communities	1961	1971	1981	1991	2001
Person					
All religious communities	**439,234,771**	**547,949,809**	**665,287,849**	**838,583,988**	**1,028,610,328**
Hindus	366,526,866	453,292,086	549,779,481	687,646,721	827,578,868
Muslims	46,940,799	61,417,934	75,512,439	101,596,057	138,188,240
Christians	10,728,086	14,223,382	16,165,447	19,640,284	24,080,016
Sikhs	7,845,915	10,378,797	13,078,146	16,259,744	19,215,730
Buddhists	3,256,036	3,812,325	4,719,796	6,387,500	7,955,207
Jains	2,027,281	2,604,646	3,206,038	3,352,706	4,225,053
Others	1,498,895	2,184,556	2,766,285	3,269,355	6,639,626
Religion not stated	113,040	36,083	60,217	415,569	727,588
Males					
All religious communities	**226,293,201**	**283,936,614**	**343,930,423**	**435,216,358**	**532,156,772**
Hindus	188,750,134	234,837,669	284,392,942	357,252,833	428,678,554
Muslims	24,262,926	31,961,789	38,989,763	52,631,365	71,374,134
Christians	5,394,783	7,161,792	8,113,569	9,848,930	11,984,663
Sikhs	4,242,565	5,583,846	6,957,891	8,610,508	10,152,298
Buddhists	1,643,476	1,942,757	2,416,780	3,272,200	4,074,155
Jains	1,053,565	1,342,870	1,651,361	1,722,715	2,177,398
Others	741,436	1,086,525	1,376,106	1,649,354	3,332,551
Religion not stated	57,216	19,366	32,011	220,253	383,019
Females					
All religious communities	**212,941,570**	**264,013,195**	**321,357,426**	**403,367,630**	**496,453,556**
Hindus	177,776,732	218,454,417	265,386,539	330,393,888	398,900,314
Muslims	22,677,873	29,456,145	36,522,676	48,964,692	66,814,106
Christians	5,333,303	7,061,590	8,051,878	9,791,354	12,095,353
Sikhs	3,603,350	4,794,951	6,120,255	7,649,236	9,063,432
Buddhists	1,612,560	1,869,568	2,303,016	3,115,300	3,881,052
Jains	973,716	1,261,776	1,554,677	1,629,991	2,047,655
Others	757,459	1,098,031	1,390,179	1,620,001	3,307,075
Religion not stated	55,824	16,717	28,206	195,316	344,569

Source : Census of India, 2001, The First Report on Religion Data Abstract (2004) p. xxvii.

India was known. Hinduism, a religion thousands of years old and whose origin is difficult to trace, evovled out of the varied Indian ways of life, so different and yet in some intangible way unified. The early pre-Vedic Hindu religion got modified in the Vedic period after the middle of the second millennium B.C.

In addition to being the birth place of four major religions of the world, India has embraced other world religions also. For example, Christianity and Islam came to India from other lands. The entry of these two religions in India goes back to almost the first days of their prophets. Syrian Christians appeared on the West Coast of India in the very first century of the Christian Era. The Arab traders brought Islam to the West Coast of India much before the Muslim conquest of this country. The prosecuted Jews and Zoroastrians (Parsis) found sanctuary on the Indian soil. Sikhism appeared on the religious scene of India only about five centuries ago.

There have been large scale changes in the religious composition of population due to conversions from one faith to another. Spatial pattern of distribution of different religious groups had undergone drastic changes due to large scale migrations as a result of partition of India in 1947. Before partition, Hindus accounted for 66.5 per cent of the population of the sub-continent and Muslims 23.7 per cent (census 1941). With partition, large number of Muslims migrated from India to Pakistan and Bangladesh and Hindus migrated to India from these countries. Consequently, the proportion of these two religious communities in the total population changed. The percentage of Hindus rose to 84.1 per cent and that of Muslims fell to 9.8 per cent (census 1951). Since then, the percentage of Hindu population has fallen marginally while that of Muslims has increased considerably. The percentage of Hindus had fallen from 83.4 per cent in 1961 to 80.5 per cent in 2001 while that of Muslims had increased from 10.7 per cent in 1961 to 13.4 in 2001. However, after making adjustment for Assam and Jammu and Kashmir, where census could not be conducted in 1981 and 1991 respectively, the percentage of the Hindus and Muslims work out at 81.4 and 12.4 respectively in 2001. (*see* **Table 11.7**).

One heartening fact about religious composition of India is that different religious groups have coexisted for the last several centuries even during the troubled times when there have been clashes based on

TABLE 11.7. Proportion of Population by Religious Communities, India, 1961-2001

Religious communities	Unadjusted					Adjusted*				
	1961	1971	1981	1991	2001	1961	1971	1981	1991	2001
All religious communities	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Hindus	83.4	82.7	82.6	82.0	80.5	84.4	83.5	83.1	82.4	81.4
Muslims	10.7	11.2	11.4	12.1	13.4	9.9	10.4	10.9	11.7	12.4
Christians	2.4	2.6	2.4	2.3	2.3	2.4	2.6	2.5	2.3	2.3
Sikhs	1.8	1.9	2.0	1.9	1.9	1.8	1.9	2.0	2.0	1.9
Buddhists	0.7	0.7	0.7	0.8	0.8	0.7	0.7	0.7	0.8	0.8
Jains	0.5	0.5	0.5	0.4	0.4	0.5	0.5	0.5	0.4	0.4
Others	0.3	0.4	0.4	0.4	0.6	0.3	0.4	0.4	0.4	0.7
Religion not stated	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.

*Excludes Jammu & Kashmir and Assam for all decades from 1961 to 2001.

Note : 1. The Census 2001 population figures for India and Manipur exclude those of Mao Maram, Paomata and Purul sub-divisions of Senapati district of Manipur.

2. No Census conducted in Assam in 1981 and in Jammu & Kashmir in 1991.

3. Neg.—Negligible.

Source : Census of India, 2001, The First Report on Religion Data Abstract, (2004), p. xxviii.

religion. India is the only country in the world where people belonging to different relgious faiths are co-existing in peace and harmony.

The Hindus

As mentioned earlier, the Hindus are the preponderant majority in most of the states and union territories of India. According to 2001 census figures here were 827.6 million Hindus which accounted for 80.5 per cent of the total population of the country . The Hindus of India account for about 12 per cent of the world population ranking below those professing Christianity and about equal with the followers of Islam, but much above other religions. However, the percentage of Hindus to total population of India is decreasing gradually. It came down from 83.4 per cent in 1961 to 80.5 per cent in 2001. This is largely because of comparatively lower growth rate of the Hindus and partly due to conversion of Hindus into other religious faiths. For example, the unadjusted growth rate of Hindu population was registered at 20.3 per cent as against 22.7 per cent for all religions in 1991-2001. But as per adjusted figures the growth rate of the Hindus was 20.0 per cent against 21.5 per cent recorded for all religions during the decade 1991-2001.

The growth rate of the Hindus had been declining consistently since 1971. It was 24.2 per cent in 1971-81, 22.8 per cent in 1981-91 and fell down to 20 per cent in 1991-2001 (**Table 11.8**).

The Hindus constitute the majority community in most states and union territories of India. While the Hindus comprised 80.15 per cent of the total population of India in 2001 they were 95.4 per cent in Himachal Pradesh, 94.7 per cent in Chhattisgarh, 94.4 per cent in Odisha, 93.5 per cent in Dadra and Nagar Haveli and 91.1 per cent in Madhya Pradesh (**Table 11.9**). However, the Hindus are in minority in certain states and union territory of Lakshadweep. They are outnumbered by the Muslims in Jammu and Kashmir and Lakshadweep, by Sikhs in Punjab, by Christians in Meghalaya, Mizoram, Nagaland and almost equalled by unspecified religions and persuasions in Arunachal Pradesh (**Fig. 11.4**). States and Union territories having Hindus less than 10 per cent of their total population are Nagaland (7.7%), Mizoram (3.6%) and Lakshadweep (3.7%).

In terms of absolute figures, Uttar Pradesh, most populous state, has the largest number of 133.98 million Hindus. This is followed by Maharashtra (77.86 million), Bihar (69.08 million), Andhra Pradesh (67.84 million), West Bengal (58.10 million), Madhya Pradesh (55.0 million), Tamil Nadu (54.98 million), Rajasthan (50.15 million), and Karnataka (44.32 million). These nine states together account for about three-fourths of the total Hindu population of India.

TABLE 11.8. Growth Rate of Population by Religious Communities, India, 1961-2001

	Unadjusted				Adjusted*			
	1961-71	1971-81	1981-91	1991-01	1961-71	1971-81	1981-91	1991-01
All religious communities	**24.8**	**21.4**	**26.0**	**22.7**	**24.8**	**24.8**	**23.8**	**21.5**
Hindus	23.7	21.3	25.1	20.3	23.4	24.2	22.8	20.0
Muslims	30.8	22.9	34.5	36.0	31.2	30.8	32.9	29.3
Christians	32.6	13.7	21.5	22.6	36.0	19.2	17.0	22.1
Sikhs	32.3	26.0	24.3	18.2	32.0	26.2	25.5	16.9
Buddhists	17.1	23.8	35.3	24.5	17.0	25.4	35.0	23.2
Jains	28.5	23.1	4.6	26.0	28.5	23.7	4.0	26.0
Others	45.7	26.6	18.2	103.1	97.7	26.6	13.2	111.3
Religion not stated	–68.1	66.9	590.1	75.1	–65.7	67.1	573.5	76.3

* Excludes Assam and Jammu and Kashmir for all decades from 1961 to 2001 as no Census was conducted in these states in 1981 and 1991 respectively.

Source : Census of India 2001, The First Report on Religion Data Abstract (2004), p. xxviii.

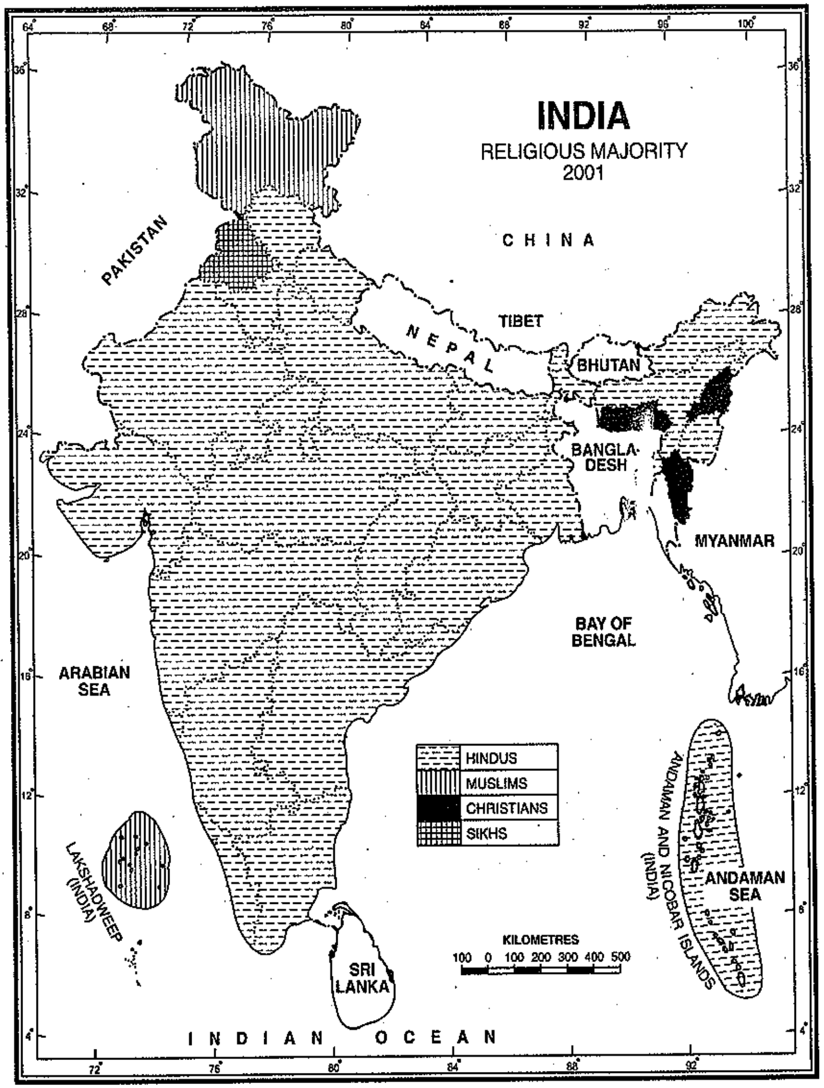

FIG. 11.4. India : Religious Majority

The Muslims

The Muslims constitute the second largest religious community and the largest minority community of India. According to 2001 census figures, the Muslim population numbered 138.19 million which worked out to be 13.4 per cent of the total population of India. The special feature of the Muslim population is that it has shown an overall growth rate of 36 per cent (unadjusted) during 1991-2001. This percentage of growth rate was arrived at by including the Muslim dominated population of Jammu and Kashmir where census could not be conducted in 1991. If adjusted data is considered, the Muslim growth rate will decline from 32.9 per cent during 1981-91 to 29.3 per

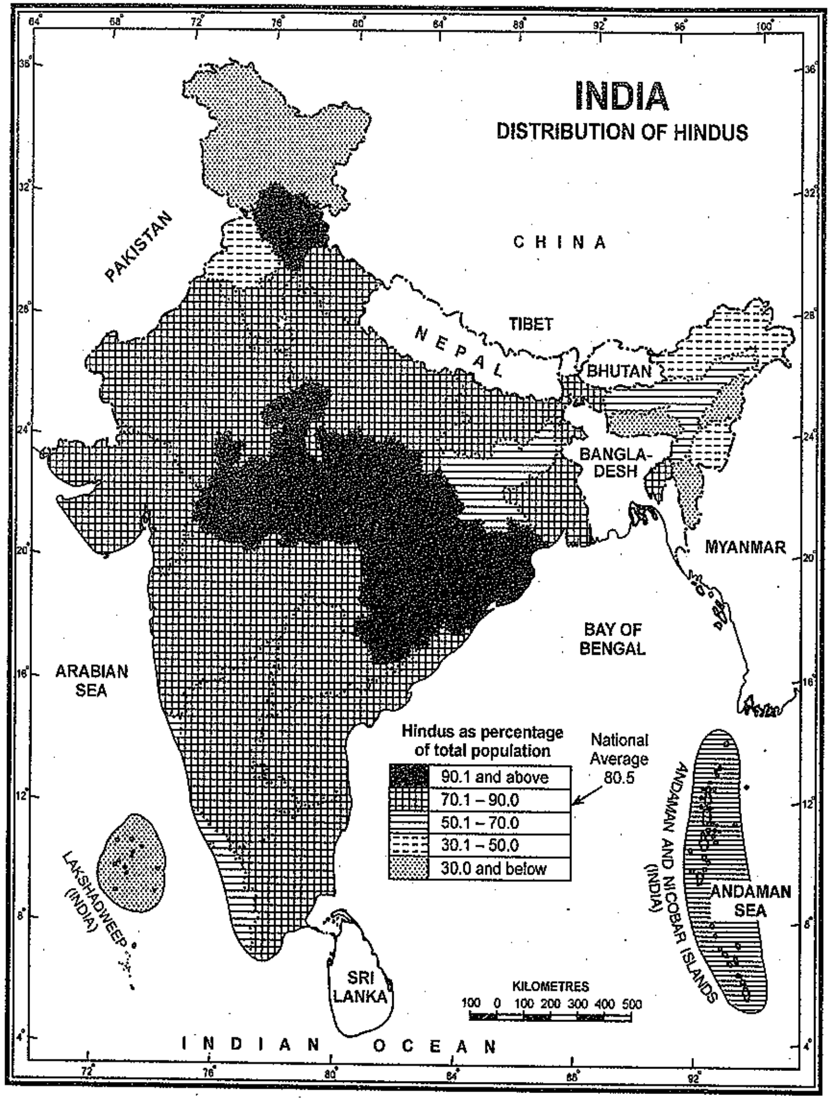

FIG. 11.5. Distribution of Hindus

cent during 1991-2001. Even this growth rate is much higher when compared to growth rate of Hindus which declined from 22.8 per cent in 1981-1991 to 20.0 per cent in 1991-2001. Muslims have rejected family planning vociferously on religious ground and higher growth rate of the Muslims is the natural sequel.

There was no census in Assam in 1981 and in Jammu and Kashmir in 1991, but heads were counted in the whole country in 1961, 1971 and 2001. The comparison of the growth rates of Hindus and Muslims during this period makes an interesting study. The Hindu population that was at 453.3 million in 1971 which grew to 827.6 million in 2001

TABLE 11.9. Proportion of Religious Communities to total Population, 2001
(India, States and Union territories, 2001)

India/ States/ Union territories	All religious communities	Hindus	Muslims	Christians	Sikhs	Buddhists	Jains	Others
India	**100.0**	**80.5**	**13.4**	**2.3**	**1.9**	**0.8**	**0.4**	**0.6**
Jammu & Kashmir	100.0	29.6	67.0	0.2	2.0	1.1	0.0	0.0
Himachal Pradesh	100.0	95.4	2.0	0.1	1.2	1.2	0.0	0.0
Punjab	100.0	36.9	1.6	1.2	59.9	0.2	0.2	0.0
Chandigarh	100.0	78.6	3.9	0.8	16.1	0.1	0.3	0.0
Uttarakhand	100.0	85.0	11.9	0.3	2.5	0.1	0.1	0.0
Haryana	100.0	88.2	5.8	0.1	5.5	0.0	0.3	0.0
Delhi	100.0	82.0	11.7	0.3	2.5	0.1	1.1	0.0
Rajasthan	100.0	88.8	8.5	0.1	1.4	0.0	1.2	0.0
Uttar Pradesh	100.0	80.6	18.5	0.1	0.4	0.2	0.1	0.0
Bihar	100.0	83.2	16.5	0.1	0.0	0.0	0.0	0.1
Sikkim	100.0	60.9	1.4	6.7	0.2	28.1	0.0	2.4
Arunachal Pradesh	100.0	34.6	1.9	18.7	0.2	13.0	0.0	30.7
Nagaland	100.0	7.7	1.8	90.0	0.1	0.1	0.1	0.3
Manipur	100.0	46.0	8.8	34.0	0.1	0.1	0.1	10.9
Mizoram	100.0	3.6	1.1	87.0	0.0	7.9	0.0	0.3
Tripura	100.0	85.6	8.0	3.2	0.0	3.1	0.0	0.0
Meghalaya	100.0	13.3	4.3	70.3	0.1	0.2	0.0	11.5
Assam	100.0	64.9	30.9	3.7	0.1	0.2	0.1	0.1
West Bengal	100.0	72.5	25.2	0.6	0.1	0.3	0.1	1.1
Jharkhand	100.0	68.6	13.8	4.1	0.3	0.0	0.1	13.0
Odisha	100.0	94.4	2.1	2.4	0.0	0.0	0.0	1.0
Chhattisgarh	100.0	94.7	2.0	1.9	0.3	0.3	0.3	0.5
Madhya Pradesh	100.0	91.1	6.4	0.3	0.2	0.3	0.9	0.7
Gujarat	100.0	89.1	9.1	0.6	0.1	0.0	1.0	0.1
Daman & Diu	100.0	89.7	7.8	2.1	0.1	0.1	0.2	0.1
Dadra & Nagar Haveli	100.0	93.5	3.0	2.7	0.1	0.2	0.4	0.0
Maharashtra	100.0	80.4	10.6	1.1	0.2	6.0	1.3	0.2
Andhra Pradesh	100.0	89.0	9.2	1.6	0.0	0.0	0.1	0.0
Karnataka	100.0	83.9	12.2	1.9	0.0	0.7	0.8	0.2
Goa	100.0	65.8	6.8	26.7	0.1	0.0	0.1	0.0
Lakshadweep	100.0	3.7	95.5	0.8	0.0	0.0	—	—
Kerala	100.0	56.2	24.7	19.0	0.0	0.0	0.0	0.0
Tamil Nadu	100.0	88.1	5.6	6.1	0.0	0.0	0.1	0.0
Puducherry	100.0	86.8	6.1	6.9	0.0	0.0	0.1	0.0
Andaman & Nicobar Island	100.0	69.2	8.2	21.7	0.4	0.1	0.0	0.1

Note : 1. Population figures for India and Manipur exclude those of Mao Maram, Paomata and Purul sub-divisions of Senapati district of Manipur State.
2. All religious communities include 'Religion not stated'.

Source : Census of India 2001, The First Report on Religion Data Abstract (2004), p. xxix.

TABLE 11.10. Religion-wise Population in India, 2001

India / States/Union territories	Hindus	Muslims	Christians	Sikhs	Buddhists	Jains	Others
India	**827,578,868**	**138,188,240**	**24,080,016**	**19,215,730**	**7,955,207**	**4,225,053**	**6,639,626**
Jammu & Kashmir	3,005,349	6,793,240	20,229	207,154	113,787	2,518	97
Himachal Pradesh	5,800,222	119,512	7,687	72,355	75,859	1,408	425
Punjab	8,997,942	382,045	292,800	14,592,387	41,487	39,276	8,594
Chandigarh	707,978	35,548	7,627	145,175	1,332	2,592	257
Uttarakhand	7,212,260	1,012,141	27,116	212,025	12,434	9,249	770
Haryana	18,655,925	1,222,916	27,185	1,170,662	7,140	57,167	1,255
Delhi	11,358,049	1,623,520	130,319	555,602	23,705	155,122	2,174
Rajasthan	50,151,452	4,788,227	72,660	818,420	10,335	650,493	5,253
Uttar Pradesh	133,979,263	30,740,158	212,578	678,059	302,031	207,111	9,281
Bihar	69,076,919	13,722,048	53,137	20,780	18,818	16,085	52,905
Sikkim	329,548	7,693	36,115	1,176	152,042	183	12,926
Arunachal Pradesh	379,935	20,675	205,548	1,865	143,028	216	337,399
Nagaland	153,162	35,005	1,790,349	1,152	1,356	2,093	6,108
Manipur	996,894	190,939	737,578	1,653	1,926	1,461	235,280
Mizoram	31,562	10,099	772,809	326	70,494	179	2,443
Tripura	2,739,310	254,442	102,489	1,182	98,922	477	1,277
Meghalaya	307,822	99,169	1,628,986	3,110	4,703	772	267,245
Assam	17,296,455	8,240,611	986,589	22,519	51,029	23,957	22,999
West Bengal	58,104,835	20,240,543	515,150	66,391	243,364	55,223	895,796
Jharkhand	18,475,681	3,731,308	1,093,382	83,358	5,940	16,301	3,514,472
Odisha	34,726,129	761,985	897,861	17,492	9,863	9,154	361,981
Chattisgarh	19,729,670	409,615	401,035	69,621	65,267	56,103	95,187
Madhya Pradesh	55,004,675	3,841,449	170,381	150,772	209,322	545,446	409,285
Gujarat	45,143,074	4,592,854	284,092	45,587	17,829	525,305	28,698
Daman & Diu	141,901	12,281	3,362	145	126	268	103
Dadra & Nagar Haveli	206,203	6,524	6,058	123	457	864	90
Maharashtra	77,859,385	10,270,485	1,058,313	215,337	5,838,710	1,301,843	236,841
Andhra Pradesh	67,836,651	6,986,856	1,181,917	30,998	32,037	41,846	4,768
Karnataka	44,321,279	6,463,127	1,009,164	15,326	393,300	412,659	115,460
Goa	886,551	92,210	359,568	970	649	820	353
Lakshadweep	2,221	57,903	509	6	1	—	—
Kerala	17,883,449	7,863,842	6,057,427	2,762	2,027	4,528	2,256
Tamil Nadu	54,985,079	3,470,647	3,785,060	9,545	5,393	83,359	7,252
Puducherry	845,449	59,358	67,688	108	73	952	158
Andaman & Nicobar Islands	246,589	29,265	77,178	1,587	421	23	238

Source : Census of India 2001, The First Report on Religion Data Abstract (2004), pp. xxxi – xxxvii.

registering a growth rate of 82 per cent. The Muslim population grew from 61.4 million in 1971 to 138.2 million in 2001, thus registering an increase of 125 per cent. Even after making adjustment for population of Jammu and Kashmir, the growth of the Muslims is the highest as per 2001 census figures. This is a dangerous trend and is likely to disturb the demographic set up of the country. The north-eastern states have registered an exceptionally high growth rate of the Muslim population primarily due to exodus of Bangladesh Muslims into these states.

In terms of absolute figures, Uttar Pradesh (30.74 million), West Bengal (20.24 million), Bihar (13.72 million), Maharashtra (10.27 million), Assam (8.20 million), Kerala (7.86 million), Andhra Pradesh (6.99 million), Jammu and Kashmir (6.79 million), Karnataka (6.46 million) are the major states where Muslim population is mainly concentrated. These nine states account for over four-fifth of the Muslim population of India. Muslims are in small numbers in other states. Curiously, Uttar Pradesh has the largest number of both Hindus and Muslims. This is justified by the fact that this is the most populous state in India with a total population of over 166 million in 2001.

Entirely different picture emerges when we consider the percentage of the Muslim population to the total population of the respective states/union territories. Lakshadweep had the highest percentage of 95.5 per cent Muslims although, this group of Islands had only 57,903 Muslims in 2001. Among the states, Jammu and Kashmir had the highest percentage of 67 per cent Muslims. The highest concentration of Muslims is found in the Kashmir Valley, where in certain areas the Muslims constitute well over 95 per cent of the total population. Assam has about 31 per cent of its population consisting of Muslims. In West Bengal, the Muslims account for 25.2 per cent of the total population. Murshidabad is the main area of concentration, where Muslims comprise over 55 per cent of the total population. Kerala has 24.7 per cent of its population comprised by the Muslims, where Malappuram is the main area of concentration. In Uttar Pradesh 18.5 per cent of the total population is Muslim. Most of the Muslims of Uttar Pradesh are concentrated in Rohilkhand and Upper Ganga plain, where the districts of Rampur, Bijnor, Moradabad, Bareilly, Pilibhit, Saharanpur, Muzaffarnagar, Meerut and Ghaziabad have fairly high proportion of Muslims. Muslims constitute less than five per cent of the total population in Punjab, Chandigarh, Himachal Pradesh, Sikkim, Arunachal Pradesh, Nagaland, Mizoram, Meghalaya, Odisha, Chhattisgarh, and Dadra and Nagar Haveli.

The Christians

The Christians form the third largest religious community in India. According to 2001 census figures there are about 24.1 million Christians living in India. Christians formed just 1.6 per cent of Indian population in 1941 but it rose to 2.3 per cent in 1951, perhaps due to partition of the sub-continent. In 1971, there were 2.6 per cent Christians in India which fell slightly to 2.5 per cent in 1981 and to 2.3 per cent in 1991 and 2001. The north-eastern states are predominantly inhabited by Christians. For example, Christians constitute 90.0 per cent of the total population in Nagaland, 87.0 per cent in Mizoram, 70.3 per cent in Meghalaya and 34.0 per cent in Manipur. Christians are in large proportion in Goa and Kerala also, where they form 26.7 and 19.0 per cent of the total population respectively. But speaking in absolute figures, Kerala has the largest number of Christians, amounting to about one-fourth of the total Christian population of India. The total number of Christians living in Kerala is over six million (2001). In Kottayam and Ernakulam districts of Kerala, Christians account for over 40 per cent of the total population. There are several other districts in this state where the Christian population ranges between 15 to 25 per cent. After Kerala the important states with Christian population are Tamil Nadu (3.78 million), Arunachal Pradesh (1.79 million), Meghalaya (1.63 million), Andhra Pradesh (1.18 million), Jharkhand (1.09 million) and Maharashtra (1.05 million).

Varying trends are observed with regard to growth rate of the Christians. It was 36.0 per cent in 1961-71 which declined to 19.2 per cent in 1971-81 and to 17.0 per cent in 1981-91. But it increased to 22.1 per cent in 1991-2001.

The Sikhs

There were 19.21 million Sikhs in 2001. Sikhs constituted just 1.7 per cent of the total population of India in 1941. Their percentage increased to 1.9 in

1951 as a result of large scale migration of the Sikhs from Pakistan to India following partition of the country in 1947. Thereafter, the percentage of the Sikhs to total population of India has been increasing steadily. They constituted 1.9 per cent of the total population in 2001. Needless to say that the Sikhs are an enterprising race and are scattered in almost all parts of the country. However, their largest concentration is in Punjab. According to 2001 census figures, 14.59 million Sikhs live in Punjab which is about sixty per cent of the total population of the state. It is estimated that 75.9 per cent of the total Sikhs of the country live in Punjab alone. This is quite obvious because Sikhism took its roots in the soil of Punjab, where Guru Nanak, the founder of the Sikhism preached his teachings. The Sikhs have an absolute majority in the districts of Amritsar, Kapurthala, Ferozepur, Gurdaspur, Bhatinda, Patiala, Ludhiana, Faridkot, Fatehgarh Sahib and Mansa. In the neighbouring state of Haryana 1.1 million Sikhs are living according to 2001 census data. This amounts to 5.5 per cent of the total population of the state. Ambala, Kurukshetra, Karnal, Fatehabad and Sirsa are the main districts of Sikh population. Minor pockets of the Sikh concentration are found in the Tarai region of Uttarakhand and Uttar Pradesh as well as in Ganganagar, Alwar and Bharatpur districts of Rajasthan. In the union territory of Delhi 5.55 lakh Sikhs are living, and they account for 4 per cent of its total population.

The most important factor about the Sikhs is that their rate of growth has declined considerably. It was 32.0 per cent in 1961-71 which came down to 26.2 per cent in 1971-81 and 25.5 per cent in 1981-91. A steep decline was observed between 1981-91 and 1991-2001. In 1991-2001 their growth rate was 16.9 per cent which was the lowest among all the religious communities.

Buddhists

India's 7.95 million Buddhists constitute only 0.8 per cent of the total population of the country. Their growth rate had been changing in each censual decade. In 1961-71 it was only 17.0 per cent and shot up rather out of proportion to 36.0 per cent in 1981-1991. This was perhaps due to large scale conversion of people from other religions to Buddhism. However, it fell to 23.2 per cent in 1991-2001.

The Buddhists are largely found in Maharashtra, Karnataka, Uttar Pradesh, West Bengal, Madhya Pradesh, Arunachal Pradesh and the Ladakh District of Jammu and Kashmir. They are also found to a lesser extent in Mizoram, Tripura and Himachal Pradesh. The concentration of Buddhists in the northern part of India is mainly because it is near here that the Buddhism originated and spread over the Himalayas. In 2001, Maharashtra had the largest number of 5.84 million Buddhists which accounted for 73.5 per cent of the total Buddhist population of India, though it was only 6% of the total population of the state. The large population of Buddhists in Maharashtra is mostly due to the wholesale conversion of a community of Harijans, following the advice of their leader, Dr. B.R. Ambedkar. Sikkim's 152,042 Buddhists, however, give this state the largest proportion of Buddhists in the country, 28.1% of its total population. Other states with reasonably good percentage of Buddhist population are Arunachal Pradesh (13.0 per cent) and Mizoram (7.9 per cent).

The Jains

4.22 million Jains of India are widely spread in the western parts of the country. Maharashtra (13 lakh), Rajasthan (6.5 lakh), Madhya Pradesh (5.4 lakh), Gujarat (5.2 lakh) and Uttar Pradesh (2 lakh) are important states. Nowhere they account for more than 1.3 per cent of the total population. The Jains have maintained their growth rate above the national growth rate. However, abnormally low growth rate of only 4.0 per cent in 1981-91 appears to an aberration when compared with the other decades.

The Parsis

As per 2001 census, the Parsis population in the country is 69,601 (33,949 males and 35,652 females) as against their population of 76,382 (37,736 males and 38,646 females) in 1991 census. This is clearly a visible but extremely unfortunate decline of a rich civilization of Zoroastrians and its people. It is apparent from 2001 census results that urgent and drastic interventions are required by all concerned including the government and definitely the Parsi community leaders to ensure survival of Parsi population in India. Fertility improvement innovative initiatives rather than fertility control measures

adopted by the community so far are-possibly the need of the hour before it reaches a point of no return. It is expected that this loud and clear message from 2001 census results awakens the country and the Parsi community from the deep slumber it is possibly in and have a beneficial effect for them. About 90 per cent of this community is concentrated in the city of Mumbai and the southern coastal Gujarat, around Surat.

SEX COMPOSITION

Sex composition of the human population is one of the basic demographic characteristics, which is extremely vital for any meaningful demographic analysis. Changes in sex composition largely reflect the underlying socio-economic and cultural pattern of a society in different ways. It is an important social indicator to measure the extent of prevailing equity between males and females at a given point of time. "The separate data for males and females are important for various types of planning and for the analysis of other demographic characteristics such as natality, mortality, migration, marital status, economic characteristics, etc. The balance of sexes affects the social and economic relationship within a community". (Chanana : 2012)

Sex composition is expressed with the help of a ratio known as sex ratio. Sex ratio in India is defined as "*number of females per 1,000 males in the population.*" It is expressed in the following form.

$$\text{Sex Ratio} = \frac{\text{Number of females}}{\text{Number of males}} \times 1000$$

Thus, a sex ratio of 1,000 implies complete parity between the two sexes. Ratios above 1,000 indicate excess of females over males; those below 1,000 indicate a deficit of females.

Sex ratio of population of a country is mainly the outcome of the interplay of sex differentials in mortality, sex selective migration, sex ratio at birth and at times the sex differential in population enumeration. According to figures of 2011 census, out of total population of 1210.1 millions, 623.7 millions are males and 586.4 millions are females. Thus, the overall sex ratio for Indian population is 940. This suggests that the number of females is quite less as compared to males. In other words the sex ratio in the country had always remained unfavourable to females. Moreover, barring some hiccups, it has shown a long term declining trend. The sex ratio at the beginning of the twentieth century was 972 and thereafter showed continuous decline until 1941. In 1951 there was a marginal increase of one point, but the country saw the sharpest decline of 11 points in sex ratio from 941 in 1961 to 930 in 1971. A slight improvement of 4 points in 1981 could not be maintained and there was a fall of 7 points from 934 in 1981 to 927 in 1991. Increase of six points from 927 in 1991 to 933 in 2001 and seven points in 2011 is a welcome improvement and it is hoped that the same trend will continue in the coming decades. However, it may be mentioned that the net deficit of females which was 3.2 million in 1901 has now widened to over 37.3 million at the time of 2011 census. **Table 11.11** and **Fig. 11.6** show the trends in sex ratio in India from 1901 to 2011.

TABLE 11.11. Sex Ratio-India : 1901–2011

Census Year	Sex Ratio	Census Year	Sex Ratio
1901	972	1961	941
1911	964	1971	930
1921	955	1981	934
1931	950	1991	927
1941	845	2001	933
1951	946	2011	940

Sex ratio in India is substantially low as compared to Russian Federation (1,167), Japan (1,055), Brazil (1,042), the USA (1,025), Nigeria (1,016) and Indonesia (988). The world sex ratio declined from 986 in 2001 to 984 in 2011.

Following are some important factors responsible for low and declining sex ratio.

1. More males are born than females. This is almost a worldwide phenomena and India is no exception. In a study of about two million births that took place in hospitals and health centres throughout India during 1949-58, the sex ratio at birth was found to be 942 for the country as a whole. The data collected by the Registrar General, India regarding six million live births that took place during 1981-91 in hospitals, health centres and institutions located

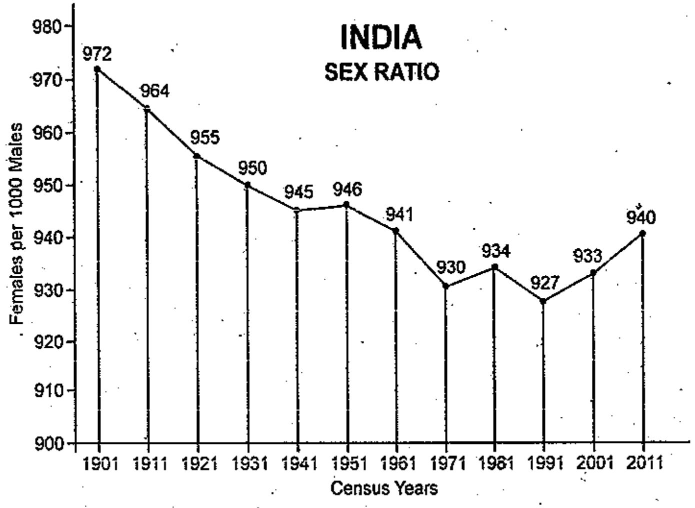

FIG. 11.6. Sex ratio in India from 1901 to 2011.

mostly in urban areas in various parts of the country, gave the sex ratio at birth at 891. Thus there has been a drastic decline in the sex ratio at birth from the 1950s to 1980s.

According to the findings of the census of India, the imbalance in the number of males and females starts in the beginning. It is now a well established law of nature that the males exceed females at the time of birth. It is believed that 943-952 female births take place for every 1,000 male births, which in effect would mean that there is a deficiency of about 50 females per 1,000 males in every birth cohort. Many demographers believe that left to its own, this is an unalterable constant.

The data on sex ratio at birth for the past many years as obtained from Sample Registration System (SRS) is indicative of a larger than usual shortfall in female births as compared to male births. During the decade 1981-90 the SRS sex ratio at birth was above 900 whereas in the succeeding decade it has shown definite sign of a decline below 900. Thus for recent period there is some primary evidence that sex ratio at birth in the country as a whole is possibly lower than generally accepted range of 943-952 but it needs to be corroborated by some more data.

2. Males get preferential treatment while females are neglected. This results in higher female mortality. More females die in India at infancy, as well as during the reproductive period. In old age too the females suffer greater neglect than their male counterparts.

3. The practice of female infanticide in the past and the cognizant foeticide at present have also resulted in low sex ratio. Although it is difficult to assess the impact of these two practices in the absence of the relevant data, the craze for the male child is reflected in increasing number of sex determination tests and the resultant termination of pregnancy in case foetus happens to be a female. Thus the number of girl children continues to fall, rather drastically, as compared to boys. Such a skewed ratio of male-female at the time of birth islargely due to female foeticide.

Despite the Pre-Conception and Pre-Natal Diagnostic Technique (Prohibition of Sex Selection) Act being in force since 1996, these tests are being conducted particularly in Punjab, Haryana and Delhi, in clear violation of the act and the girl child is killed in the womb itself before she takes her birth. Obviously the law has failed to yield the desired result because of its inherent loopholes and faulty implementation.

4. With small family norms, many young couples do not go for a second child if the first child happens to be a male.

5. There has been a steady rise in dowry deaths in the recent past, although its exact impact on sex ratio cannot be specified in the absence of relevant data.

State Level Patterns of Sex Ratio

There are large spatial and temporal variations in sex ratio at state level. **Table 11.12** gives the trends in sex ratio for hundred years in between 1901 and 2001 in respect of all the States and Union territories, except Arunachal Pradesh, for which data are not available from 1901 to 1951. In 1901, there were as many as eleven States and Union territories that had sex ratio of more than unity. Among these, except Kerala all other States and Union territories have shown a downward slide. The major States that are largely responsible for the decline in the overall sex ratio in India are Uttar Pradesh, Bihar, Jharkhand, Odisha, Chhattisgarh, Madhya Pradesh, Gujarat, Maharashtra and Tamil Nadu, although some of these states have shown some improvement with regard to sex ratio. Although the sex ratio in Punjab has been consistently low, it has shown a long term upward trend and has not contributed to the overall deterioration in sex ratio of the country. In Rajasthan, the sex ratio kept fluctuating in a narrow band and always remained at a low level. Haryana, Andhra Pradesh, Telangana and Karnataka are the States where the sex ratio has remained more or less stagnant. In West Bengal the sex ratio declined sharply from 1901 to 1941 and then made a gradual turnaround on an upward path to reach 947 in 2011. Goa, Manipur, Mizoram, Odisha and Lakshadweep (except in 1911 and 1931) have invariably shown sex ratio of over one thousand upto 1961, although for different reasons. In spite of the fact that data for 1901, 1931 and 1941 in respect of Puducherry are not available, this Union Territory is supposed to have sex ratio in favour of females upto 1961. This union territory experienced a steep fall in sex ratio from 1,013 in 1961 to 979 in 1991. But in decades 1991-2001 and 2001-11 Puducherry made a remarkable recovery to reach a sex ratio of 1,038 in 2011 from 1001 in 2001. Thus in 2011, Kerala and Puducherry are the only two areas to record a sex ratio favourable to women. Sex ratio favourable to females has been shown by Bihar and Meghalaya upto 1921 and by Tamil Nadu upto 1951. Kerala is the only state which has shown more females than males throughout the census history of India. In 2011, Kerala with a sex ratio of 1,084 was at the top among all the states. This is a demographic trait which is more characteristic of the developed countries.

The other states and union territories with sex ratio higher than the national average in 2001 are Himachal Pradesh, Uttarakhand, Manipur, Mizoram, Tripura, Meghalaya, Assam, West Bengal, Odisha, Chhattisgarh, Andhra Pradesh (including Telangana), Karnataka, Goa, Lakshadweep, Kerala, Tamil Nadu and Puducherry. Thus 18 states and union territories have sex ratio above the national average. The remaining 17 states and union territories have sex ratio below the national average. Sex ratio of 950 is considered tolerable in the Indian context. Jammu and Kashmir, Punjab, Chandigarh, Haryana, Delhi, Sikkim, Daman and Diu, Dadra and Nagar Haveli, and Andaman and Nicobar Islands have a very low sex ratio of 900 or below. Five union territories of Andaman and Nicobar Islands, Delhi, Dadra and Nagar Haveli, Chandigarh and Daman and Diu have critically low sex ratio. None of them has sex ratio exceeding 878. In the states of Punjab and Haryana and the Union territories of Delhi and Chandigarh, extremely low sex ratio prevails due to large scale sex determination and female foeticide. Chandigarh and Delhi are highly urbanized union territories where people (mostly males) migrate in large numbers in search of livelihood, leaving their families (mostly females) in their native towns and villages.

One conspicuous improvement has been with respect to Andaman and Nicobar Islands, where the sex ratio was desperately low at 318 in 1901 and remained below 600 till 1941. This was perhaps due to the repressive policy of the British regime, when freedom fighters from the main land of India were sent as prisoners there most of whom were males. The situation, however, improved after Independence and this Union Territory showed a record sex ratio of 878 in 2011 throughout its census history.

TABLE 11.12. Sex Ratio (females per 1,000 males), 1901-2011

State/UT Code	India / State / Union territory*	Census year											
		1901	1911	1921	1931	1941	1951	1961	1971	1981	1991	2001	2011
	INDIA	972	964	955	950	945	946	941	930	934	927	933	940
1	Jammu & Kashmir	882	876	870	865	869	873	878	878	892	896	892	883
2	Himachal Pradesh	884	889	890	897	890	912	938	958	973	976	968	974
3	Punjab	832	780	799	815	836	844	854	865	879	882	876	893
4	Chandigarh*	771	720	743	751	763	781	652	749	769	790	777	818
5	Uttarakhand	918	907	916	913	907	940	947	940	936	936	962	963
6	Haryana	867	835	844	844	869	871	868	867	870	865	861	877
7	Delhi*	862	793	733	722	715	768	785	801	808	827	821	866
8	Rajasthan	905	908	896	907	906	921	908	911	919	910	921	926
9	Uttar Pradesh	938	916	908	903	907	908	907	876	882	876	898	908
10	Bihar	1,061	1,051	1,020	995	1,002	1,000	1,005	957	948	907	919	916
11	Sikkim	916	951	970	967	920	907	904	863	835	878	875	889
12	Arunachal Pradesh	NA	NA	NA	NA	NA	NA	894	861	862	859	893	920
13	Nagaland	973	993	992	997	1,021	999	933	871	863	886	900	931
14	Manipur	1,037	1,029	1,041	1,065	1,055	1,036	1,015	980	971	958	978	987
15	Mizoram	1,113	1,120	1,109	1,102	1,069	1,041	1,009	946	919	921	935	975
16	Tripura	874	885	885	885	886	904	932	943	946	945	948	961
17	Meghalaya	1,036	1,013	1,000	971	966	949	937	942	954	955	972	986
18	Assam	919	915	896	874	875	868	869	896	910	923	935	954
19	West Bengal	945	925	905	890	852	865	878	891	911	917	934	947
20	Jharkhand	1,032	1,021	1,002	989	978	961	960	945	940	922	941	947
21	Odisha	1,037	1,056	1,086	1,067	1,053	1,022	1,001	988	981	971	972	978
22	Chhattisgarh	1,046	1,039	1,041	1,043	1,032	1,024	1,008	998	996	985	989	991
23	Madhya Pradesh	972	967	949	947	946	945	932	920	921	912	919	930
24	Gujarat	954	946	944	945	941	952	940	934	942	934	920	918
25	Daman & Diu*	905	1,040	1,143	1,088	1,080	1,125	1,169	1,099	1,062	969	710	618
26	Dadra & Nagar Haveli*	960	967	940	911	925	946	963	1,007	974	952	812	775
27	Maharashtra	978	966	950	947	949	941	936	930	937	934	922	925
28	Andhra Pradesh (including Telangana)	985	992	993	987	980	986	981	977	975	972	978	992
29	Karnataka	983	981	969	965	960	966	959	957	963	960	965	968
30	Goa	1,091	1,108	1,120	1,088	1,084	1,128	1,066	981	975	967	961	968
31	Lakshadweep*	1,063	987	1,027	994	1,018	1,043	1,020	978	975	943	948	946
32	Kerala	1,004	1,008	1,011	1,022	1,027	1,028	1,022	1,016	1,032	1,036	1,058	1084
33	Tamil Nadu	1,044	1,042	1,029	1,027	1,012	1,007	992	978	977	974	987	995
34	Puducherry*	NA	1,058	1,053	NA	NA	1,030	1,013	989	985	979	1,001	1038
35	Andaman & Nicobar Islands*	318	352	303	495	574	625	617	644	760	818	846	878

* Union Territory

Source : Census of India 2011, Provisional Populatin Totals Paper 1 of 2011, Series 1, pp. 1974-75.

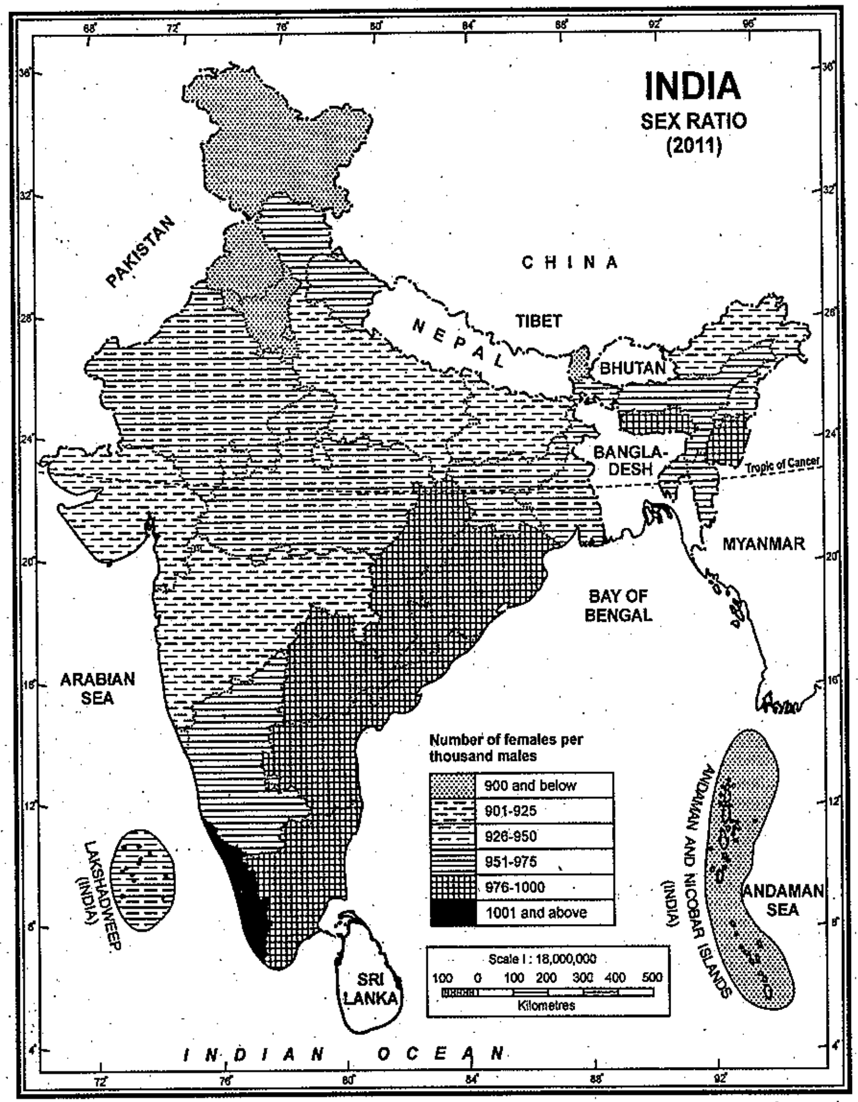

FIG. 11.7. India : Sex Ratio, 2011

Table 11.13 enables us to compare the condition of range of sex ratios in 2011 with that of 2001. Slight improvement seems to be with respect to extremely low range of sex ratio of below 880, wherein the number of states has decreased from 8 to 6 and the percentage of population has decreased from 5.98 to 3.65. On the other end, the number of states in the range above 986 has increased from 4 to 7 and the percentage of population has increased from 11.28 to 18.4.

The table also shows that the maximum number of states and percentage of population is in the sex ratio range of 916 to 950.

TABLE 11.13. Distribution of States/Union Territories by range of sex ratio of India : 2001 and 2011

Sex ratio	2001		2011	
	No. of states	Percentage of population to total population	No. of states	Percentage of population to total population
880 and below	8	5.98	6	3.65
881-915	4	17.44	4	19.87
916-950	11	47.18	10	45.08
951-985	8	18.12	8	13.01
986 and above	4	11.28	7	18.4

Source : Census of India 2011, Provisional Population Totals, Paper 1 of 2011 Series 1, p. 89.

Child Sex Ratio

Although overall sex ratio in India gives a gloomy picture, situation with respect to child sex ratio in the age group of 0-6 years is more depressing. Whereas overall sex ratios has slightly improved between 1991 and 2011, the child sex ratio has registered a steep fall from 976 in 1961 to a desperate 914 in 2011 (**Table 11.14** and **Fig. 11.8**). This is the lowest child sex ratio India has ever recorded since Independence. The current child sex ratio is very critical for any demographic set up because it is this sex ratio that will determine the overall sex ratio in the coming years. In 27 states and Union Territories, including Delhi, the child sex ratio had declined. "The rate of decline ranges from normal to alarming" the provisional census report for 2011 notes. This tragic picture has emerged largely due to craze of Indian parents for a male child and rampant sex determination in the womb, female infanticide, and foeticide in large parts of the country.

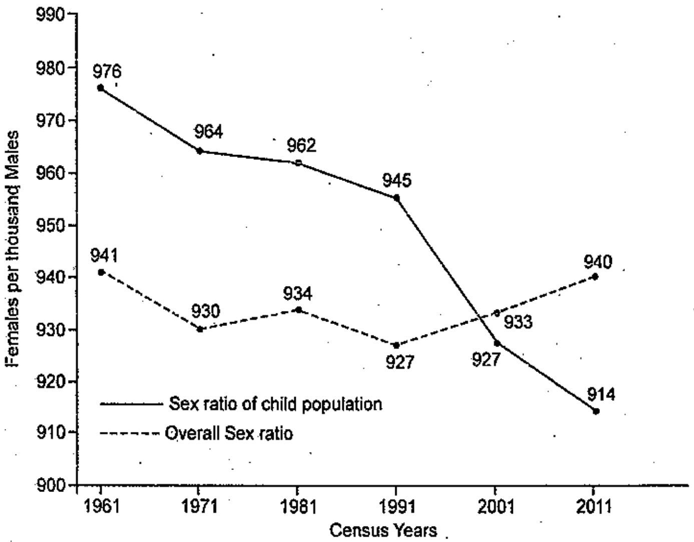

FIG. 11.8. Child sex ratio and overall sex ratio in India 1961-2011.

TABLE 11.14. Sex ratio of total population and child population in the age group 0-6 years : 1961-2011

Year	Sex ratio in the age group 0-6 years	Overall sex ratio
1961	976	941
1971	964	930
1981	962	934
1991	945	927
2001	927	933
2011	914	940

Source : Census of India 2011, Provisional Population Totals, Paper 1 of 2011 Series 1, p. 90.

The above mentioned grim reality prevails in spite of several steps taken by the Central and the State Governments to protect and empower the girl child. Some of the steps are briefly described as under :

1. Complete ban under law on sex determinaption during pregnancy and termination of pregnancy if the child happens to be a girl.
2. Declaring *24th January* as the National Girl Child Day in 2012.
3. *The Ladli Scheme* implemented by the Delhi and Haryana Governments aims at curbing female facticide and enhancing the social status of the girl child by promoting their education and protecting them from discrimination and deprivation.
4. *Sabla Scheme* launched on the International Women's Day in 2011 aims at enabling self development and empowerment of adolescent girls, improvement in their health and nutrition status, spread awareness about health, hygiene, nutrition, adolescent reproductive and several health, family and child care.
5. *Dhanlaxmi Scheme* launched as a pilot project in March, 2008 by the Ministry of Women and Child Development, Government of India, aims at providing a set of staggered financial incentives for families to encourage them to retain the girl child and educate her.
6. *Kishori Shakti Yojna* seeks to empower adolescent girls, so as to enable them to take charge of their lives.

A casual look at **table 11.15** brings us to the following conclusions :

1. The lowest child sex ratio has been observed in Haryana (830), Punjab (846) and Jammu and Kashmir (859) while among the Union Territories, Delhi (866), Chandigarh (867) and Lakshadweep (908) occupy the bottom position.
2. Child sex ratio has increased only in six states and two Union Territories. Some cause of cheer is the fact that the states where the child sex ratio had dropped alarmingly in census 2001 have shown slight improvement in 2011. This increase is substantial in Punjab (789 to 846—57 points), Haryana (819 to 830—11 points), Himachal Pradesh (896 to 906—10 points), Chandigarh (845 to 867—22 points), Gujarat (883 to 886—3 points) and Tamil Nadu (942 to 946—4 points). In addition, Mizoram (964 to 971—7 points) and Andaman and Nicobar Islands (957 to 966—9 points) have also shown some improvement.
3. The situation in other states and union territories has been discouraging. The child sex ratio has declined in 27 states and union territories. Sharp fall in the range of 22 to 82

Some of the findings of Census of India are glaring and will put any civilized society to shame.

- Child sex ratio has fallen drastically from 976 in 1961 to 914 in 2011.
- Haryana has the lowest child sex ratio of 830.
- Jhajjar in Haryana is the worst district with lowest child sex ratio of 774 in the country.
- The capital city of Delhi has a low child sex ratio of 866.
- India is a nation that so hates its female population, so many girls are killed before they are born, despite the fact that the absence of women for any society—certain death for they are after all, the reproducers.
- There are certain villages in Haryana where there are no women at all. So when it comes to seeking marriage partners, men have to import them from other states. The situation is almost the same in certain villages of Punjab also.

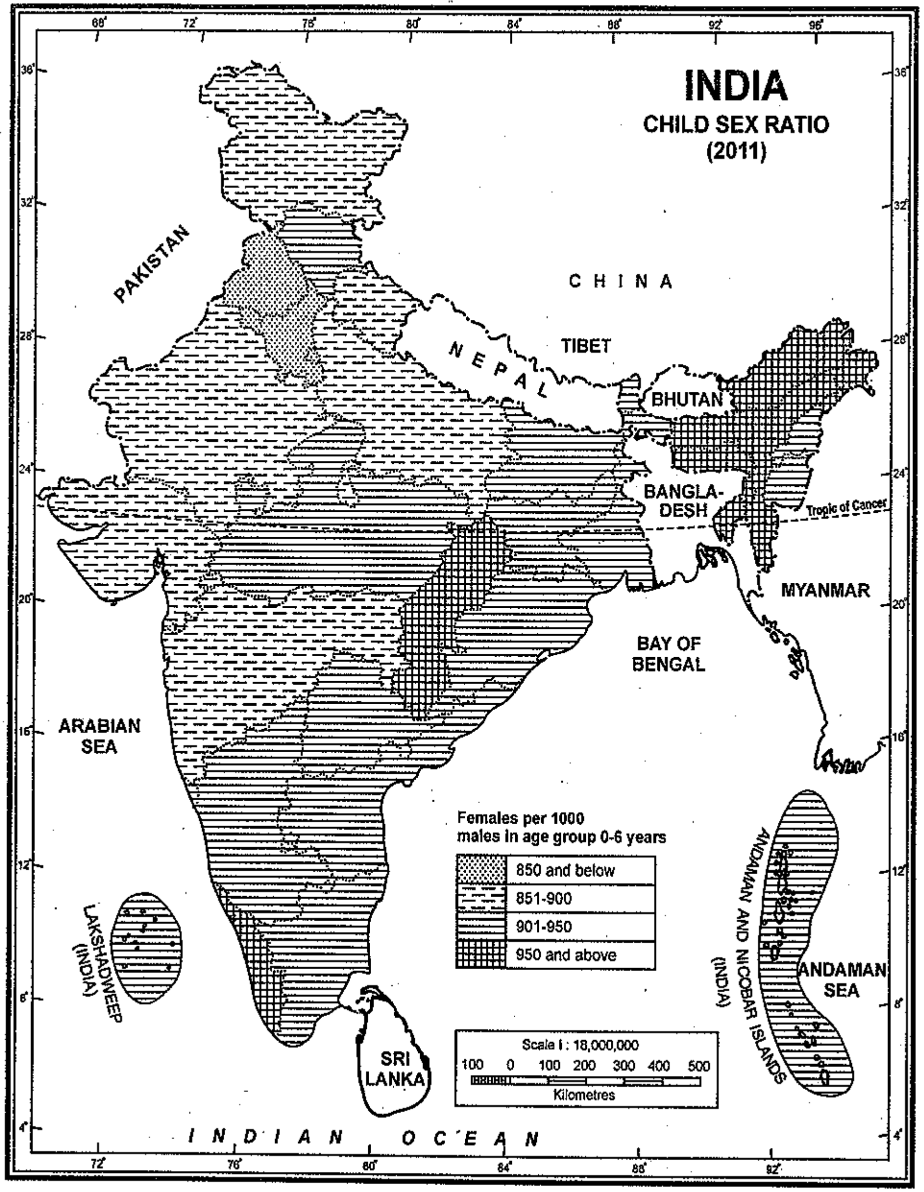

FIG. 11.9. India : Child Sex Ratio (2011).

ɔints has been reported in Jammu and Kashmir, adra and Nagar Haveli, Lakshadweep, Maharashtra, ajasthan, Manipur, Uttarakhand, Jharkhand, Madhya Pradesh and Tamil Nadu. Even the north eastern states like Sikkim and Arunachal Pradesh have shown declining trend.

TABLE 11.15. Sex Ratio of Child Population in the Age Group 0-6 : 2001-2011

State	India/States/Union Territory#	Sex ratio in the age group 0-6	
		2001	2011
	INDIA	927	914
01	Jammu & Kashmir	941	859
02	Himachal Pradesh	896	906
03	Punjab	798	846
04	Chandigarh#	845	867
05	Uttarakhand	908	886
06	Haryana	819	830
07	NCT of Delhi#	868	866
08	Rajashthan	909	883
09	Uttar Pradesh	916	899
10	Bihar	942	933
11	Sikkim	963	944
12	Arunachal Pradesh	964	960
13	Nagaland	964	944
14	Manipur	957	934
15	Mizoram	964	971
16	Tripura	966	953
17	Meghalaya	973	970
18	Assam	965	957
19	West Bengal	960	950
20	Jharkhand	965	943
21	Odisha	953	934
22	Chhattisgarh	975	964
23	Madhya Pradesh	932	912
24	Gujarat	883	886
25	Daman & Diu#	926	909
26	Dadra & Nagar Haveli#	979	924
27	Maharashtra	913	883
28	Andhra Pradesh (including Telangana)	961	943
29	Karnataka	946	943
30	Goa	938	920
31	Lakshadweep#	959	908
32	Kerala	960	959
33	Tamil Nadu	942	946
34	Puducherry#	967	965
35	Andaman & Nicobar Islands#	957	966

Source : Census of India, 2011, Provisional Population Totals, Paper 1 of Series I, p. 88.

LITERACY

It is necessary for a person to be literate before he becomes educated. Higher level of education provides dynamism to society and helps in social upliftment.

The Population Commission of United Nations considers the *ability, to both read and write a simple message with understanding in any language, a sufficient basis for classifying a person as literate.* The Census of India has adopted this definition with a little bit of modification. According to Census of India, "*person aged seven and above, who can both read and write with understanding in any language, is treated as literate.* A person, who can only read but cannot write, is not literate." In the Censuses prior to 1991, children below five years of age were necessarily treated as illiterates.

The age limit was raised to 7 years based on the advice of experts that the ability to read and write with understanding is not ordinarily achieved until that age. It was, therefore decided at the 1991 Census that all children in the age group 0-6, would be treated as illiterate by definition and the population aged seven years and above only would be classified as literate or illiterate. The same criterion has been retained in the Censuses of 2001 and 2011. It should be clearly understood that it is not necessary that to be treated as literate, a person should have received any formal education or acquired any minimum educational standard.

Literacy Rate—Definition

In earlier Censuses up to 1981, it was customary to work out the literacy rate taking into account the total population. Since literacy rate is more meaningful if the sub-population in the age group 0-6 is excluded from the total population. it was decided in 1991 to calculate literacy rate for the population seven years and above. The same concept has been retained in all Censuses since 1991.

The literacy rate taking into account the total population in the denominator has now been termed as 'crude literacy rate', while the literacy rate calculated taking into account the 7 and above population in the denominator is called the effective literacy rate. The formula for computing crude literacy rate and effective literacy rate are as follows :

Crude Literacy Rate =

$$\frac{\text{Number of Literate persons}}{\text{Total Population}} \times 100$$

Effective Literacy Rate =

$$\frac{\text{Number of Literate persons aged 7 and above}}{\text{Population aged 7 and above}} \times 100$$

Effective literacy rate and literacy rate have been used interchangeably in this chapter.

Literates and Illiterates by Gender

As per the provisional population totals of Census 2011, out of the provisional total population of 1,210,193,422, the number of persons aged seven years and above is 1,051,404,135. Out of this, 778,454,120 are literate and 272,950,015 are illiterates There has been an increase of 186,504,094 persons in the age group seven years and above during 2001-2011, while 217,700,941 additional persons have become literate during the decade.

A significant milestone reached in Census 2011, is that the total number of illiterates has come down from 304,146,862 in 2001 to 272,950,015 in 2011, showing a decline of 31,196,847 persons.

One of the interesting features of Census 2011 is that out of total of 217,700,941 literates added during the decade, females (110,069,001) out number males (107,631,940). A reverse trend was noticed during 1991-2001. The decadal increase in number of literates among males is of 31.98 percentage points while the corresponding increase in case of females is of 49.10 percentage points.

A notable feature is that out of the total decrease of 31,196,847 in the number of illiterates, the females (17,122,197) out number males (14,074,650). The above two changes are a clear indication of the fact that the gender gap in literacy is shrinking in the country. This trend of rising female literates will have far reaching consequences on the development of society.

Figure 11.10 gives a comparative picture of literacy and illiteracy in the country in 2001 and 2011 censuses.

Table 11.16 gives the number of literates and illiterates among the population aged seven years and above in absolute figures for India at the 2001 and 2011 censuses.

Literacy Rate—Trends

The effective literacy rate for India in Census 2011, works out to 74.04 per cent. The corresponding figures for males and females are 82.14 and 65.46 per cent respectively. Thus three-fourth of the population of aged 7 years and above is literate in the country. Four out of every five males and two out of every three females in the country are literate. The country has continued its march in improving literacy rate by recording a jump of 9.21 percentage points during 2001-11. The increase in literacy rates in males and females are in the order of 6.88 and 11.79 percentage points respectively.

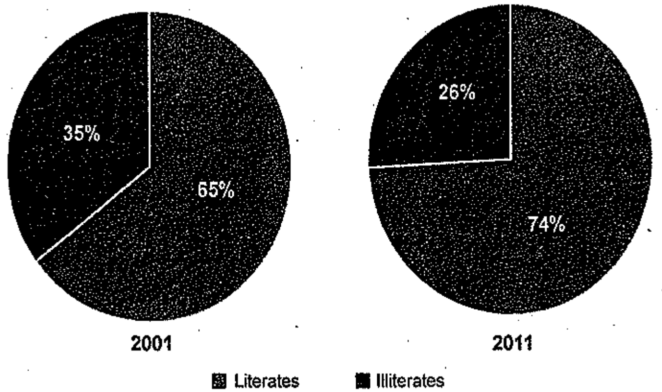

FIG. 11.10. Share of literates and illiterates in India according to Census 2001 and 2011.

TABLE 11.16. Number of literates and illiterates among population aged 7 years and above and their change—India : 2001 and 2011

Literates/illiterates		Persons	Males	Females
Population (aged 7 and above	2001	86,49,00,041	44,72,14,823	41,76,85,218
	2011	1,05,14,04,135	54,07,72,113	51,06,32,022
	Increase in 2011 over 2001	18,65,04,094	9,35,57,290	9,29,46,804
Literates	2001	56,07,53,179	33,65,71,822	22,41,81,357
	2011	77,84,54,120	44,42,03,762	33,42,50,358
	Increase in 2011 over 2001	21,77,00,941	10,76,31,940	11,00,69,001
Illiterates	2001	30,41,46,862	11,06,43,001	19,35,03,861
	2011	27,29,50,015	9,65,68,351	17,63,81,664
	Increase in 2011 over 2001	–3,11,96,847	–1,40,74,650	–1,71,22,197

Source : Census of India 2011, Provisional Population Totals, Paper 1 of Series 1, p. 100.

An extremely positive development in the decade 2001-11 is that the gap of 21.59 percentage points recorded between male and female literacy rates in 2001 census has reduced to 16.68 percentage points in 2011. Though the target set for the year 2011-2012 by the Planning Commission of reducing the gap to 10 percentage points has not been achieved, it is heartening that the reduction has been to the order of almost 5 percentage points.

Table 11.17 presents the effective literacy rate for the country by persons, males, females and the male-female gap since 1951.

TABLE 11.17. Literacy Rate in India 1951-2011

Census year	Persons	Males	Females	Male-Female gap in literacy rate
1951	18.33	27.16	8.86	18.30
1961	28.30	40.4	15.35	25.05
1971	34.45	45.96	21.97	23.98
1981	43.57	56.38	29.76	26.62
1991	52.21	64.13	39.29	24.84
2001	64.83	75.26	53.67	21.59
2011	74.04	82.14	65.46	16.68

Source : Census of India, Provisional Population Totals Paper 1 of Series 1 p. 102.

The above trends have been shown in **Fig. 11.11. Table 11.18** provides the crude literacy rate for India by sex during 1901-2011. The literacy rate designated as crude literacy rate in this statement has been computed with total population as base without removing the mandatory illiterate population aged 0-4 or 0-6 from the denominator. The crude literacy rate from 1901 onwards show a consistent increase both for males and females.

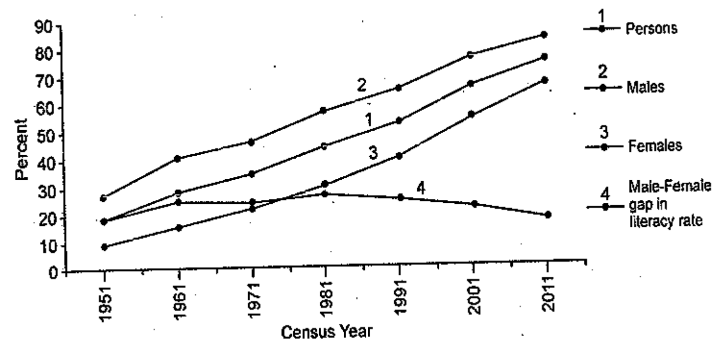

FIG. 11.11. Literacy rates in India.

The improvement in crude literacy rate has been phenomenal (48.22 percentage points) in post independent India. The corresponding increase in case of males has been of 46.32 percentage points and among females it is of 49.69 percentage points. The crude literacy rate has increased by almost 10 percentage points during the last decade. It surged forward by 12 percentage points in case of females while there was an increase of 8 percentage points in male crude literacy rate during the last decade. The gap in crude literacy rates of males and females has decreased from 18.09 percentage points in 2001 to 14.23 percentage points in 2011.

TABLE 11.18. Crude Literacy Rate in India by Sex : 1901 to 2011

Census Year	Crude literacy rate			Change in Percent points		
	Persons	Males	Females	Persons	Males	Females
1901	5.35	9.83	0.60	–	–	–
1911	5.92	10.56	1.05	0.57	0.73	0.45
1921	7.16	12.21	1.81	1.24	1.65	0.76
1931	9.50	15.59	2.93	2.34	3.38	1.12
1941	16.10	24.90	7.30	6.60	9.31	4.37
1951	16.67	24.95	7.93	0.57	0.05	0.63
1961	24.02	34.44	12.95	7.35	9.49	5.02
1971	29.45	39.45	18.69	5.43	5.01	5.74
1981	36.23	46.89	24.82	6.78	7.44	6.13
1991	42.84	52.74	32.17	6.61	5.85	7.35
2001	54.21	63.24	45.15	11.67	10.50	12.98
2011	64.32	71.22	56.99	9.81	7.98	11.84

Notes :

1. Figures upto 1941 are for undivided India.
2. Figures for 1981 excludes Assam as 1981 census could not be conducted in this state due to disturbed conditions.
3. Figures for 1991 census do not include Jammu and Kashmir, as no census was held in the state.

***Source* :** Census of India 2011, Provisional Population Totals, Paper 1 of 2011, Series 1, p. 103.

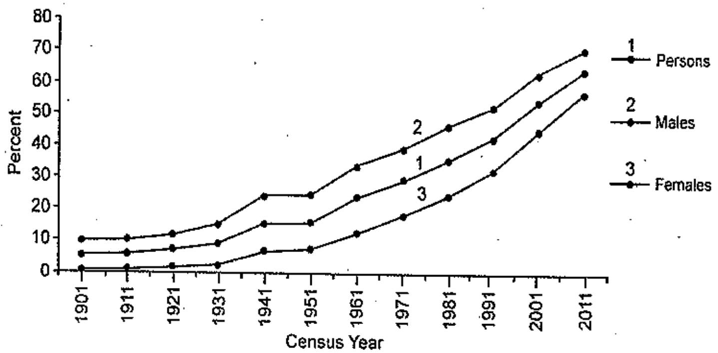

FIG. 11.12. India : Crude Literacy Rate by sex (1901-2011)

TABLE 11.19. Ranking of States and Territories by literacy rate : 2011

Rank	Persons: State/ Union Territory	Literacy rate	Rank	Males: State/ Union Territory	Literacy rate	Rank	Females: State/Union Territory	Literacy rate
1	Kerala	93.91	1	Lakshadweep#	96.11	1	Kerala	91.98
2	Lakshadweep#	92.28	2	Kerala	96.02	2	Mizoram	89.40
3	Mizoram	91.58	3	Mizoram	93.72	3	Lakshadweep#	88.25
4	Tripura	87.75	4	Goa	92.81	4	Tripura	83.15
5	Goa	87.40	5	Tripura	92.18	5	Goa	81.84
6	Daman & Diu#	87.07	6	Puducherry#	92.12	6	Andaman & Nicobar Islands#	81.84
7	Puducherry#	86.55	7	Daman & Diu#	91.48			
8	Chandigarh#	86.43	8	NCT of Delhi#	91.03	7	Chandigarh#	81.38
9	NCT of Delhi#	86.34	9	Himachal Pradesh	90.83	8	Puducherry#	81.22
10	Andaman & Nicobar Islands#	86.27	10	Chandigarh#	90.54	9	NCT of Delhi#	80.93
			11	Andaman & Nicobar Islands#	90.11	10	Daman & Diu#	79.59
11	Himachal Pradesh	83.78				11	Nagaland	76.69
12	Maharashtra	82.91	12	Maharashtra	89.82	12	Himachal Pradesh	76.60
13	Sikkim	82.20	13	Uttarakhand	88.33	13	Sikkim	76.43
14	Tamil Nadu	80.33	14	Sikkim	87.29	14	Maharashtra	75.48
15	Nagaland	80.11	15	Gujarat	87.23	15	Tamil Nadu	73.86
16	Manipur	79.85	16	Tamil Nadu	86.81	16	Meghalaya	73.78
17	Uttarakhand	79.63	17	Manipur	86.49	17	Manipur	73.17
18	Gujarat	79.31	18	Dadra & Nagar Haveli#	86.46	18	Punjab	71.34
19	Dadra & Nagar Haveli#	77.65	19	Haryana	85.38	19	West Bengal	71.16
20	West Bengal	77.08	20	Nagaland	83.29	20	Gujarat	70.73
21	Punjab	76.68	21	Karnataka	82.85	21	Uttarakhand	70.70
22	Haryana	76.64	22	West Bengal	82.67	22	Karnataka	68.13
23	Karnataka	75.60	23	Odisha	82.40	23	Assam	67.27
24	Meghalaya	75.48	24	Punjab	81.48	24	Haryana	66.77
25	Odisha	73.45	25	Chhattisgarh	81.45	25	Dadra & Nagar Haveli#	65.93
26	Assam	73.18	26	Madhya Pradesh	80.53	26	Odisha	64.36
27	Chhattisgarh	71.04	27	Rajashthan	80.51	27	Chhattisgarh	60.59
28	Madhya Pradesh	70.63	28	Uttar Pradesh	79.24	28	Madhya Pradesh	60.02
29	Uttar Pradesh	69.72	29	Assam	78.81	29	Andhra Pradesh (including Telangana)	59.74
30	Jammu & Kashmir	68.74	30	Jharkhand	78.45			
31	Andhra Pradesh (including Telangana)	67.66	31	Jammu & Kashmir	78.26	30	Arunachal Pradesh	59.57
			32	Meghalaya	77.17	31	Uttar Pradesh	59.26
32	Jharkhand	67.63	33	Andhra Pradesh (including Telangana)	75.56	32	Jammu & Kashmir	58.01
33	Rajasthan	67.06				33	Jharkhand	56.21
34	Arunachal Pradesh	66.95	34	Arunachal Pradesh	73.69	34	Bihar	52.33
35	Bihar	63.82	35	Bihar	73.39	35	Rajasthan	52.66

#Union Territory.

***Source* :** Census of India 2011, Provisional Population Totals, Paper 1 of 2011, Series 1 pp. 110-11.

nal Variations on Literacy Rates

ıtes and Union Territories of India have been ɔd in descending order will respect to overall ɾe literacy rates along with effective male and female literacy rates. Regional variations of overall, male and female literacy rates have been shown in **Fig. 11.13, 11.14** and **11.15** respectively. A brief description of overall male and female literacy rates is given below.

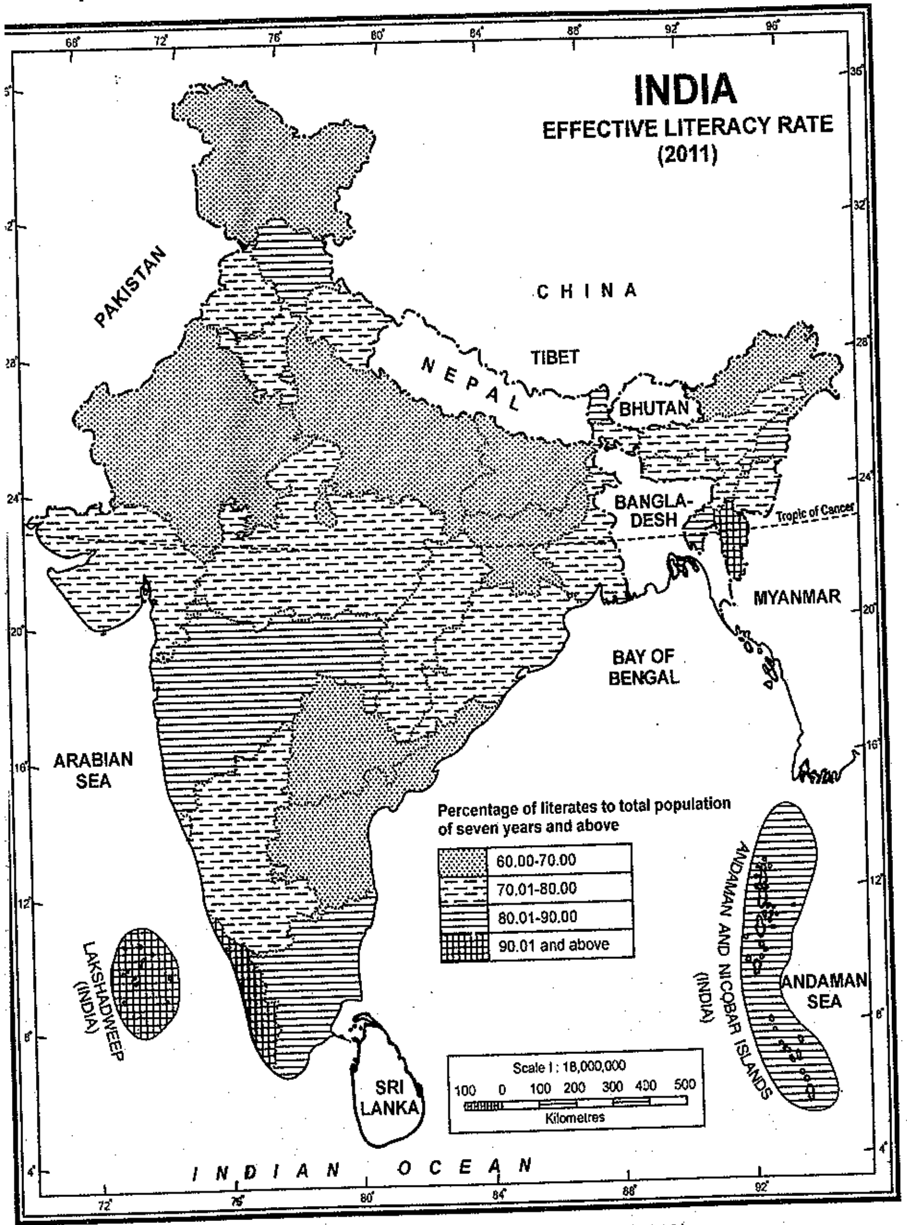

FIG. 11.13. India : Overall effective literacy rate (2011).

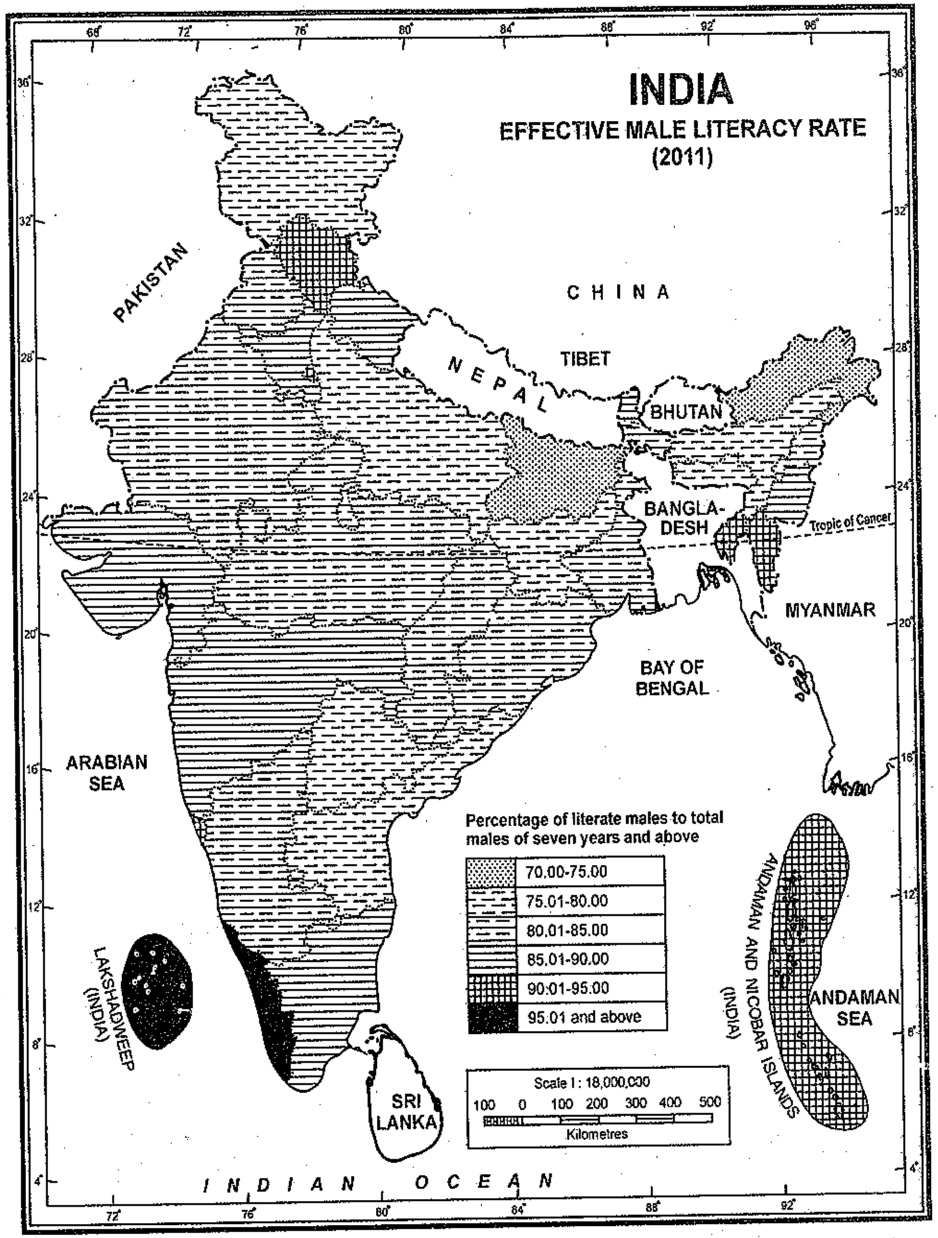

FIG. 11.14. India : Effective male literacy rate (2011).

Overall Effective Literacy Rate

Kerala ranks first in the country with a literacy rate of 93.91 per cent, closely followed by Lakshadweep (92.28 per cent) and Mizoram (91.58 per cent). Bihar with a literacy rate of 63.82 per cent ranks last in the country preceded by Arunachal

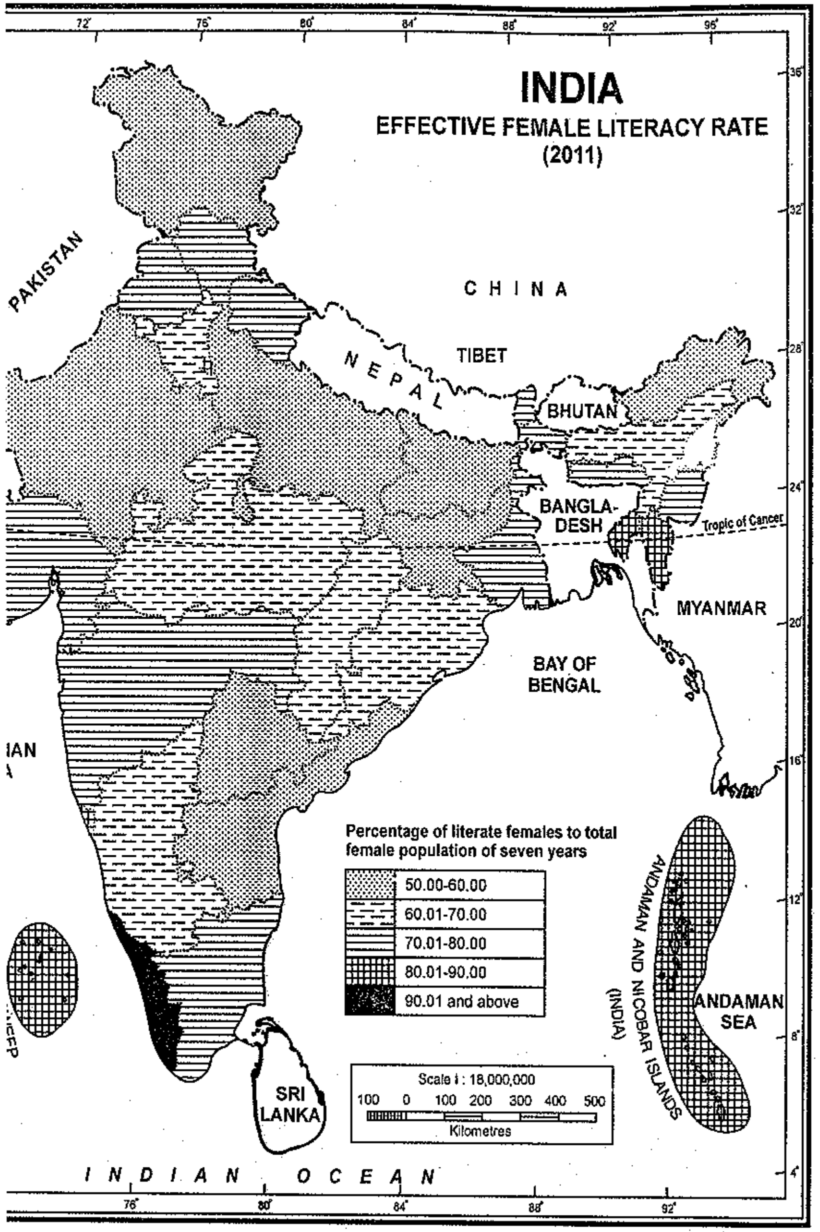

FIG. 11.15. India : Effective female literacy rate (2011)

per cent) and Rajasthan (67.06 per he major States, Maharashtra (82.91 after Kerala, followed by Tamil Nadu (80.33 per cent). The States and Union Territories with literacy rates below the National average (74.04 per cent) are Jammu and Kashmir in the North, Rajasthan in the West, Andhra Pradesh and Telangana in the South, Madhya Pradesh, Chhattisgarh, Uttar Pradesh in Central, Bihar, Jharkhand, Odisha in the East and Arunachal Pradesh and Assam in the North-East of the country. Ten States and Union Territories viz., Kerala, Lakshadweep, Mizoram, Tripura, Goa, Daman & Diu, Puducherry, Chandigarh, NCT of Delhi and Andaman & Nicobar Islands have achieved literacy rate of above 85 per cent, the target set by Planning Commission for the year 2011-2012. The States and Union Territories, which have literacy rate below the National average in respect of all the three categories i.e., persons, males and females are Arunachal Pradesh, Chhattisgarh, Madhya Pradesh, Andhra Pradesh (including Telangana), Bihar, Rajasthan, Jammu and Kashmir, Jharkhand and Uttar Pradesh.

Male Effective Literacy Rate

Lakshadweep (96.11 per cent) holds the first rank in the country with respect to male literacy rate. Kerala (96.02 per cent) ranks second. Bihar (73.39 per cent) has recorded the lowest literacy rate in case of males preceded again by Arunachal Pradesh (73.69 per cent). The States and Union Territories with literacy rates below the National average for males (82.14 per cent) are Madhya Pradesh, Assam, Meghalaya, Arunachal Pradesh, Andhra Pradesh (including Telangana), Bihar, Rajasthan, Jammu and Kashmir, Chhattisgarh, Punjab, Jharkhand and Uttar Pradesh.

Female Effective Literacy Rate

Kerala holds the first rank in the country in female literacy with 91.98 per cent. Rajasthan (52.66 per cent) has recorded the lowest female literacy rate preceded by Bihar (53.33 per cent). Similarly, the States and Union Territories with female literacy rate below the National average (65.46 per cent) are Odisha, Chhattisgarh, Madhya Pradesh, Andhra Pradesh (including Telangana), Arunachal Pradesh, Uttar Pradesh, Jammu and Kashmir, Jharkhand, Bihar and Rajasthan.

Effective Literacy Rate-Gender Gap

At the National level, the male-female gap for Census 2001 stood at 21.59 whereas for Census 2011 it is only 16.68. The decadal difference in literacy rates for males and females stands at 6.88 and 11.79 percentage points respectively, indicating a substantial improvement in respect of females. In Census 2001, in 12 States and Union Territories, the male-female gap was higher than the National average and for 23 States and Union Territories, it was below the National average. In Census 2011, in 11 States, the male female gap is higher than the National average and for 24 States and Union Territories, it is below the National average. The North-Eastern States of Meghalaya and Mizoram and Kerala from the South have reported minimum differentials in male-female gap in Census 2011 as well as in Census 2001. Mizoram had also reported the lowest differential even during 1991 Census followed by Kerala and Meghalaya. These States are consistent forerunners since decades. It is interesting to note that although average literacy rate in Meghalaya (75.48 per cent) is not high the male-female gap (3.39 percentage points) in literacy rate is lowest. Rajasthan, Jharkhand, Chhattisgarh, Madhya Pradesh and Jammu & Kashmir are at the bottom, showing huge gap in male-female differentials in literacy both at 2001 and 2011 Censuses. The States and Union Territories which have achieved male-female gap of literacy rate of 10 percentage points or below, the target set by the Planning Commission to be achieved by year 2011-2012, are Punjab, Chandigarh, NCT of Delhi, Nagaland, Mizoram, Tripura, Meghalaya, Lakshadweep, Kerala and Andaman & Nicobar Islands. Male-female literacy gaps for State sand Union Territories for 2011 and 2011 are depicted in table 11.20.

WORK

Work is defined as participation in any economically productive activity with or without compensation, wages or, profit. Such participation may be physical and/or mental in nature. Work involves not only actual work but also includes effective supervision and direction of work. It even includes part time help or unpaid work on farm, family enterprise or in any other economic activity. All persons engaged in 'work' as defined above are workers. Persons who are engaged in cultivation or milk production even solely for domestic consumption are also treated as workers.

TABLE 11.20. Literacy Rates and Male-Female Gap in Literacy

India/State/ Union Territory	2001		Gap in literacy rate	2011		Gap in literacy rate
	Males	Females		Males	Females	
India	75.26	53.67	21.59	82.14	65.46	16.68
Jammu & Kashmir	66.60	43.00	23.60	78.26	58.01	20.25
Himachal Pradesh	85.35	67.42	17.93	90.83	76.60	14.23
Punjab	75.23	63.36	11.87	81.48	71.34	10.14
Chandigarh#	86.14	76.47	9.67	90.54	81.38	9.16
Uttarakhand	83.28	59.63	23.65	88.33	70.70	17.63
Haryana	78.49	55.73	22.76	85.38	66.77	18.61
NCT of Delhi#	87.33	74.71	12.62	91.03	80.93	10.10
Rajashthan	75.70	43.85	31.85	80.51	52.66	27.85
Uttar Pradesh	68.82	42.22	26.60	79.24	59.26	19.98
Bihar	59.68	33.12	26.56	73.39	53.33	20.06
Sikkim	76.04	60.40	15.64	87.29	76.43	10.86
Arunachal Pradesh	63.83	43.53	20.30	73.69	59.57	14.12
Nagaland	71.16	61.46	9.70	83.29	76.69	6.60
Manipur	79.54	60.10	19.44	86.49	73.17	13.32
Mizoram	90.72	86.75	3.97	93.72	89.40	4.32
Tripura	81.02	64.91	16.11	92.18	83.15	9.03
Maghalaya	65.43	59.61	5.82	77.17	73.78	3.39
Assam	71.28	54.61	16.67	78.81	67.27	11.54
West Bengal	77.02	59.61	17.41	82.67	71.16	11.51
Jharkhand	67.30	38.87	28.43	78.45	56.21	22.24
Odisha	75.35	50.51	24.84	82.40	64.36	18.04
Chhattisgarh	77.38	51.85	25.53	81.45	60.59	20.86
Madhya Pradesh	76.06	50.29	25.77	80.53	60.02	20.51
Gujarat	79.66	57.80	21.86	87.23	70.73	16.50
Daman & Diu#	86.76	65.61	21.15	91.48	79.59	11.89
Dadra & Nagar Haveli#	71.18	40.23	30.95	86.46	65.93	20.53
Maharashtra	85.97	67.03	18.94	89.82	75.48	14.34
Andhra Pradesh (including Telangana)	70.32	50.43	19.89	75.56	59.74	15.82
Karnataka	76.10	56.87	19.23	82.85	68.13	14.72
Goa	88.42	75.37	13.05	92.81	81.84	10.97
Lakshadweep#	92.53	80.47	12.06	96.11	88.25	7.86
Kerala	94.24	87.72	6.52	96.02	91.98	4.04
Tamil Nadu	82.42	64.43	17.99	86.81	73.86	12.95
Puducherry#	88.62	73.90	14.72	92.12	81.22	10.90
Andaman & Nicobar Islands#	86.33	75.24	11.09	90.11	81.84	8.27

erritory

Census of India, Provisional Population Totals, Paper 1 of 2011, Series 1, Pp. 116-17.

Reference period for determining a person as worker and non-worker is one year preceding the date of renumeration.

Main Workers

Those workers who had worked for the major part of the reference period (*i.e.*, 6 months or more) are termed as *main workers*.

Marginal Workers

Those workers who had not worked for the major part of the reference period (*i.e.*, less than 6 months) are termed as *marginal workers*.

Cultivators

For purposes of the census a person is classified as cultivator if he or she is engaged in cultivation of land owned or held from Government or held from private persons or institutions for payment in money, kind or share. Cultivation includes effective supervision or direction in cultivation. A person who has given out her/his land to another person or persons or institution(s) for cultivation for money, kind or share of crop and who does not even supervise or direct cultivation of land, is not treated as cultivator. Similarly, a person working on another person's land for wages in cash or kind or a combination of both (agricultural labourer) is not treated as cultivator.

Cultivation involves ploughing, sowing, harvesting and production of cereals and millet crops such as wheat, paddy, jowar, bajra, ragi etc., and other crops such as sugarcane, tobacco, ground-nuts, tapioca, etc., and pulses, raw jute and kindred fiber crop, cotton, cinchona and other medicinal plants, fruit growing, vegetable growing of keeping orchards or groves, etc. Cultivation does not include the following plantation crops—tea, coffee, rubber, coconut and betel-nuts (areca).

Agricultural Labourers

A person who works on another person's land for wages in money or kind or share is regarded as an agricultural labourer. She or he has no risk in the cultivation, but merely works on another person's land for wages. An agricultural labourer has no right of lease or contract on land on which she/he works.

Household Industry Workers

Household Industry is defined as an industry conducted by one or more members of the household at home or within the village in rural areas and only within the precincts of the house where the household lives in urban areas. The larger proportion of workers in the household industry consists of members of the household. The industry is not run on the scale of a registered factory which would qualify or has to be registered under the Indian Factories Act.

The main criterion of a Household industry even in urban areas is the participation of one or more members of a household. Even if the industry is not actually located at home in rural areas there is greater possibility of the members of the household participating even if it is located anywhere within the village limits. In the urban areas, where oraganised industry takes greater prominence, the Household Industry is confined to the precincts of the house where the participants live. In urban areas, even if the members of the household run an industry by themselves but at a place away from the precincts of their home it is not considered as a Household Industry. It should be located within the precincts of the house where the members live in the case of urban areas.

Household Industry relates to production, processing, servicing, repairing or making and selling (but not merely selling) of goods. It does not include professions such as Pleader, Doctor, Musician, Dancer, Waterman, Astrologer, *Dhobi*, Barber, etc., or merely trade or business, even if such professions, trade or services are run at home by members of the household. Some of the typical industries that can be conducted on a household industry basis are : Foodstuffs : such as production of flour, milking or dehusking of paddy, grinding of herbs, production of pickles, preservation of meat etc. Beverages : such as manufacture of country liquor, ice cream, soda water etc., Tobacco Products : such as bidi, cigars, Textile

·ol or Silk, Manufacture of Wood and , Paper and Paper Products, Leather ducts, Petroleum and Coal Products : foot wear from torn tyres and other , Chemical and Chemical Products : ture of toys, paints, colours, matches, mes, ink etc., Service and Repairing uipments : such as cycle, rickshaw, riven carts etc.

rs

, *i.e.*, those who have been engaged in activity during the last one year, but ·ors or agricultural labourers or in stry are 'Other Workers (OW)'. The ; that come under this category of ıll government servants, municipal chers, factory workers, plantation ngaged in trade, commerce, business, ıg, mining, construction, political or iests, entertainment artists, etc. In : workers other than cultivators or urers or household industry workers, ers'.

'ho did not at all work during the l was treated as a non-worker. The adly constitute students who did not y economic activity paid or unpaid, es who were attending to daily es like cooking, cleaning utensils, ldren, fetching water etc. and are not he unpaid work in the family farm or lching, dependent such as infants or ple not included in the category of ers those who are drawing pension ınd are not engaged in any economic s, vagrants, prostitutes and persons ified source of income and with es of subsistence and not engaged in lly productive work during the . Other category includes all Non-nay not come under the above ı as rentiers, persons living on cultural or non-agricultural royalty, l persons who are seeking/available

Work Participation Rate

Work participation rate is defined as the percentage of total workers (main and marginal workers) to total population.

$$\text{Work participation rate} = \frac{\text{Total Workers (Main + Marginal)}}{\text{Total Population}} \times 100$$

According to the 2011 census, the participation rate in India is 39.79 which is a slight improvement over 39.1 in 2001. This leaves a huge 60.21 per cent population as non-workers. Thus a large percentage of non-working population depends upon a low percentage of workers which is less than 40 per cent of the total population. This is not congenial to economic growth of the country. India's low percentage of working force is the outcome of her demographic, socio-cultural and economic structure. Among the major factors responsible for low percentage of work force are high birth rate and consequent large proportion of children below the age of 15, prejudices against females' education, mobility and employment, and incapability of the Indian economic structure to generate enough employment opportunities.

The composition of working force varies with sex, residence and age. The disparity in participation rates of males and females are quite glaring. According to 2011 census figures, while 53.26 per cent of males are recorded as main workers, the corresponding figure for females is only 25.51 per cent. Such a situation is the result of prejudices against females as discussed earlier. In a male dominated society as that of India, earning of bread still continued to rest on masculine shoulders and femineity is given a secondary place in social and economic activities. Similar variations are observed in the participation rates of rural and urban areas. The relatively low participation rates in urban areas is attributed to the differences in the nature of economy and society in urban and rural areas. The nature of jobs in urban areas is such for which education and skill is a pre-requisite. The acquisition of education and skill takes its own time and delays entry into work-force. Moreover, the urban society is comparatively more awakened and the incidence of child participation in the work force is low as compared to that of the countryside. In contrast to this, education and skill have little relevance in the countryside and the incidence of child and female participation in the workforce is more than that prevalent in the urban areas. This factor contributed a great deal to the relatively low participation rates in urban areas. The participation rates in urban areas would have been still lower, but for large scale in migration of workers from rural areas to urban areas.

The 1971 census divided the entire work force into nine industrial categories which had been adopted till the 1991 census. However, the main categories of work force at the time of 2011 census have been recognised as cultivators, agricultural labourers and household industry workers (*see* **Table 11.21**).

TABLE 11.21. Working Force in India, 2011

Sl. No.	Category	Percentage
1.	Participation rate	39.79
2.	Male participation	53.26
3.	Female participation	25.57
4.	Main workers to total workers	75.24
5.	Marginal workers to total workers	24.76
6.	Cultivators to total workers	47.43
7.	Agricultural labourers to total workers	17.89
8.	Household workers to total workers	2.56
9.	Other workers to total workers	38.7

Source **:** Data computed from Census of India 2011, C.D. released in 2014.

Table 11.22 and **Fig. 11.16** depict the areal distribution of participation rate in India in 2011. It is observed that more than half the population is working in Himachal Pradesh and Sikkim. As many as 19 states and union territories have above 40 per cent participation rate which is higher than the national average of 39.79. All states of the peninsular India with the exception of Kerala, Puducherry, Jharkhand and Goa have participation rate higher than the national average. The mountain areas of Mizoram, Himachal Pradesh, Sikkim, Arunachal Pradesh and Nagaland also have sufficiently high participation rate. Almost all the states and union

TABLE 11.22. Participation Rate in India, States and Union Territories (2011)

Sl No.	States/Union Territories	Participation Rate (pecentage of workers to total population)
	INDIA	39.79
01	Jammu & Kashmir	34.47
02	Himachal Pradesh	51.85
03	Punjab	35.67
04	Chandigarh#	38.29
05	Uttarakhand	38.39
06	Haryana	35.17
07	NCT of Delhi#	33.28
08	Rajashthan	43.59
09	Uttar Pradesh	32.94
10	Bihar	33.35
11	Sikkim	50.47
12	Arunachal Pradesh	42.47
13	Nagaland	49.24
14	Manipur	45.09
15	Mizoram	44.36
16	Tripura	39.99
17	Meghalaya	39.96
18	Assam	38.36
19	West Bengal	38.08
20	Jharkhand	39.71
21	Odisha	41.79
22	Chhattisgarh	47.68
23	Madhya Pradesh	43.47
24	Gujarat	40.97
25	Daman & Diu#	49.86
26	Dadra & Nagar Haveli#	45.72
27	Maharashtra	43.99
28	Andhra Pradesh (including Telangana)	46.61
29	Karnatka	45.62
30	Goa	39.58
31	Lakshadweep#	29.09
32	Kerala	34.78
33	Tamil Nadu	45.58
34	Puducherry#	35.66
35	Andaman & Nicobar Islands#	40.08

Union Territory
Source **:** Data computed from Census 2011, C.D. released in 2014.

TABLE 11.20. Literacy Rates and Male-Female Gap in Literacy

State/ UT code	India/State/ Union Territory	2001		Gap in literacy rate	2011		Gap in literacy rate
		Males	Females		Males	Females	
	India	75.26	53.67	21.59	82.14	65.46	16.68
01	Jammu & Kashmir	66.60	43.00	23.60	78.26	58.01	20.25
02	Himachal Pradesh	85.35	67.42	17.93	90.83	76.60	14.23
03	Punjab	75.23	63.36	11.87	81.48	71.34	10.14
04	Chandigarh#	86.14	76.47	9.67	90.54	81.38	9.16
05	Uttarakhand	83.28	59.63	23.65	88.33	70.70	17.63
06	Haryana	78.49	55.73	22.76	85.38	66.77	18.61
07	NCT of Delhi#	87.33	74.71	12.62	91.03	80.93	10.10
08	Rajashthan	75.70	43.85	31.85	80.51	52.66	27.85
09	Uttar Pradesh	68.82	42.22	26.60	79.24	59.26	19.98
10	Bihar	59.68	33.12	26.56	73.39	53.33	20.06
11	Sikkim	76.04	60.40	15.64	87.29	76.43	10.86
12	Arunachal Pradesh	63.83	43.53	20.30	73.69	59.57	14.12
13	Nagaland	71.16	61.46	9.70	83.29	76.69	6.60
14	Manipur	79.54	60.10	19.44	86.49	73.17	13.32
15	Mizoram	90.72	86.75	3.97	93.72	89.40	4.32
16	Tripura	81.02	64.91	16.11	92.18	83.15	9.03
17	Maghalaya	65.43	59.61	5.82	77.17	73.78	3.39
18	Assam	71.28	54.61	16.67	78.81	67.27	11.54
19	West Bengal	77.02	59.61	17.41	82.67	71.16	11.51
20	Jharkhand	67.30	38.87	28.43	78.45	56.21	22.24
21	Odisha	75.35	50.51	24.84	82.40	64.36	18.04
22	Chhattisgarh	77.38	51.85	25.53	81.45	60.59	20.86
23	Madhya Pradesh	76.06	50.29	25.77	80.53	60.02	20.51
24	Gujarat	79.66	57.80	21.86	87.23	70.73	16.50
25	Daman & Diu#	86.76	65.61	21.15	91.48	79.59	11.89
26	Dadra & Nagar Haveli#	71.18	40.23	30.95	86.46	65.93	20.53
27	Maharashtra	85.97	67.03	18.94	89.82	75.48	14.34
28	Andhra Pradesh (including Telangana)	70.32	50.43	19.89	75.56	59.74	15.82
29	Karnataka	76.10	56.87	19.23	82.85	68.13	14.72
30	Goa	88.42	75.37	13.05	92.81	81.84	10.97
31	Lakshadweep#	92.53	80.47	12.06	96.11	88.25	7.86
32	Kerala	94.24	87.72	6.52	96.02	91.98	4.04
33	Tamil Nadu	82.42	64.43	17.99	86.81	73.86	12.95
34	Puducherry#	88.62	73.90	14.72	92.12	81.22	10.90
35	Andaman & Nicobar Islands#	86.33	75.24	11.09	90.11	81.84	8.27

Union Territory

Source : Census of India, Provisional Population Totals, Paper 1 of 2011, Series 1, Pp. 116-17.

Reference period for determining a person as worker and non-worker is one year preceding the date of renumeration.

Main Workers

Those workers who had worked for the major part of the reference period (*i.e.*, 6 months or more) are termed as *main workers*.

Marginal Workers

Those workers who had not worked for the major part of the reference period (*i.e.*, less than 6 months) are termed as *marginal workers*.

Cultivators

For purposes of the census a person is classified as cultivator if he or she is engaged in cultivation of land owned or held from Government or held from private persons or institutions for payment in money, kind or share. Cultivation includes effective supervision or direction in cultivation. A person who has given out her/his land to another person or persons or institution(s) for cultivation for money, kind or share of crop and who does not even supervise or direct cultivation of land, is not treated as cultivator. Similarly, a person working on another person's land for wages in cash or kind or a combination of both (agricultural labourer) is not treated as cultivator.

Cultivation involves ploughing, sowing, harvesting and production of cereals and millet crops such as wheat, paddy, jowar, bajra, ragi etc., and other crops such as sugarcane, tobacco, ground-nuts, tapioca, etc., and pulses, raw jute and kindred fiber crop, cotton, cinchona and other medicinal plants, fruit growing, vegetable growing of keeping orchards or groves, etc. Cultivation does not include the following plantation crops—tea, coffee, rubber, coconut and betel-nuts (areca).

Agricultural Labourers

A person who works on another person's land for wages in money or kind or share is regarded as an agricultural labourer. She or he has no risk in the cultivation, but merely works on another person's land for wages. An agricultural labourer has no right of lease or contract on land on which she/he works.

Household Industry Workers

Household Industry is defined as an industry conducted by one or more members of the household at home or within the village in rural areas and only within the precincts of the house where the household lives in urban areas. The larger proportion of workers in the household industry consists of members of the household. The industry is not run on the scale of a registered factory which would qualify or has to be registered under the Indian Factories Act.

The main criterion of a Household industry even in urban areas is the participation of one or more members of a household. Even if the industry is not actually located at home in rural areas there is greater possibility of the members of the household participating even if it is located anywhere within the village limits. In the urban areas, where oraganised industry takes greater prominence, the Household Industry is confined to the precincts of the house where the participants live. In urban areas, even if the members of the household run an industry by themselves but at a place away from the precincts of their home it is not considered as a Household Industry. It should be located within the precincts of the house where the members live in the case of urban areas.

Household Industry relates to production, processing, servicing, repairing or making and selling (but not merely selling) of goods. It does not include professions such as Pleader, Doctor, Musician, Dancer, Waterman, Astrologer, *Dhobi*, Barber, etc., or merely trade or business, even if such professions, trade or services are run at home by members of the household. Some of the typical industries that can be conducted on a household industry basis are : Foodstuffs : such as production of flour, milking or dehusking of paddy, grinding of herbs, production of pickles, preservation of meat etc. Beverages : such as manufacture of country liquor, ice cream, soda water etc., Tobacco Products : such as bidi, cigars, Textile cotton, Jute, Wool or Silk, Manufacture of Wood and Wood Products, Paper and Paper Products, Leather and Leather Products, Petroleum and Coal Products : such as making foot wear from torn tyres and other rubber footwear, Chemical and Chemical Products : such as manufacture of toys, paints, colours, matches, fireworks, perfumes, ink etc., Service and Repairing of Transport Equipments : such as cycle, rickshaw, boat or animal driven carts etc.

Other Workers

All workers, *i.e.*, those who have been engaged in some economic activity during the last one year, but are not cultivators or agricultural labourers or in Household Industry are 'Other Workers (OW)'. The type of workers that come under this category of 'OW' include all government servants, municipal employees, teachers, factory workers, plantation workers, those engaged in trade, commerce, business, transport, banking, mining, construction, political or social work, priests, entertainment artists, etc. In effect, all those workers other than cultivators or agricultural labourers or household industry workers, are 'Other Workers'.

Non-Workers

A person who did not at all work during the reference period was treated as a non-worker. The non-workers broadly constitute students who did not participate in any economic activity paid or unpaid, household duties who were attending to daily household chores like cooking, cleaning utensils, looking after children, fetching water etc. and are not even helping in the unpaid work in the family farm or cultivation or milching, dependent such as infants or very elderly people not included in the category of worker, pensioners those who are drawing pension after retirement and are not engaged in any economic activity. Beggars, vagrants, prostitutes and persons having unidentified source of income and with unspecified sources of subsistence and not engaged in any economically productive work during the reference period. Other category includes all Non-workers who may not come under the above categories such as rentiers, persons living on remittances, agricultural or non-agricultural royalty, unpaid work and persons who are seeking/available for work.

Work Participation Rate

Work participation rate is defined as the percentage of total workers (main and marginal workers) to total population.

$$\text{Work participation rate} = \frac{\text{Total Workers (Main + Marginal)}}{\text{Total Population}} \times 100$$

According to the 2011 census, the participation rate in India is 39.79 which is a slight improvement over 39.1 in 2001. This leaves a huge 60.21 per cent population as non-workers. Thus a large percentage of non-working population depends upon a low percentage of workers which is less than 40 per cent of the total population. This is not congenial to economic growth of the country. India's low percentage of working force is the outcome of her demographic, socio-cultural and economic structure. Among the major factors responsible for low percentage of work force are high birth rate and consequent large proportion of children below the age of 15, prejudices against females' education, mobility and employment, and incapability of the Indian economic structure to generate enough employment opportunities.

The composition of working force varies with sex, residence and age. The disparity in participation rates of males and females are quite glaring. According to 2011 census figures, while 53.26 per cent of males are recorded as main workers, the corresponding figure for females is only 25.51 per cent. Such a situation is the result of prejudices against females as discussed earlier. In a male dominated society as that of India, earning of bread still continued to rest on masculine shoulders and femineity is given a secondary place in social and economic activities. Similar variations are observed in the participation rates of rural and urban areas. The relatively low participation rates in urban areas is attributed to the differences in the nature of economy and society in urban and rural areas. The nature of jobs in urban areas is such for which education and skill is a pre-requisite. The acquisition of education and skill takes its own time and delays entry into work-force. Moreover, the urban society is comparatively more awakened and the incidence of child participation in the work force is low as compared to that of the countryside. In contrast to

this, education and skill have little relevance in the countryside and the incidence of child and female participation in the workforce is more than that prevalent in the urban areas. This factor contributed a great deal to the relatively low participation rates in urban areas. The participation rates in urban areas would have been still lower, but for large scale in migration of workers from rural areas to urban areas.

The 1971 census divided the entire work force into nine industrial categories which had been adopted till the 1991 census. However, the main categories of work force at the time of 2011 census have been recognised as cultivators, agricultural labourers and household industry workers (*see* **Table 11.21**).

TABLE 11.21. Working Force in India, 2011

Sl. No.	Category	Percentage
1.	Participation rate	39.79
2.	Male participation	53.26
3.	Female participation	25.57
4.	Main workers to total workers	75.24
5.	Marginal workers to total workers	24.76
6.	Cultivators to total workers	47.43
7.	Agricultural labourers to total workers	17.89
8.	Household workers to total workers	2.56
9.	Other workers to total workers	38.7

Source **:** Data computed from Census of India 2011,. C.D. released in 2014.

Table 11.22 and **Fig. 11.16** depict the areal distribution of participation rate in India in 2011. It is observed that more than half the population is working in Himachal Pradesh and Sikkim. As many as 19 states and union territories have above 40 per cent participation rate which is higher than the national average of 39.79. All states of the peninsular India with the exception of Kerala, Puducherry, Jharkhand and Goa have participation rate higher than the national average. The mountain areas of Mizoram, Himachal Pradesh, Sikkim, Arunachal Pradesh and Nagaland also have sufficiently high participation rate. Almost all the states and union

TABLE 11.22. Participation Rate in India, States and Union Territories (2011)

Sl No.	States/Union Territories	Participation Rate (pecentage of workers to total population)
	INDIA	39.79
01	Jammu & Kashmir	34.47
02	Himachal Pradesh	51.85
03	Punjab	35.67
04	Chandigarh#	38.29
05	Uttarakhand	38.39
06	Haryana	35.17
07	NCT of Delhi#	33.28
08	Rajashthan	43.59
09	Uttar Pradesh	32.94
10	Bihar	33.35
11	Sikkim	50.47
12	Arunachal Pradesh	42.47
13	Nagaland	49.24
14	Manipur	45.09
15	Mizoram	44.36
16	Tripura	39.99
17	Meghalaya	39.96
18	Assam	38.36
19	West Bengal	38.08
20	Jharkhand	39.71
21	Odisha	41.79
22	Chhattisgarh	47.68
23	Madhya Pradesh	43.47
24	Gujarat	40.97
25	Daman & Diu#	49.86
26	Dadra & Nagar Haveli#	45.72
27	Maharashtra	43.99
28	Andhra Pradesh (including Telangana)	46.61
29	Karnatka	45.62
30	Goa	39.58
31	Lakshadweep#	29.09
32	Kerala	34.78
33	Tamil Nadu	45.58
34	Puducherry#	35.66
35	Andaman & Nicobar Islands#	40.08

Union Territory

Source **:** Data computed from Census 2011, C.D. released in 2014.

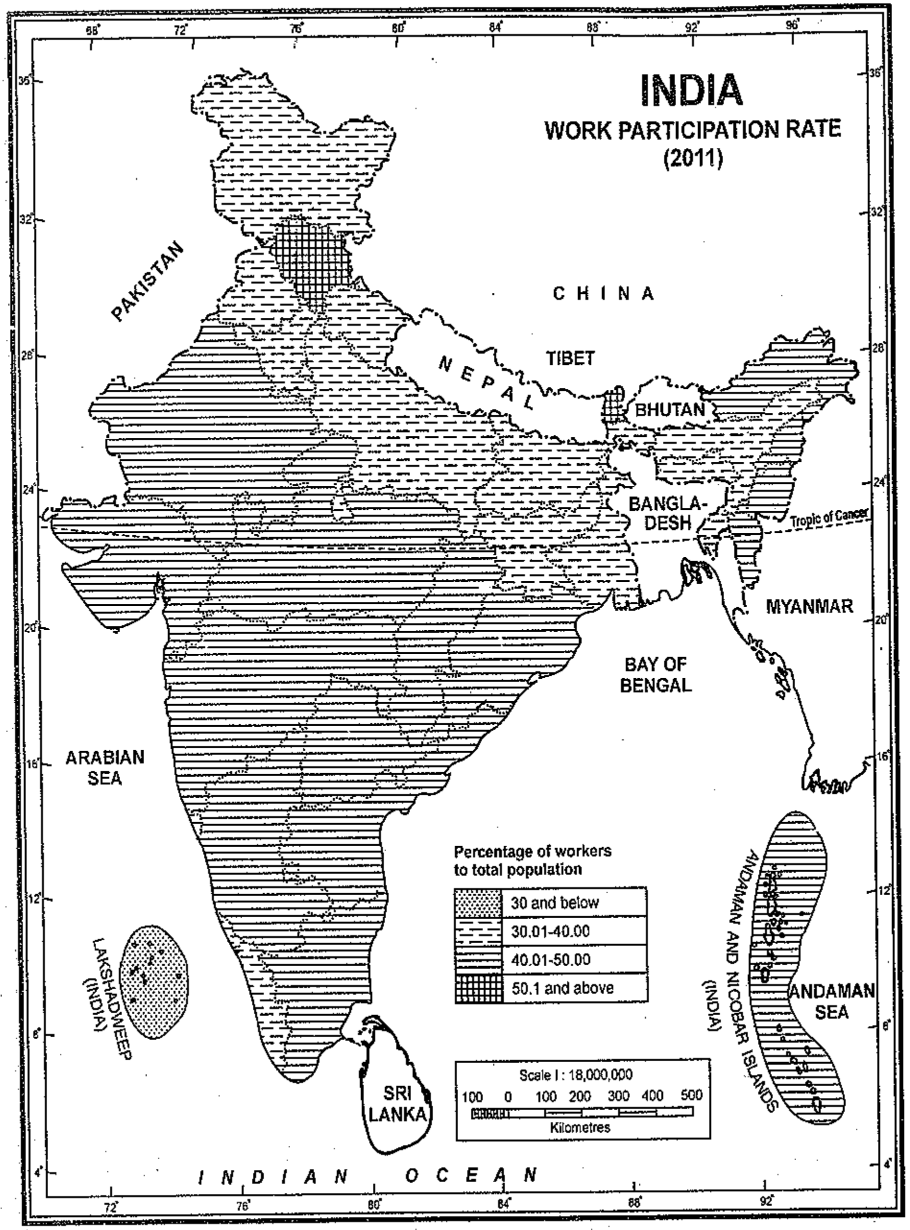

FIG. 11.16. India : Work Participation Rate (2011)

territories in the northern plain of India have participation rate below the national average. Some mountainous states like Jammu and Kashmir and Uttaranchal also have low participation rate. The lowest participation rate of 29.09 is found in union territory of Lakshadweep.

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CHAPTER 12

Migration Patterns

INTRODUCTION AND DEFINITION

Migration is a form of spatial mobility of population between one geographical unit and another involving a permanent change of residence (UN : 1958). The Census of India determines migration by place of birth or residence. *If a person was born at a place other than the place of enumeration, then he is treated as a migrant*. Of the three components of population change, migration holds a place of prominence—the other two components being *fertility* and *mortality*. Migration cannot be considered as a mere shift of people from one place of residence to another, as it is most fundamental to the understanding of continuously changing space-content and space-relationships of area (Gosal, 1961). Gill (1981) is of the opinion that movement over territories is a characteristic feature of all human populations irrespective of their stage of development. Bogue (1959) considers it an instrument of cultural diffusion and social integration, which yields more meaningful redistribution of population. Smith (1960) has talked about three-fold impact of migration on (*i*) the area of out-migration (*ii*) the area of in-migration and (*iii*) the migrants themselves. He has rightly remarked that areas of out-migration, in-migration and the migrants themselves never remain the same. The population of the area of out-migration decreases whereas the population of the area of in-migration increases. Migrants are also affected because there is a change in the residence of the migrants.

The studies regarding migration are seriously hampered due to lack of methodology and data constraints. Most scholars who write about migration theories and models recognise the very imperfect state of present-day theoretical and empirical knowledge of migration phenomenon (Germani, 1964). There is considerable agreement, that the study of migration has been hampered by the grave deficiencies in migration theories, which tend to be *time bound*, *culture bound and description bound* (Manglam and Schwarzweller: 1968). To some extent, this situation may be attributed to the greater complexity of migration as compared with the other two components of population change—mortality and fertility. According to Jones (1981), "Of the three components of population change, migration is the most difficult to conceptualize and measure". Because, it involves a change from the place of origin to the place of destination, migration has both a separative and an additive effect and both aspects are relevant to an understanding of why people move. The data constraints are no less pronounced than the lack of methodology. The census of India does not provide any direct data on migration. It is only with the help of place of birth data that some idea of magnitude and direction of patterns of migration can be obtained. Although, post-independence censuses have tried to improve the quality and quantity of migration data, yet the census data are far from satisfactory for a reasonable analysis of migration. Census data of 2011 on migration has yet not been published and we have to content ourselves with 2001 census data only.

Migration and Census of India. Along with other things, census data contain information about migration also. In fact, migration data were recorded at the time of first Indian census in 1881. It was based on the place of birth. In 1961, modification was made to include place of birth and duration of residence (if born elsewhere). In 1971, additional information on place of last residence and duration of stay at the place of enumeration were incorporated. Information on reasons for migration were incorporated in 1981 census and modified in consecutive censuses.

Following questions are asked about migration at the time of census enumeration:

- Is the person born in this village or town? If no, then further information is taken on rural/urban status of the place of birth, name of district and state and if outside India then name of the country of birth.
- Has the person come to this village or town from elsewhere? If yes, then further questions are asked about the status (rural/urban) of previous place of residence, name of district and state and if outside India then name of the country.

In addition, reasons for migration from the place of last residence and duration of residence in place of enumeration are also asked.

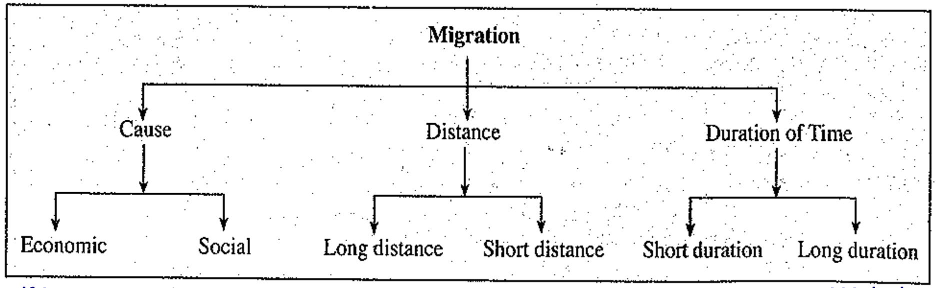
In the Census of India, migration is enumerated on the following two bases.

(i) **Place of birth,** if the place of birth is different from the place of enumeration (known as life-time migrant);

(ii) **Place of residence,** if the place of last residence is different from the place of enumeration (known as migrant by place of last residence).

Definition of Certain Terms Associate with Migration. *Place of origin* is the place which the migrant leaves, and, for that place, the person is an *out-migrant*. *Place of destination* is the place where the migrant arrives and for that place, the person is called in-migrant. Thus the same person is an out-migrant for the place of origin and in-migrant in the place of destination. When the migration takes place across international boundaries, the terms used are *emigration* and *immigration* to describe migration phenomenon, and migrant and immigrant to define a person.

Classification of migration. Migration can be classified on the basis of cause, distance and duration of time as illustrated below :



TYPES OF MIGRATION

Migration may be broadly classified as *international* and *internal*. India has experienced both, though at a much lesser scale as compared to other countries of the world.

International Migration

Movement of population from one country to another, across the international borders, is called ***international migration.*** International migration is of two types *viz.* out-migration of Indians to other countries and immigration into India from other countries.

OUT-MIGRATION

Instances of Indians migrating to other countries have been noticed in the historical times. In fact migration by Indians to other countries has a long history. During the reign of Ashoka the Greate, several preachers travelled to south-east Asian countries to spread the Buddhist religion and popularize Indian art and culture. In the 19th century many Indians migrated to Mauritius, Burma (Myanmar), Sri Lanka, Malaysia, Fiji, Guyana, Surinam, Trinidad, South Africa and East Africa as labourers and settled permanently there. The first group of Indian labourers consisting of convicts and criminals was transported from Kolkata (Calcutta) in 1815 to work in sugarcane fields. After 1934, a large number of free workers were attracted by the mild oceanic climate of Mauritius. At present about three-fourths of the total population of Mauritius consists of people of Indian origin. There is a big colony of about 8000 Indians in the Reunion Islands near Mauritius. A large number of Indians also migrated to West Indies.

Indians also migrated to different countries of Africa during 18th and 19th centuries. Several merchants of Indian origin established their business with the help of Arab traders. A large number of Indians were encouraged by the European rulers to migrate to African countries and work there as labourers to clear the forests and provide land for agricultural purposes, to work in their plantations and to provide labour force for constructing railways. These labourers were followed by other professionals such as traders, shop-keepers and money lenders. Thus large Indian colonies came up in central and southern parts of Africa. The countries where Indian colonies were developed include Kenya, Uganda, Tanganika, Mozambique, Tanzania, Zimbabwe, Somalia, Ethiopia, Zambia, Natal, South Africa, etc. Most migrations to African countries originated from the states of Punjab, Gujarat, Maharashtra, Tamil Nadu and Kerala.

Indians started migrating to West Indies after 1840 and their main destinations were Guinea and Trinidad. Each has over two lakh Indians. Some Indians had migrated to Jamaica, Martinique and Guadeloupe also. Most of the Indians migrated to these islands as labourers to work in the agricultural fields. Majority of such migrants were from Eastern Uttar Pradesh and Bihar. At present, Indians constitute over 50% of the population of West Indies.

THREE WAVES OF INDIAN DIASPORA

There have been three waves of Indian Diaspora at three different times in the history of India. According to Migration Policy Institute diaspora is defined as "people of Indian origin who live outside the country but continue to exhibit some of India's ethnocultural characteristics."

1. The first wave took place during the British period when a large number of labourers were sent to Mauritius, Caribbean islands (Trinidad, Tobago and Guyana), Fiji and South Africa by British from Uttar Pradesh and Bihar; to Reunion Island, Guadeloupe, Martinique and Surinam by French and Dutch and by Portuguese from Goa, Daman and Diu to Angola, Mozambique to work as plantation workers. All such migrations were covered under the time-bound contract known as ***Girmit Act*** (Indian Emigration Act). These labourers were living in inhuman conditions and their living conditions were as bad as those of slaves.

2. The second wave of migrants went to settle in the neighbouring countries like Thailand, Malaysia, Singapore, Indonesia, Brunei and some African countries. This is a recent development under which professionals, artisans, traders, factory workers went out of the country in search of better quality of life. This trend is still continuing. In the 1970s, there was oil boom in West Asia and a large number of skilled and semi-skilled workers went there to avail of the opportunity Some entrepreneurs, store owners, professionals, businessmen etc. went to western countries also.

3. The third wave started in 1960s and still continues to operate. In this period high profile professionals like doctors, engineers etc. migrated out of India. In 1980s, software engineers, management consultants, financial experts, media persons etc. moved out of the country to work in countries like the U.S.A., Canada, U.K., Australia, New Zealand, Germany etc. After liberalisation in 1991, education and knowledge based Indian migration has made Indian Diaspora most powerful in the world.

By the end of the 19th country, a large number of Indians migrated to Sri Lanka and Malaysia to work as labourers in tea and rubber plantations respectively. At present there are about five million Indians in Sri Lanka which account for about one-third of the total population of that country. Similarly about 10 per cent population of Malaysia is of Indian origin. Most of the migrants to Sri Lanka and Malaysia are from Tamil Nadu and they had been fighting a long war for their rights. Some labourers from Bihar, Uttar Pradesh, West Bengal and Odisha also migrated to these countries.

Since 1970s, highly educated and skilled professionals have migrated from India to some of the most advanced countries such as the U.S.A., U.K., Canada, Australia, New Zealand, Japan and some countries of Western Europe, leading to a serious problem of *brain drain*. A less educated work force had earlier migrated to these countries since Independence as labourers. During the last four decades or so, many Indians have migrated to the oil-rich countries of the Middle East. Some migration from India has taken place to South-east Asian and south American countries.

But global recession in 2007-08 dealt a big blow to migration and many Indians had to come back to India due to heavy reduction in job opportunities in North American and European countries. Out migration from India again picked up after normalization of world economy. But Indian migration to Australia has suffered a set back due to racial discrimination and violence against Indians. Migration of people from India during historic times is shown in **Fig. 12.1**.

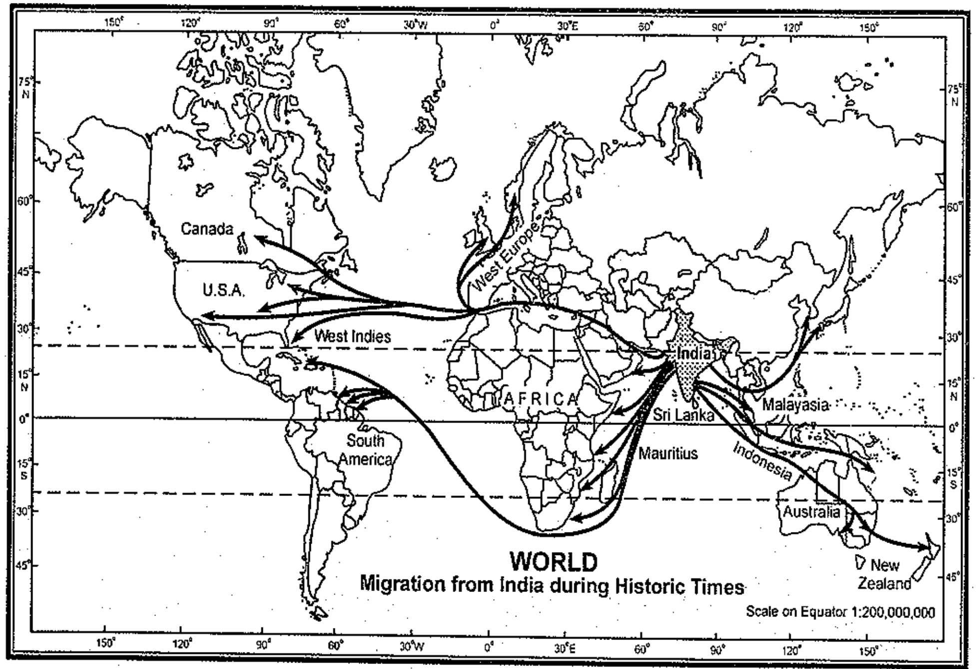


FIG. 12.1. Migration from India during Historic Times

Partition of Indian subcontinent and International Migra tion

Partition of the Indian subcontinent in 1947 resulted in large scale migration of population from India to Pakistan and Bangladesh and *vice versa*. This has been termed as one of the greatest movements of human beings in the history of the world. In spite of its short duration, it had long term consequences for the economy and society of the three concerned countries. About 14.5 million people moved across

the border. Hindus and Sikhs came to India from Pakistan and Bangladesh and Muslims from India went to these countries. In 1951, 7.3 million refugees were enumerated in India (4.7 million from Pakistan and 2.6 million from Bangladesh). The 1951 census of Pakistan enumerated 7.2 million *muhajirs* (refugees) from India. The patterns of migration due to partition of subcontinent are shown in **Fig. 12.2**.

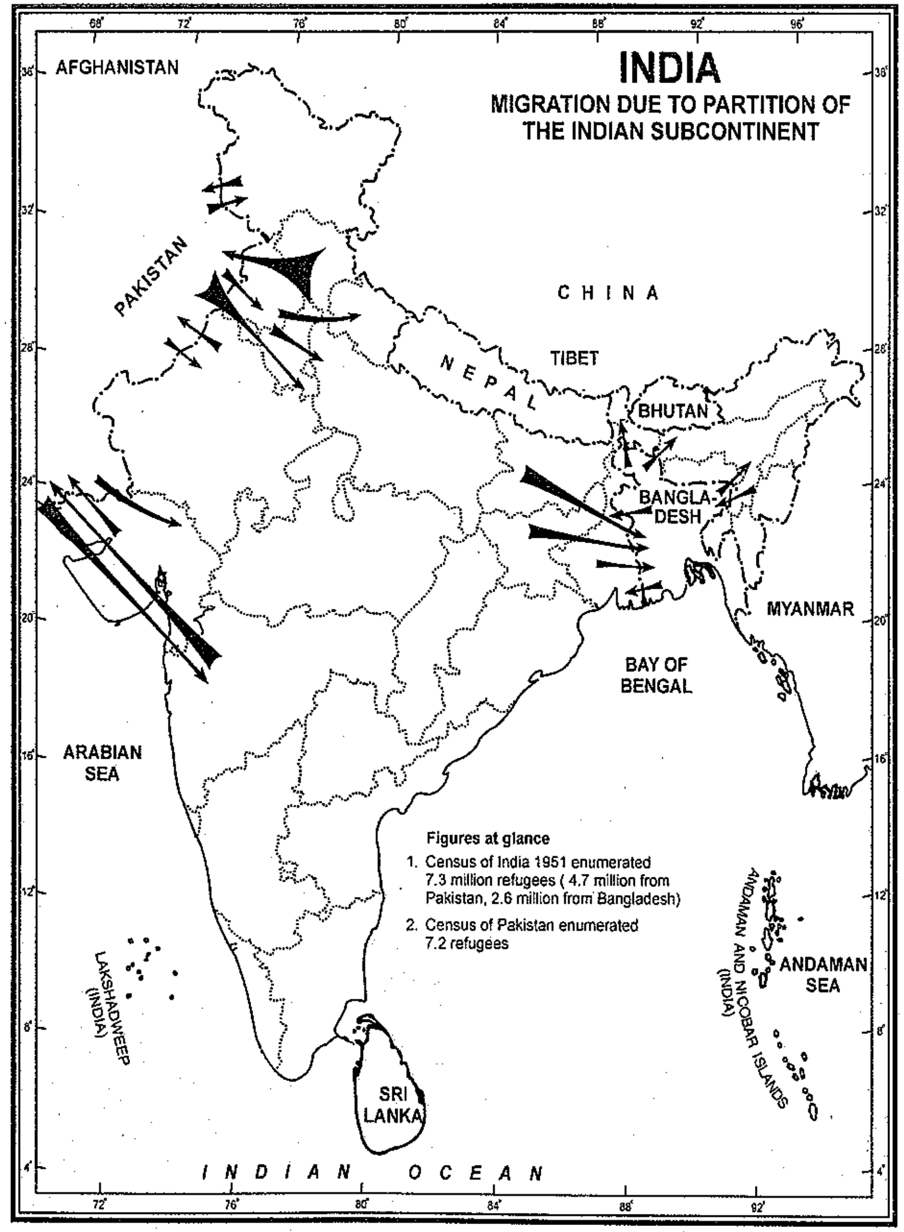


FIG. 12.2. Partition of Indian Subcontinent and International Migration

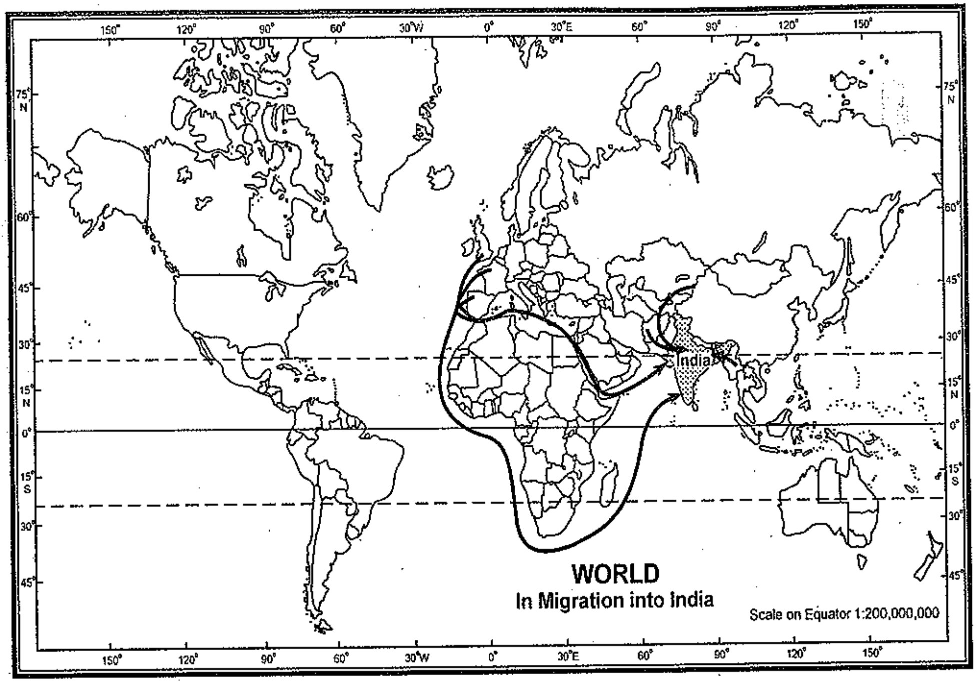


FIG. 12.3. In-migration into India

> According to report in 2009 by the Migration Policy Institute, Myanmar is the surprise home largest Indian diaspore. More than 2.9 million out of 18.5 million strong Indian disaspore live there (see region-wise details below):
>
> **S.E. Asia**—Myanmar 2,902,000, Malaysia 1,665,000, Sri Lanka 855,025.
>
> **North America**—U.S.A. 1,678,765, Canada 851,000.
>
> **Caribbean**—Trinidad and Tobago 500,600, Guyana 3,937,350
>
> **Persian Gulf**—Saudi Arabia 1,500,600, U.A.E. 950,000, Oman, 312,000, Kuwait 295,000.
>
> **Europe**—U.K. 1,200,600, Netherlands 217,000.
>
> **Africa**—S. Africa 1,000,000, Mauritius 715,756.
>
> **Oceania**. Fiji 336,829, Australia 190,000.

IN-MIGRATION

The present day population of India consists of descendants of people who migrated to this country at different pre-historic and historic times from different parts of the world. These include the Dravidians, the Aryans, Muslisms, Moghals, Europeans, etc. Most of the international migrants in India are from the Asian countries, followed by Europeans, Africans, Americans and Australians. The maximum migration in India has taken place from the neighbouring countries like Pakistan, Nepal, Bangladesh and Afghanistan. Most of the immigrants in India from the neighbouring countries mainly from Bangladesh and Nepal, are concentrated in Assam and Uttar Pradesh. Assam receives more Bangladeshis than the Nepalese while Uttar Pradesh has more Nepalese for the obvious reason of significance of distance factor in population migration. Foreign Nationals have settled in West Bengal, Maharashtra, Delhi, Tamil Nadu, Bihar, Punjab, Himachal Pradesh, Madhya Pradesh, Arunachal Pradesh, Odisha, Gujarat, Goa and Kerala.

According to 2001 Census figures, more than 5 million persons have migrated to India from other countries. Out of these, 96 per cent came from the neighbouring countries: Bangladesh (3.0 million) followed by Pakistan (0.9 million) and Nepal (0.5

million). Included in this are 0.16 million refugees from Tibet, Sri Lanka, Bangladesh, Pakistan, Afghanistan, Iran, and Myanmar.

TABLE 12.1. Immigrants by last residence from neigh-bouring countries by all duration in India, 2001

Countries %	No. of immigrants	% of total immigrants
Total international migration	**5,155,423**	**100**
Migration from neighbouring countries	4,918,266	95.5
Afghanistan	9,194	0.2
Bangladesh	3,084,826	59.8
Bhutan	8,337	0.2
China	23,721	0.5
Myanmar	49,086	1.0
Nepal	596,696	11.6
Pakistan	997,106	19.3
Sri Lanka	149,300	2.9

***Source*:** Census of India, 2001.

Refugee Influx into India. Although India has not signed the 1951 Refugee convention, yet, India has been the main destination for refugees during the last about six decades and there has been a surge in refugees from the neighbouring countries like Tibet (China), Afghanistan, Sri Lanka, Myanmar and Bangladesh. The estimated figures say that there are more than 3 lakh refugees in India in 2011 making India one of the top 25 refugee recipients in the world. The following brief description gives an idea of refugee influx into India.

1. Tibetans. Dalai Lama was allowed to set up a government in-exile at Dharamsala (Himachal Pradesh) in 1959. This brought in a wave of Tibetan refugees and currently there are about 1,10,000 Tibetans in India. Of them 80,000 have resident permits and are offered low paying public works jobs by the Indian government.

2. Afghans. In 1979 about 60,000 Afghans fled to India when Soviet Union invaded that country. In 1992 and afterwards, thousands of Afghanistanis took refuge in India when Taliban captured power in that country. In 2007, UNHCR estimated 9,200 Afghans in India and 4,000 asylum seekers in the process of refugees certification.

3. Sri Lanka. The civil war in 1983 triggered first wave of Sri Lanka Tamil refugees to India. By 1995 India and UNHCR repatriated 100,000 Tamil Sri Lankans as the war ended. In 2008, 73,000 Sri Lankan refugees were living in 117 camps mostly in Tamil Nadu.

4. Myanmar. 50,000 people fled from Myanmar into Mizoram in 2004 in the wake of military oppression.

5. Bangladeshis. About 50,000 Chakma refugees fled Bangladesh into Tripura in 1988.

Until December 2008, the Indian policy did not charge refugees a "visa or penalty fee" for a residence permit. This was one of the main reasons for surge of refugees into India. However, since then the numbers are divindling. But thousands of Bangladeshis are sneaking illegally into India, making use of porous border between India and Bangladesh.

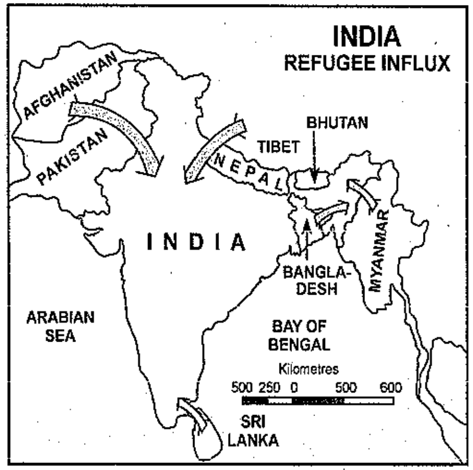


FIG. 12.4. India : Refugee Influx

Figure 12.4 shows that India has been a greater refuge for refugees from the neighbouring countries in the Indian subcontinent.

Reverse Migration. The world wide economic succession in 2008 forced a large number of Indian overseas to return to their home land. This reverse migration gathered momentum in 2008 and countries to operate till date. An estimated 3 lakh Indian professionals working overseas are expected to return to India between 2011 and 2015. The sustained economic growth and the resilience that India had shown during the slow down has fueled the reverse movement by those who had left the country in search of better job opportunities and higher standard of living. Most of them had been working in the U.S.A., European countries and oil rich Middle East countries. The main reasons assigned by those who planned reverse migration during 2008-11 are given below :

48% felt that there is insecure job market overseas.

29% felt that personal growth opportunities are better back home.

23% felt attraction for the native place is more important than opportunities abroad.

Non-resident Indians see the country's growth story as an opportunity to cash on.

Internal Migration

The Indian population has been considered as one of the least mobile populations of the world (Davis 1951, Gosal 1961, Skeldon 1986). Migration rates in India are desperately low in comparison to most of the European and North American countries. Davis (1951) found from an analysis of place-of-birth statistics from the 1931 census that while 22.5 per cent of the native population in the United States in 1940 lived outside the state in which they were born, only 3.6 per cent of the Indian population in 1931 lived outside the state or province of birth. Blunt (1938) commented that nowhere in the world is the population so immobilised as it is in India. At every census, some 90 per cent of the people are enumerated in the district in which they were born; and of the rest, some seven per cent were born in neighbouring districts. This has been supported by Zachariah (1964) during his study of inter-state migration in India between 1902 and 1931. Several factors have been held responsible for the stubborn immobility of Indian population. These include factors of economic, social, cultural and demographic character. Several scholars like Kamath (1914), Wattal (1934), Chandershekhar (1951), Davis (1951), Gosal (1961), D'Souza (1964) and Majumdar and Majumdar (1978) have tried to elaborate the impact of these factors. The familistic system and agrarian culture and majority of people gripped by widespread poverty in rural society are considered to be the major factors, which impede movement of people. Farming attaches the farmer to the soil and precludes the necessity of widespread travel. Caste system, regional and communal mores, early marriage, diversity in language and culture, low levels of education and literacy and prejudices against female mobility have also contributed a lot to meagre migration in India. Lack of adequate means of transportation and communication and want of knowledge of outside world, especially the area of destination, are also very important impediments to migration (Raju, 1989). A very large section of rural population is completely isolated and has no knowledge of work and wages available elsewhere (Gosal, 1961).

The above description is validated by the fact that interstate life time migration in India was only 3.3 per cent of the total population in 1961. This figure increased marginally to 3.6 per cent in 1981 and 4.1 per cent in 2001. Migration by rural people was not even half of this percentage. Proportionately, it has been much higher for migrants to urban areas than to rural areas (**Table 12.2**).

TABLE 12.2. Size of lifetime interstate migrants (based on birthplace statistics and the same as percentage of total population by sex and by rural or urban place of enumeration, (2001)

Sex	*Total*	*Rural*	*Urban*
Both sexes	42,342 (4.1)	14,020 (1.9)	28,322 (9.9)
Males	19,676 (3.7)	4,390 (2.7)	15,285 (10.2)
Females	22,686 (4.6)	9,629 (2.7)	13,036 (9.6)

Note : Figures in parenthesis are in percentages.
Source : Census of India 2001.

It would be of great interest to examine the states which were net gainers and net lossers with respect to interstate migration. Among the major losers where out migration has been more than in-migration, are Andhra Pradesh, Bihar, Chhattisgarh, Jammu and Kashmir, Jharkhand, Kerala, Madhya Pradesh, Odisha, Rajasthan, Tamil Nadu, Uttar Pradesh and a West Bengal. In contrast, Gujarat, Haryana, Karnataka, Maharashtra, Punjab and all Union Territories have gained in total population where the number in-migrants had been more than the number of out-migrants (**Table 12.3**).

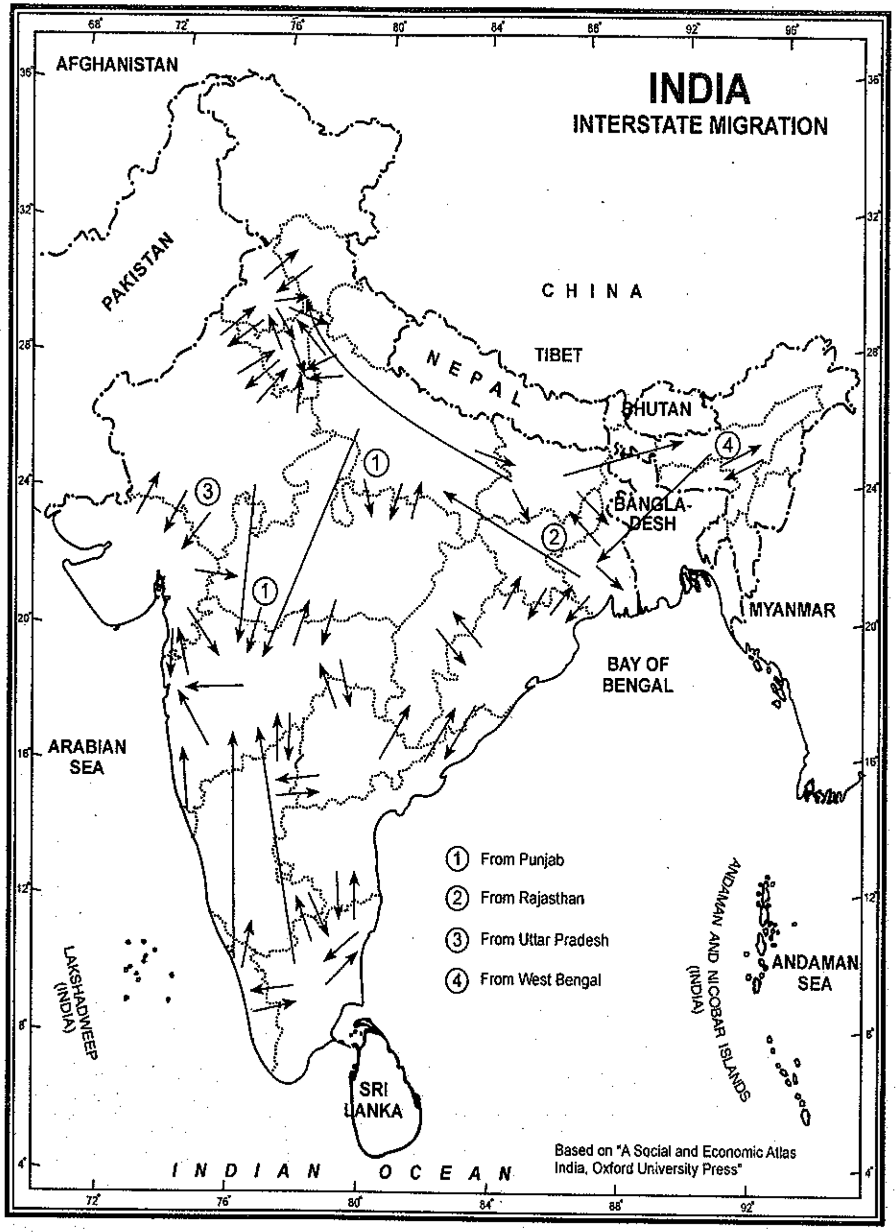


FIG. 12.5. India : Interstate Migration

Net lifetime in-migration in Maharashtra was 3.4 per cent in 2001. All union territories and small states experienced increase in population through net inmigration, barring a few exception. Chandigarh (14.7 per cent) and Delhi (12.8 per cent) experienced substantially high in-migration. Chandigarh has been

TABLE 12.3. Interstate migration trends (2001)

State/U.T.	In-migrants	Out-migrants	Net-migrants
1	2	3	4
India	**16,826,879**	**16,826,879**	**0**
Jammu & Kashmir	86,768	122,175	–35,407
Himachal Pradesh	188,223	165,776	22,447
Punjab	811,060	501,285	309,775
Chandigarh	239,263	106,734	132,529
Uttarakhand	352,496	354,718	–2,222
Haryana	1,231,480	588,001	643,479
Delhi	2,172,760	457,919	1,714,841
Rajasthan	723,639	997,196	–273,557
Uttar Pradesh	1,079,055	3,810,701	–2,731,646
Bihar	460,782	2,241,413	–1,780,631
Sikkim	22,519	6,238	16,281
Arunachal Pradesh	71,789	12,507	59,282
Nagaland	33,594	51,857	–18,263
Manipur	4,529	30,867	–26,338
Mizoram	22,599	31,739	–9,140
Tripura	40,262	23,538	16,724
Meghalaya	33,710	20,434	13,276
Assam	121,803	281,510	–159,707
West Bengal	724,524	730,226	–5,702
Jharkhand	502,764	616,160	–113,396
Odisha	229,687	440,893	–211,206
Chhattisgarh	338,793	444,679	–105,886
Madhya Pradesh	814,670	842,937	–28,267
Gujarat	1,125,818	451,458	674,360
Daman & Diu	48,362	5,401	42,961
Dadra & Nagar Haveli	47,649	3,440	44,209
Maharashtra	3,231,612	896,988	2,334,624
Andhra Pradesh	421,989	637,360	–215,371
Karnataka	879,106	769,111	109,995
Goa	120,824	32,578	88,246
Lakshadweep	4,444	1,149	3,295
Kerala	235,087	431,821	–196,734
Tamil Nadu	270,473	674,304	–403,831
Puducherry	105,208	35,755	69,453
A & N Islands	29,538	8,011	21,527

a new union territory and capital of Punjab and Haryana besides its own capital. This union territory has expanded vary fast and a little more than one-fourth of its population consists of life-time in-migrants. Delhi is the national capital and attracts a large number of people from the surrounding as well from far-off areas who migrate to this city in search of livelihood and better standard of life. In past, also Delhi has been a greater magnet attracting people in large numbers. Uttar Pradesh is the largest contributor to in-migration in Delhi which accounts for about 50 per cent of the total in-migration into Delhi. This is followed by Haryana, Rajasthan, Punjab, Bihar and Madhya Pradesh. In the recent years, migration to Delhi has decreased from the neighbouring states and increased from far off states. There are other states also which have attracted in-migrants from far-off areas. For example, Assam attracted labourers to work in its tea gardens in the past and in the recent years, this state has attracted technicians, professionals and skilled labour for its industries and administration. Maharashtra and Gujarat are two industrially advanced states and have attracted labourers from a number of states like Uttar Pradesh, Bihar, Rajasthan and Odisha. This process of in-migration to these two states started with establishment of industries and still continues to operate. With the advent of Green Revolution, Punjab attracted a large number of labourers from Bihar and eastern part of Uttar Pradesh to work in agricultural fields.

Reasons for Migration

Data on reasons for migration were collected for the first in the 1981 census. These reasons were classified into five categories *viz.* (1) employment, (2) education, (3) family moved (associational), (4) marriage and (5) others. Two new categories of reasons were added at the time of 1991 census. They were (1) business and (2) natural calamities like drought, floods, etc. Reasons for migrations were again revised on the eve of 2001 census. According to this scheme reasons for migration were classified into work/employment, business, education, marriage, moved after birth, moved with household and others. **Table 12.4** gives migrants sex-wise classification according to reason for migration into above categories.

TABLE 12.4. Sex-wise distribution of migrants according to reason of migration in percentages (2001)

Reason	Male	Female
1. Work/employment	28.09	1.66
2. Business	2.55	0.20
3. Education	2.55	0.44
4. Marriage	2.33	69.61
5. Moved after birth	9.94	2.94
6. Moved with household	19.39	11.27
7. Others	35.15	13.88

Source : Census of India, 2001.

Work/Employment. The above table shows that the largest percentage of male migration takes place for the sake of *work/employment*. In 1991 about 27.0 per cent males migrated for work/employment and this percentage increased to more than 28 per cent in 2001. People migrate in large number from rural to urban areas in search of employment. The agricultural base of rural areas does not provide employment to all the people living there. Even the small-scale and cottage industries of the villages fail to provide employment to the entire rural folk. Contrary to this, urban areas provide vast scope for employment in industries, trade, transport and services.

Marriage. Among the females, the largest percentage of 69.61 migrate due to marriage. This is much higher than 56.1% in 1991.

In fact marriage is a very important social factor of migration. Every girl has to migrate to her in-law's place of residence after marriage. Thus, the entire female population of India has to migrate over short or long distance.

Education is another important reason for migration. Rural areas, by and large, lack educational facilities, especially those of higher education and rural people have to migrate to the urban centres for this purpose. Many of them settle down in the cities for earning a livelihood after completing their education.

Lack of security also causes migration. Political disturbances and interethnic conflicts drive people away from their homes. Large number of people have migrated out of Jammu and Kashmir and Assam during the last few years due to disturbed conditions there. A large number of Kashmiri Pandits had to leave Kashmir in wake of prolonged ethnic conflict.

Similarly, thousands of people had to migrate out of Punjab during the period of terrorism by religious fundamentalists. People also migrate on a short-term basis in search of better opportunities for recreation, health care facilities, legal advices or for availing service which the nearby towns provide.

'Pull' and 'Push' Factors

Urban centres provide vast scope for employment in industries, transport, trade and other services. They also offer modern facilities of life. Thus, they act as 'magnets' for the migrant population and attract people from outside. In other words, cities pull people from other areas. This is known as *'pull factor'*.

People also migrate due to *'push factors'* such as unemployment, hunger and starvation. When they do not find means of livelihood in their home villages, they are 'pushed' out to the nearby or distant towns. Millions of people who migrated from their far-off villages to the big cities of Kolkata, Mumbai or Delhi did so because these cities offered them some promise for a better living. Their home villages had virtually rejected them as surplus population which the rural resources of land were not able to sustain any longer.

CONSEQUENCES OF MIGRATION

Consequences of migration are as varied and diverse as its causes. Migration affects both the areas of origin of migration and the areas of destination of the migrant population. Over and above, the people are affected in a number of ways. The consequences of migration can be broadly grouped as demographic, social and economic.

(*i*) Demographic Consequences

Migration brings about changes in the characteristics of the population in both the regions, *i.e.*, region of out migration and region of in-migration. It changes not only the age and sex composition of population but also affects the rate of growth of population. Generally, the proportion of the old, children and females increases in population of source areas due to out-migration. On the other hand, the proportion of these persons in the population of in-migration areas gets generally lowered. Migration is one of the major causes of high sex ratio in source areas and low sex ratio in the receiving areas. This happens because it is mostly the youthful male population which is involved in migration. Thus not only the number of people but also the structure of population in both the regions involved in migration is changed. This leads to change in rates of fertility, mortality and consequently in the growth of population. The source regions are depleted of the youthful population and this results in lowered rates of births and comparatively lower rates of growth. An inverse impact is observed in case of the population structure of the receiving areas.

(ii) Social Consequences

Migrants are very good agents of social change as they bring new ideas related to technologies, family planning, girl education etc.

Migration results in intermixing of diverse cultures and leads to the evolution of composite culture. It breaks the narrow considerations and widens the mental horizon of the people. In the historic times, India received migrants belonging to different cultural groups which led to inter-mixing of one culture with the other. But at the same time, migration has serious negative consequences. These include anonymity, which creates social vacuum and sense of dejection among individuals. Continued feeling of dejection may motivate people to fall in the trap of anti-social activities like crime and drug abuse.

(iii) Economic Consequences

The effects on the resource population ratio is one of the major economic consequences of migration. This ratio changes in both the source regions and the receiving regions. The resource-population ratio may be such in an area which might be called either ***under populated*** or ***over populated or optimally populated***. The condition of under population means that population is too low to allow development and utilisation of its resources. On the other hand, over population leads to high pressure of population on resources and this condition generally results in low standards of living. A country having enough number of people to enable development and utilisation of its resources without lowering the quality of life is called ***optimally populated***. If the people are moving from an over populated area to an area of under population, the result is in the balancing of the resource-population ratio. On the other hand, if the migration is from an area of under population to over populated or optimally populated, the consequences may be harmful to both the areas.

Migration affects the occupational structure of the population in both the regions. Generally the proportion of working population in source areas is lowered and the same proportion in the receiving areas is increased. Thus the population of the receiving areas tends to become more productive and in the source areas it results in increasing the dependency ratio by reducing the proportion of the working people in the population. One of the serious consequences of migration is **'brain drain'**. This refers to the migration of the skilled persons from the poorer countries to the developed countries in search of better economic opportunities. An example can be of the migration of doctors and engineers etc. from India to the U.S.A. the U.K. and Canada. This type of migration does not alter the resource-population ratio significantly as the number of people involved in migration is not very large. However the quality of human resources in the source region suffers a lot. The resources of the source regions which are generally poorer countries can not be developed fully because of the huge size of the population.

Most people migrate for economic gain and economic benefit is the most important consequence of migration. People migrating out send remittance to their families at home and add to economic prosperity. Remittances from the international migrants are one of the major sources of foreign exchange. According to World Bank's Migration and Remittances Factbook 2008, India is the top receiver of remittances from abroad and received US $27.0 billion in 2007. This is followed by China (US $25.7 billion), Mexico (US $25.0 billion), Philippines (US $17.0 billion), France (US $12.5 billion), Spain (US $8.9 billion), Beligium (US $7.2 billion), Germany and UK (US $7.0 billion each), and Romania (US $6.8 billion). Punjab, Kerala and Tamil Nadu receive very significant amount from their international migrants. Remittances by internal migrants also plays a significant role in the economic growth of the source regions. These remittances are used for food, repayment of debts, treatment, marriages, children's education, agricultural inputs, construction of houses, etc. For thousands of the poor villages of Bihar, U.P., Odisha, Andhra Pradesh, Himachal Pradesh, etc. remittance works as life blood for their economy.

With the ushering of the Green Revolution particularly in Punjab, Haryana and western part of Uttar Pradesh, large number of poor people migrated to these states from eastern part of Uttar Pradesh, Bihar, Madhya Pradesh and Odisha. These agricultural labourers had been a great source of remittance to their home villages. But a large number of Bihari labourers working in Punjab have starting going back to their places as prospects of employment opportunities have increased there.

(iv) Environmental Consequences

Large scale rural-urban migration leads to overcrowding in the cities and puts tremendous pressure on the infrastructure. It also results in unplanned and haphazard growth of cities in which slums and shanty colonies are very common.

Over-crowding is also related to over-exploitation of natural resources and cities are facing serious problems of water shortage, air and water pollution, problem of sewage disposal and management of solid wastes.

(v) Other Consequences

Migration has a deep impact on the status of women. Generally, male members of the family migrate from rural to urban areas and leave their wives behind at home. This puts tremendous physical and mental pressure on the women. Although migration of women enhances their autonomy and role in economy yet it increases their vulnerability.

Migration enhances remittances to the source region but there is heavy loss of human resources, particularly those of skilled people. Market for advanced skills has increased considerably at the international level. As such most dynamic industrial economies are admitting and recruiting significant proportions of the highly trained professionals from poor regions. Consequently, the existing under-development in the source region gets reinforced.

MIGRATION STREAMS

Depending on place of birth (or last residence) and place of enumeration, migrants can be classified into following four migration streams, which are roughly indicative of migration distance.

1. **Intradistrict migrants** are the persons born (or with last residence) outside the place of enumeration but within the same district.
2. **Interdistrict migrants** are the persons born (or with last residence) outside the district of enumeration but within the same state.
3. **Interstate migrants** are the persons born (or with last residence) outside the state of enumeration but within India.
4. **Immigrants** are the persons born (or with last residence) outside the country.

Based on the rural or urban nature of the place of birth (or of last residence) and the place of enumeration, internal migrants can be further classified into following four migration streams :

(*a*) rural-to-rural, (*b*) rural-to-urban, (*c*) urban-to-urban, and (*d*) urban-to-rural.

A combination of the above mentioned two types of migration streams gives rise to twelve streams of **internal migrants.** But there can be only two streams of **international migrants** as the nature of immigrants birth place (or last residence), whether it was rural or urban was not been identified.

(a) Rural-to-Rural (Rural Turn Over)

This stream of migration dominates over all other streams in terms of volume of migration. An outstanding feature of rural-to-rural stream of migration is the preponderance of female migrants. Studies made by Zachariah (1964), Bose (1965), Agarwal (1968), Narain (1975), Bhande *et al.* (1976), Premi (1976) and Kumar and Sharma (1979) have shown that this preponderance of female migrants is primarily due to the prevalence of patriarchal residence after marriage (marriage migration). According to Indian tradition, the girl has to move from her parents' residence to the residence of her in-laws and live with her husband.

Apart from marriage migration, there are several other factors which contribute to large scale rural-to-rural migration. Migration of agricultural labourers and movement of people to the newly reclaimed areas for agricultural purposes constitute the most important component of such migrations. In slack agricultural season, a large number of villagers move out to seek casual employment in irrigation projects, construction of roads, rail-roads and buildings and other miscellaneous menial jobs.

Normally, rural-to-rural migration originates from crowded areas of low productivity and is destined towards sparsely populated areas experiencing large scale developmental activities. Such a migration may take place even for longer distances and may result in permanent redistribution of population. The introduction of Green Revolution in Punjab, Haryana and western Uttar Pradesh in 1960s generated considerable migration of labour force from economically depressed areas of eastern Uttar Pradesh and Bihar to these areas. Neither the innate love of home nor the caste system, that figured in earlier explanations, could hold back the poor labourers from such migration. Similarly, thousands of villagers have moved to plantations in West Bengal and Assam as labourers. Sometimes decisions taken by the government also affect migration pattern. The resettlement of sikh immigrants from Pakistan in the *tarai region* of Uttar Pradesh is an outstanding example of such a migration. The Dandakarnya Project is another such example. A vast area of several thousand square kilometres in the districts of Koraput and Kalahandi (Odisha) and Bastar (Chhattisgarh) was carved out for agricultural development and to resettle thousands of displaced families. Resettlement projects in the northern parts of Rajasthan and in Andaman and Nicobar Islands have also resulted in movement of people. Peasants (owner-cultivators) move to large river valley project areas either on their own or under sponsorship of the government. Peasants who have experience of flow irrigation, voluntarily move to new river valley project areas, where they legally buy land from the locals and establish their settlements called ***camps***. Labourers also move as it becomes labour demand area (Vaidyanathan, 1972).

(*b*) Rural-to-Urban

Rural-to-urban migration is next only to rural-to-rural migration in terms of volume of migration. Rural-urban migration is caused by both *push* of the rural areas as well as *pull* of the urban areas. In rural areas appalling poverty, unbearable unemployment, low and uncertain wages, uneconomic land holdings and poor facilities for education, recreation and other services work as *push factors*. By contrast, the *pull* of urban areas may include better employment opportunities, regular and higher wages, fixed working hours, better amenities of living, facilities for education and socio-cultural activities (Chandna, 1992). The glamour of urban life and rigid caste system in the countryside have given further strength to push and pull factors. Both poor and rich from the countryside migrate to the urban areas under the influence of push and pull factors. While the poor migrate out of economic compulsion to eke out their living, the rich migrate due to their desire for better and greater comforts of life. In brief, rural-to-urban migration is an outcome of interplay of forces hostile to comfortable living in the villages and of availability of lucrative opportunities in urban areas (Raju, 1987).

Both males and females migrate from rural to urban areas but males have always outnumbered females in this stream of migration. *If rural-to-rural migration is women-migration, rural to urban migration is man-migration.* The rural-to-urban migration has substantially affected the areal distribution of population and has contributed a great deal to urban growth in India. It has been estimated that about one-third of the total urban growth in India has been due to migration (United Nations 1984). This had led to over-crowding in urban centres resulting in great population pressure on the urban infrastructure. The growth and spread of slum areas, as a result of population pressure, is quite glaring and painful.

(*c*) Urban-to-Urban (Urban Turn Over)

This is a stream of migration which is believed to be dominated by the middle class people (Singh, 1980). Generally, people migrate from small towns with less facilities to large cities with more facilities. This is the reason that class I cities have grown at a much faster rate as compared to other towns. In fact, *small towns are constantly loosing to big cities.* The vacuum thus caused in small towns is filled by the subsequent in-migration from the surrounding rural areas. This migration forms a part of what is known as ***step-migration.***

(*d*) Urban-to-Rural (Pushback or Reverse Migration)

This stream has the lowest volume of migrants accounting for about five per cent only in 2001. However, there has been slight increase in this stream of migration between in the recent past. Such a movement takes place at the advanced stage of urbanization when urban centres are characterised by over-congestion, haphazard growth, high cost of living, heavy pressure on public utility services, unemployment, etc. Usually females outnumber their male counterparts in this stream of migration. This is largely due to matrimonial alliance (Premi, 1978).

Figures 12.6(*a*) and **12.5(*b*)** show the distribution of male and female migrants in different streams of intrastate and interstate migrations. In both types of migration females predominate the streams of short distance rural-rural migration. This is primarily because of marriage because females have to leave their parents and live with in-laws. In contrast men pre-dominate the rural to urban stream of interstate migration because men migrate to urban areas in search of jobs and better quality of life.

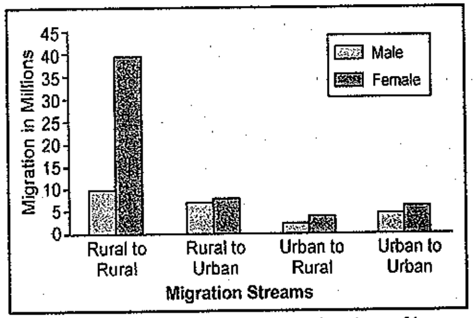


FIG. 12.6.(*a*). Intra state migration by place of last residence indicating migration streams (Duration 0-9 years), India, 2001

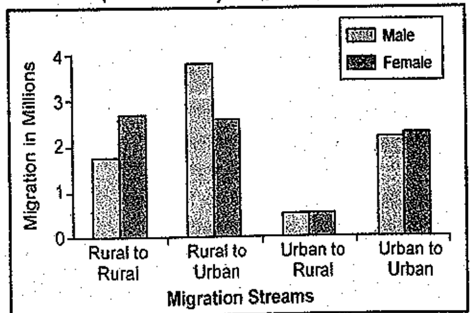


FIG. 12.6(*b*). Interstate migration by place of last residence indicating migration streams (Duration 0—9 years), India, 2001

CONCLUSIONS

Following conclusions can be drawn from the study of migration patterns :

1. Nearly 85 per cent of the intra state migrants were born in rural areas, while 63 per cent were born in rural areas in inter-state migration category.
2. About three fourths of all migrants in the intra-state category were women; mainly because of marriage.
3. Over half of the intra-state migrants moved from rural to rural areas. Such people migrated in search of employment on farms or other establishments located in the rural areas.
4. Rajasthan, Uttar Pradesh, Bihar, Andhra Pradesh and Kerala are the major areas from where out-migration takes place.
5. West Bengal, Maharashtra, Assam, Punjab, Delhi, Chandigarh and Andaman and Nicobar Islands are mostly in migrating states or union territories.
6. Disparities in economic development seems to be the main cause of migration in case of males and marriage in case of females.
7. Densely populated rural areas with increasing pressure of population on land register out migration. Big cities, mining and industrial centres, plantation agriculture etc. are the main "Pull" factors behind in-migration.

Comparatively small states had larger share of inter-state migrants in their populations. By contrast, larger states such as Andhra Pradesh, Odisha, Tamil Nadu, Bihar, Uttar Pradesh displayed relatively smaller proportion of inter-state migrants. Jammu and Kashmir enjoys special status under Article 370 of Indian Constitution which inhibits the permanent settlement of people from other states. Consequently, this state had the lowest proportion of inter-state migrants.

The urbanized and small sized union territories of Chandigarh and Delhi had high percentage of inter-state migration.

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Settlements

INTRODUCTION

Shelter is the third most essential and basic need of man after food and clothing. Man builds houses to lead a settled life and the place where he builds houses is known as ***settlement***. Thus settlement is a permanently occupied human dwelling place which indicates a community of dwellings and associated buildings ranging from a small hamlet to metropolitan city or megalopolis. In the opinion of **A.N. Chark** (1989), even a single dwelling may be termed as a settlement although the term is normally applied to a group of dwellings. By constructing settlements, man tries to adopt himself to his physical and cultural environment. According to **Perpillon** (1986 : 433), "Settlement is man's first step towards adopting himself to his environment. A settlement is essentially an occurrence unit consisting of houses, served by roads and streets." According to **R.L. Singh** (1961), "Settlement as an occupance unit represents an organised colony of human beings including the buildings in which they live or work or store or use them otherwise and the tracts or streets over which their movements take place.

CLASSIFICATION OF SETTLEMENTS

Settlements may be classified on the basis of their functions, size, morphology, number and density of houses, etc. but the most widely used criteria is the function carried out by the inhabitants of a settlement. On this basis two types of settlements are recognised *viz.* (1) rural settlements, and (2) urban settlements.

Rural Settlements

Rural settlements refer to clusters of dwellings called 'villages' together with the surrounding land from which the inhabitants derive their sustenance. Village has been defined in different ways by various authors. According to **Richthofen**, "They (Villages) are groups of families, united by common descent, or at least having rites in common, who cleave to one another because of the necessity for cooperating in the cultivation of the same crops." **Blache** has termed the village as the expression of a type of community larger than family or clan. To quote **Bruhnes**, "Village is a term applied to a geographical fact—the collection of houses and residents of the most

numerous aggregations". **Zalinskey** pointed out that an individual village is not simply a collection of farms but a definite social entity. The village has a number of characteristics—territorial, ethnic, cultural—which defines it as an entity. **M. deClerck** describes "a village is above all, a socio-psychological environment, where everybody knows everybody else, where everyone's attitude is strictly controlled by the group; the cultural system defines the patterns of behaviour and the habits of the individuals coincide with village custom".

In India, however, officially a village stands for the area demarcated as a *mauza* meaning "parcel of ground with definite boundaries for revenue purposes without clear and consistent regard for its population". A revenue village thus defined, is a definite administrative unit and includes one or more clusters of dwellings together with the land territory under its possession. Each village has a distinctive place name which helps in distinguishing one village from the other. The hamlet, locally named as *faliya*, *para*, *dhana*, *dhani* etc. means a separate aggregate of houses within the village boundary, sometimes having a name and always forming a part of the whole.

Classification of Villages

Although there are several ways of classifying villages, classification based on size, population and area of land is the most popular and accepted classification of villages. On the basis of this criteria, following classes of villages are recognised.

1. Pura. The place where a habitat had been in ancient days and where chief habitats are all around or nearby areas is called pura. This habitat can thus be called the nucleus of the area. In agricultural areas solitary habitats generally become "puravas" which under favourable circumstances grow into villages.

2. Khas. The word khas is used for the main village or sadar. Sometimes people of the main village settle at some distance and call this new village after their main village. When the population increases, the word khas is used for the village from where people spread around.

3. Kalan. The word kalan is used for large villages and used at the end of the name of the village *i.e.* Bound Kalan. People of several classes and castes live in such villages.

4. Khurd. The word khurd is a degraded form of the urdu word *barkhurdar* (meaning son or small). Therefore this word is used for small villages *i.e.* Dumarkha Khurd.

5. Khera. This word is used for small colonies and also for the higher land of the village. Khera has great social value for the village community because almost all the shows such as *Ramlila*, *Nautanki*, etc. take place here. In some areas the word khera is used for those places where the ruins of an ancient fort are found.

6. Nanglay. It comprises a group of small villages where one village is surrounded by several satellite villages.

Rural Landscape in India

Rural landscape in India is dominated by the villages and the primary activities carried out by the inhabitants of those villages. Over 6.4 lakh villages are spread all over the country. According to Blache, "*India is par excellence, a country of villages*". Agriculture is the most important of all the primary activities carried out by villagers. Thus villages are *par excellence characteristic of agricultural landscape of the rural India*.

Settlement Types

Before we proceed to discuss settlement types, it is worth making a distinction between settlement types and settlement patterns. In the geographical literature, these terms convey various meanings, sometimes synonymous, at others interchangeable and in yet others as one being element/part of the other. But, actually, these are neither of them. In simple language, *types of rural settlements imply the degree of dispersion or nucleation of the dwellings whereas the patterns refer to geometrical shapes formed by the arrangement of dwellings*.

Various authors have suggested different schemes of discussing settlement types. **Finch** and **Trewartha** *et al.* refer to two primary types of settlements. (*i*) the isolated or dispersed and (*ii*) the nucleated. These are two extreme types of groupings, wherein isolated settlements refer to a single family residence and the nucleated settlements refer to a group of dwellings clustered almost in the centre of the village lands.

D.C. Money has given three broad classes of settlements *viz*. (*i*) the single large nucleated village, (*ii*) hamlets scattered throughout the countryside and (*iii*) single homesteads. **Enayat Ahmed** gives four types : (*i*) compact, (*ii*) cluster and hamlet type, (*iii*) fragmented or hamleted and (*iv*) dispersed settlement. **R.L. Singh** discerns four main types : (*i*) compact settlements, (*ii*) semi-compact or hemleted cluster, (*iii*) semi-sprinkled or fragmented or hamleted settlements and (*iv*) sprinkled or dispersed type. On the basis of number of villages, hamlets and number of occupance units, **R.B. Singh** identified four settlements. They are (*i*) compact, (*ii*) semi-compact, (*iii*) hamleted and (*iv*) dispersed or scattered type.

(*i*) Compact settlements. If the number of villages equals the number of hamlets in an area unit, the settlement is designated as compact. Such settlements are found throughout the plateau region of Malwa, in the Narmada Valley, Nimar upland, large parts of Rajasthan, paddy lands in Bihar, Uttar Pradesh, Vindhyan Plateau and several other cultivated parts of India. In such villages all the dwellings are concentrated in one central site. The inhabitants of the village live together and enjoy the benefits of community life. Such settlements range from a cluster of about thirty to hundreds of dwellings of different forms, sizes and functions. Their size varies from 500 to 2,500 persons in sparsely populated parts like Rajasthan to more than 10,000 in the Ganga plain.

Different geographical factors contribute to the growth and development of compact rural settlements. In the fertile plains of north India they develop in areas of intensive subsistence agriculture. The site of such settlements in this vast plain is generally *bhangar* area free from the annual floods, water points (oisis) in the Thar desert region and Ox-bow lakes in the Middle Ganga Plain. Availability of water is a very important factor in the siting of such settlements. In vast tracts of Punjab, Haryana, western part of Uttar Pradesh, Rajasthan and the Deccan Trap, peasants flock to the perennial sources of water like wells, canals, ponds, etc. In the tribal areas, these settlements are constructed on hill tops, ridges and spurs, etc. Such sites are selected from the defence point of view.

(*ii*) Semi-compact or Hamletted settlements. If the number of villages equals more than half of the hamlets, it is semi-compact settlement. The dwellings in such settlements are not very closely knitted and are huddled together at one common site. It covers more area than the compact settlements; the hamlets occupy new sites near the periphery of the village boundary.

The chief characteristic of these settlements is an early recognised site and one or more than one hamlets which are closely linked with the main site, foot-paths, cart-tracks or roads,. The Purvas and Mazras (hamlets) in the near neighbourhood of the main village grow due to increase in population of the main settlement. The pressure of population on the main site forces many families to shift and built their houses outside the main village. The families which shift outside the main village are generally those of agricultural labourers, artisan castes and other poor people. Care is taken that the *Purvas* and *Mazras* built by such people are located close to the main village considering the close social links among the village communities and the prevailing economic interdependence.

Semi-compact or halmetted rural settlements are found both in plains and plateaus depending upon the environmental conditions prevailing there. These are very common in the *khadar* areas of the Ganga, the Yamuna, the Brahmaputra and several of their tributaries, the *Bet* banks of Punjab, the *Tarai* region of Uttar Pradesh and Uttarakhand and in the deltas of the peninsular rivers of the Mahanadi, the Godavari, the Krishna and the Cauvery.

(*iii*) Hamleted settlements. If the number of villages is equal to half of hamlet number, it is a hamlet settlement. The hamlets are spread over the area with intervening fields and the main or central settlement is either absent or has feeble influence upon others. Often the original site is not easily distinguishable and the morphological diversity is rarely noticed. Such settlements are found in West Bengal, eastern Uttar Pradesh, Madhya Pradesh and coastal plains.

(*iv*) Dispersed settlements. If the number of villages is less than half the number of hamlets, the settlement is regarded as dispersed. The inhabitants of dispersed settlements live in isolated dwellings scattered in the cultivated fields. Individualism, sentiments of living freely, custom of marriage relations are conducive to such settlements. However,

these dwellings are deprived of neighbourhood, communal interdependence and social interaction. Dispersed settlements are found in tribal areas covering central part of India, eastern and southern Rajasthan, Himalayan slopes and land with dissected and uneven topography. Homesteads or farmsteads of wheat producing areas in Punjab, Haryana and western Uttar Pradesh also belong to this category.

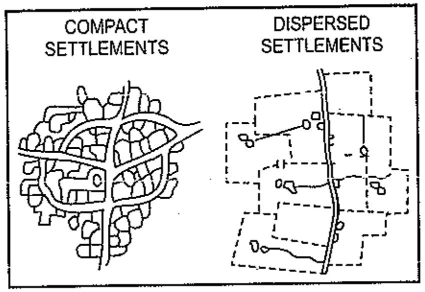

FIG. 13.1. Compact and Scattered Settlements

Difference between Compact Settlements and Dispersed Settlements	
Compact Settlements	**Dispersed Settlements**
1. Compact settlements are mainly found in fertile plains and river valleys.	Scattered settlements are mainly found in hills, plateaus, highlands, and arid and semi-arid lands.
2. The main occupation is agriculture.	Animal grazing and lumbering are the main occupations.
3. Houses are built in close vicinity to each other and have lesser living space.	Houses are isolated and scattered over the land. They provide more living space.
4. Size of the fields is small.	Fields are large.
5. Streets are dirty due to lack of proper drainage.	These settlements are quite neat and clean.
6. The inhabitants of compact settlements work and defend themselves collec-tively.	People of dispersed settlements lead isolated life.

RURAL SETTLEMENT PATTERNS

Pattern refers to geometrical form and shape of the settlement and different settlements have different types of pattern depending on the site and historical background of the settlement. **Embryos Jones** defined pattern of settlement as the relationship between one house or building and another. The pattern of a settlement provides a picture of its shape and a distinct pattern gets its name *i.e.* linear, elongated, square, etc. Pattern also refers to two dimensional geometrical arrangement of rural settlements in an area. Sometimes, a rural settlement may not depict any geometrical shape and the pattern may be termed as ***non-geometrical***. Thus two patterns—geometrical and non-geometrical—are easily discernible on a large scale map or an airphoto of the concerned area.

Following are some of the most common patterns of rural settlements found in India.

1. Linear pattern. This is also known as ***ribbon*** or ***string*** pattern. The main street of the village runs

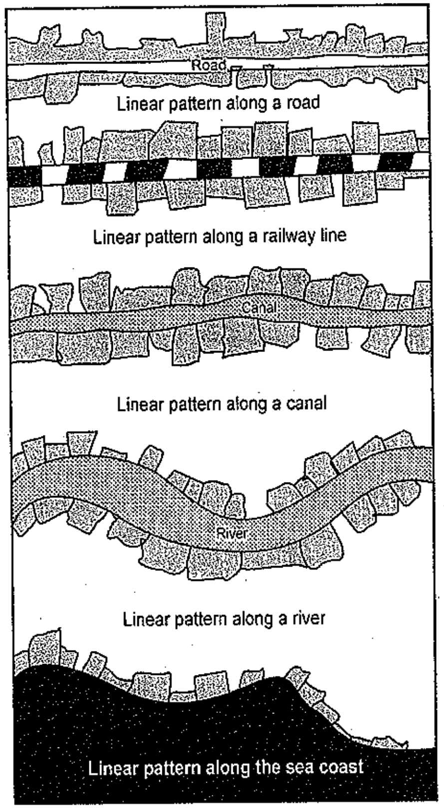

FIG. 13.2. Linear Patterns

parallel to a road, railway line or water front and most of the village shops are located on this road. Some villages of fisherman along the coast have their houses where water level at high tide determines their location (**Fig. 13.2**). Such pattern is found largely in middle and lower Ganga plain, parts of the Himalayan region, along the coasts, especially in Malabar and Konkan and north-east Indian states.

2. Checkerboard Pattern. This pattern develops at a place where two roads or some other mode of transport meet almost at right angles. The point of intersection of two main roads is the focus of growth of the settlement. The other roads or streets are parallel to the main roads and also parallel to each other. They meet each other at right angles (**Fig. 13.3**). Such villages are found in large numbers in the fertile plain of north India. They are highly concentrated in the Ganga-Yamuna Doab. In south India, the checkerboard pattern is a quite common in Tamil Nadu, Karnataka, Andhra Pradesh and Telangana.

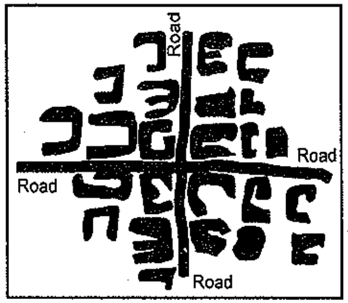

FIG. 13.3. Checkerboard Pattern

3. Rectangular Pattern. The geometry of these settlements is largely rectangular and sometimes square. Such settlements normally develop in the fertile plains of north India where intensive cultivation is practised. These settlements have straight streets which meet each other at right angles. They are connected to each other by roads or foot-paths (**Fig. 13.4**). In India, the rectangular pattern is the heritage of our old system of land measurement in '*Bighas*' which acted as a major factor because the entire cultivated plots and orchards were designed in rectangular shape.

According to **J.P. Misra** (1989 : 126) "The rectangular shape of the fields facilitates ploughing process and making cart-tracts and foot-paths and hence it is maintained by peasants at all costs. Furthermore, the rectangular shape of plots adjusts fairly several rows of houses and render them more spacious." The village streets also confirm to the field patterns and give strength to the rectangular pattern. It may be mentioned that the village is not able to maintain its square shape for a long time because it grows in a particular direction, especially along the transport routes as the time passes.

In certain cases there is a vacant space within the village and the pattern is said to be 'hollow rectangle'. This vacant space may be ascribed to the site of old places, religious places or some water body. This space is the common land and is used by the entire village community.

They are abundantly found in Punjab, Haryana and western part of Uttar Pradesh. In Rajasthan, the Indira Gandhi Canal Command Region has a large number of rural settlements planned as rectangles. Their highest concentration is found in Suratgarh, Hanumangarh and Ganganagar districts. In south India, the deltas of the peninsular rivers have a large number of villages of rectangular shape.

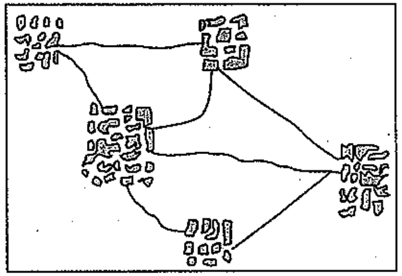

FIG. 13.4. Rectangular Pattern

4. Radial Pattern. Radial pattern develops at a nodal place where number of roads and streets or foot-paths coming from different directions converge at a site. Conversely the roads, streets and foot-paths radiate from a nodal place to different directions and give rise to radial pattern. Houses are built along the transport routes and a radial pattern comes into being. Obviously the central or the nodal part is a vital point in the evolution of the settlement and is occupied by the landlord or village head or some religious place. Some socio-cultural buildings may also come at this place.

About one-third of Indian villages have radial pattern. Most of them are found in the northern plain of India.

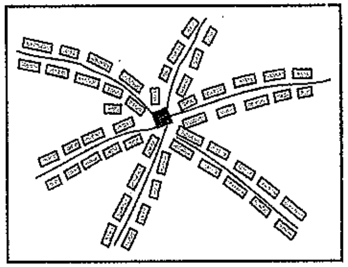

FIG. 13.5. Radial Pattern

5. Star-like Pattern. It is a refined form of radial pattern. It develops when the space between the transport routes like roads, streets and foot-paths is occupied by houses and other buildings. The building process of the houses starts from the nodal place and spreads in all directions. However, the maximum building process takes place along the transport routes and the entire village takes the shape of a star (**Fig. 13.6**).

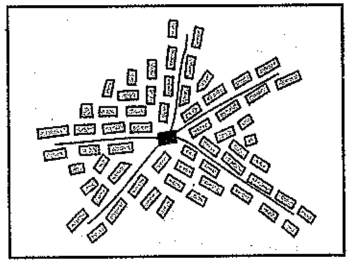

FIG. 13.6. Star-like Pattern

This pattern is mainly found in the fertile areas of Punjab, Haryana and western part of Uttar Pradesh where there is a dense network of roads.

6. Triangular Pattern. This pattern is the result of hindrance occurring on three sides. This hindrance may be physical or cultural or both. The growth of settlement is restricted on three sides by such hindrances and the settlement assumes a triangular pattern. Such a pattern usually develops at the confluence of two rivers or two roads. The lateral expansion of dwellings at the confluence is restricted by the rivers and triangular shape of the dwelling emerges (**Fig. 13.7**).

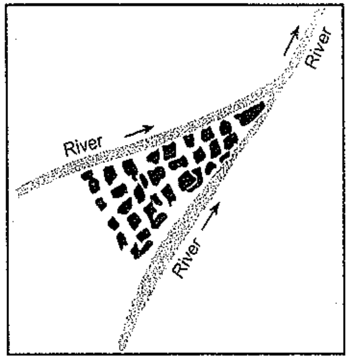

FIG. 13.7. Triangular pattern

7. Circular Pattern. Circular pattern develops around a pond, a lake or a crater. People prefer to construct their houses close to pond or lake because of easy accessibility of water (**Fig. 13.8**). Sometimes a pattern may develop around a temple or a mosque. Villages having circular pattern are found in the upper part of the Ganga-Yamuna Doab, trans-Yamuna region, Madhya Pradesh, Punjab, Maharashtra and Gujarat.

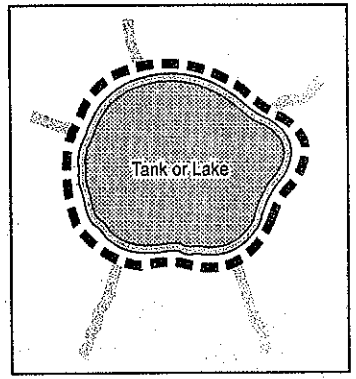

FIG. 13.8. Circular Pattern

8. Semi-circular Pattern. Villages which grow along the river meanders, oxbow lakes or a lake located at the foothill assume semi-circular shape. The Ganga and its several tributaries have semi-circular villages (**Fig. 13.9**).

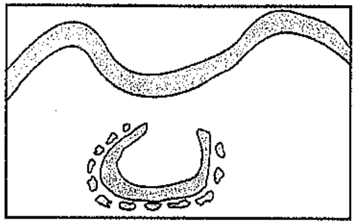

FIG. 13.9. Semi-circular Pattern

9. Arrow Pattern. The villages which grow at the end of a cape, or at a sharp bend of a meandering river or a lake often assume arrow shape. The main concentration of houses is along the roads and the number of houses increases away from the arrow point (**Fig. 13.10**). In India, such settlements are found at Kanniyakumari, Chilka lake, Gulf of Khambhat and along the banks of Sonar river in Madhya Pradesh and Burhi Gandak in Bihar.

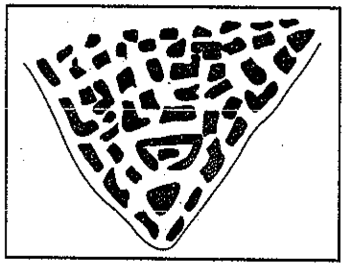

FIG. 13.10. Arrow Pattern

10. Nebular Pattern. Settlements resembling the shape of a nebula are said to have nebular pattern. The roads in such settlements are generally circular which end at the centre or nucleus of the village. These settlements are usually of small size and are

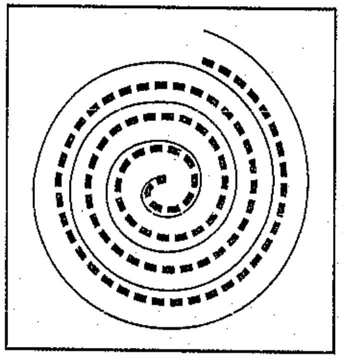

FIG. 13.11. Nebular Pattern

found in hilly and undulating areas of Himachal Pradesh, Uttarakhand, Vindhyachal, Kandi lands of Jammu and Kashmir and to a lesser extent in the Ganga-Yamuna Doab.

11. Terraced Pattern. Villages having terraced pattern are mostly found on the hill slopes. These slopes are cut and converted into terraces for cultivation. Farmers construct their houses along the terraces and terraced pattern comes into being. Houses in these settlements can be close to each other or they be distant apart. They are constructed at different heights depending on the slope of land. They are usually constructed near a spring or some stream. Such villages may be seen along the hill slopes in Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Mizoram and Western Ghats.

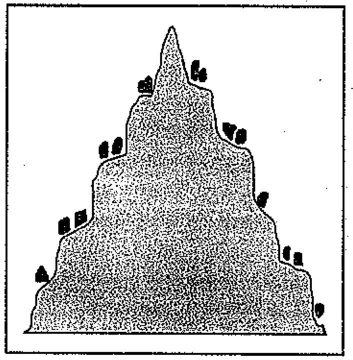

FIG. 13.12. Terraced Pattern

12. T-Shape Pattern. Sometimes the routes meet in such a way that they make a 'T' junction. People

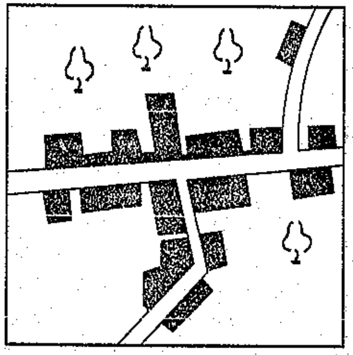

FIG. 13.13. T-shape Pattern

start making their houses along the routes extending in all the three directions and T-shape pattern develops.

Some villages do not have any particular shape and are called shapeless or amorphous villages. Such villages are found in south-west of Uttar Pradesh, Punjab, Rajasthan, Malwa Plateau, Chota Nagpur Plateau, Madhya Pradesh, Andhra Pradesh, etc.

Size, Spacing and Distribution of Rural Settlements

According to census of India 2011, there are 640,867 villages in the country including un-inhabited villages (**Table 13.1**). The largest number of 106,704 (*i.e.* more than 16.6 per cent) are in Uttar Pradesh alone. In fact the whole of Ganga plain is dotted with villages of varied sizes. In the peninsular plateau, Madhya Pradesh and Odisha have more than fifty thousand villages each. Kerala has only 1018 villages but the size of villages is very large. Goa is a small state and has 334 villages only. This is the minimum number of villages for any state of India. Among the union territories, Chandigarh has the minimum number of 5 villages only, while Andaman and Nicobar Islands have maximum of 555 villages.

According to Census of India, size of villages is determined on the basis of their population. **Table 13.2** shows that the highest number of villages in India are in the population slab of 500-999 persons per village. This category of villages account for about one-fourth of the total villages in India. There is a gradual decrease in number of villages both in higher and lower population slabs. However, this decrease is more conspicuous in the higher population slabs. For example, only 0.78 per cent of the total villages in India are having population above 10,000 persons. There are a few exceptions to this general observation. For example, Kerala has only three villages with population 500-900 but 797 *i.e.* 78.4% of total villages of the state have population more than 10,000 persons. Even some of the larger states like Uttar Pradesh, Madhya Pradesh, Rajasthan, Maharashtra, Andhra Pradesh, Karnataka, etc. having pre-dominantly rural population do not have so many villages with population exceeding ten thousand.

The above mentioned aggregate pattern of the size of the villages varies greatly from one region to another owing to diversified physiography, climate

TABLE 13.1. India : Villages

State Code	India/State/ Union Territory#	Villages*	Area sq. km	Village Density (No. of villages per 100 sq. km)
	INDIA	**640,867**	**32,87,263**	**19**
01	Jammu & Kashmir	6,551	2,22,236	3
02	Himachal Pradesh	20,690	55,673	37
03	Punjab	12,581	50,362	25
04	Chandigarh#	5	114	4
05	Uttarakhand	16,793	53,484	31
06	Haryana	6,841	44,212	15
07	NCT of Delhi#	112	1,483	8
08	Rajasthan	44,672	3,42,239	13
09	Uttar Pradesh	106,704	2,38,566	45
10	Bihar	44,874	94,163	48
11	Sikkim	452	7,096	6
12	Arunachal Pradesh	5,589	83,743	7
13	Nagaland	1,428	16,579	9
14	Manipur	2,588	22,327	12
15	Mizoram	830	21,081	12
16	Tripura	875	10,492	8
17	Meghalaya	6,839	22,429	30
18	Assam	26,395	78,438	34
19	West Bengal	40,203	88,752	45
20	Jharkhand	32,394	79,714	41
21	Odisha	51,313	1,55,707	33
22	Chhattisgarh	20,126	1,36,034	15
23	Madhya Pradesh	54,903	3,08,000	18
24	Gujarat	18,225	1,96,024	9
25	Daman & Diu#	19	112	17
26	Dadra & Nagar Haveli#	65	491	13
27	Maharashtra	43,663	3,07,713	14
28	Andhra Pradesh including Telangana	27,800	2,75,069	10
29	Karnataka	29,340	1,91,791	15
30	Goa	334	3,702	9
31	Lakshadweep#	21	32	65
32	Kerala	1,018	38,863	3
33	Tamil Nadu	15,979	1,30,058	12
34	Puducherry#	90	492	18
35	A&N Islands#	555	8,249	7

*includes un-inhabited villages.

Source : Data computed from Census of India 2011, *Provisional Population Totals* Paper 2 of 2011, Series 1, p. 40.

TABLE 13.2. Distribution of Villages according to Population 2001 Census and Total Number of Inhabited Villages

States/UTs No.	10,000 and above	5,000-9,999	2,000-4,999	1,000-1,999	500-999	200-499	Less than 200	Total No. of inhabited villages.
1. Jammu and Kashmir@	23	212	1152	1641	1521	1275	513	6337
2. Himachal Pradesh	1	12	219	832	2459	5898	8461	17882
3. Punjab	41	330	2227	3471	3237	1903	959	12168
4. Chandigarh	0	3	2	0	0	0	0	5
5. Uttarakhand	21	96	471	824	1826	4684	7823	15745
6. Haryana	121	594	2256	1967	1035	437	232	6642
7. NCT of Delhi	6	9	55	21	6	2	4	103
8. Rajasthan	120	832	5802	10530	12421	8869	4690	43264
9. Uttar Pradesh	545	3432	21013	28020	23381	13591	7832	97814
10. Bihar	1129	3216	10128	10076	7536	4584	2404	39073
11. Sikkim	0	4	42	127	150	75	27	425
12. Arunachal Pradesh	0	1	21	112	325	1026	3773	5258
13. Nagaland	1	30	158	240	337	423	211	1400
14. Manipur	7	28	175	230	377	768	794	2379
15. Mizoram	0	2	43	105	233	236	85	704
16. Tripura	18	131	375	196	80	52	11	863
17. Meghalaya	0	7	82	254	953	2515	2648	6459
18. Assam	21	309	3304	5718	6076	5649	4295	25372
19. West Bengal	417	1716	7552	8731	8574	6848	3640	37478
20. Jharkhand	35	224	2365	5215	7948	8219	5456	29492
21. Odisha	10	195	3058	7902	11978	13271	11263	47677
22. Chhattisgarh	2	88	1913	5392	6142	4252	1778	19567
23. Madhya Pradesh	31	583	5084	12515	16339	11943	5434	51929
24. Gujarat	106	963	4781	5566	3891	1900	576	17843
25. Daman and Diu	0	5	4	5	3	2	0	19
26. Dadra & Nagar Haveli	1	6	28	18	6	5	1	65
27. Maharashtra	310	1175	7170	12154	11144	6426	2582	40961
28. Andhra Pradesh	482	1923	7158	6397	4245	3243	2838	26286
29. Karnataka	164	836	4433	6492	7039	5296	3137	27397
30. Goa	1	14	87	75	57	57	29	320
31. Lakshadweep	0	1	2	0	0	1	2	6
32. Kerala	797	146	58	11	3	1	1	1017
33. Tamilnadu	209	1490	5100	4231	2376	1171	472	15049
34. Puducherry	3	26	46	13	2	0	0	90
35. Andaman and Nicobar Islands	0	2	24	53	61	78	178	396
INDIA@*	**4682**	**18641**	**96388**	**139134**	**141761**	**114730**	**82149**	**597485**

Note :

@ India and Jammu & Kashmir State excludes the villages of the areas under unlawful occupation of Pakistan and China where Census could not be taken.

* India and Manipur figures excludes those of the three sub-divisions viz. Mao Maram, Paomata and Purul of Senapati district of Manipur as census results of 2011 census in these sub-divisions were not included due to technical and administrative reasons.

Source : India 2014, Reference Annual, p. 27

and cultural set up. The hilly areas are not suitable for large villages due to difficult terrain and have small villages, most of them having population less than 1000 persons. States and Union Territories of Sikkim, Arunachal Pradesh, Mizoram, Meghalaya, Diu and Daman, Lakshadweep and Andaman and Nicobar Islands did not have even a single village with population exceeding ten thousand while Himachal Pradesh, Nagaland, Dadra and Nagar Haveli and Goa had one village each belonging to this category. On the contrary, the Great Plain of India has large number of medium and large sized villages.

The spacing of the villages is also affected by physiography and other environmental factors. In the hilly areas of Jammu and Kashmir, Himachal Pradesh, Sikkim, Arunachal Pradesh, Mizoram etc. the spacing of villages is very high and sometimes it reaches upto 5 km. In the Ganga Plain, on the other hand, the spacing of villages is low and is often less than 2 km. To conclude, we can say that *high spacing with low density is the character of mountainous areas while low spacing with high density is the character of plain areas.*

According to 2011 census figures 68.84 per cent or more than two-thirds of India's population lives in more than 6.4 lakh villages and still larger number of purvas, nanglas and isolated houses. For the sake of convenience and simplicity, Indian rural settlements are divided into three categories *viz.* (1) dispersed settlements, (2) nucleated settlements and (3) linear settlements. A brief description of these three types of settlements is given below :

1. Dispersed Settlements

Although India is primarily a country of nucleated settlements, yet dispersed settlements can be found in different parts of the country. Following areas are specifically identified with dispersed settlements :

(*i*) Ridges and spurs in the hilly and mountain areas of Jammu & Kashmir, Uttarakhand, Sikkim and Arunachal Pradesh.

(*ii*) Forest areas of Assam, Arunachal Pradesh, Nagaland, Manipur, Mizoram and Tripura.

(*iii*) Higher areas of Western Ghats from Satara in Maharashtra to Kerala.

(*iv*) Flood prone areas in Uttar Pradesh and Bihar.

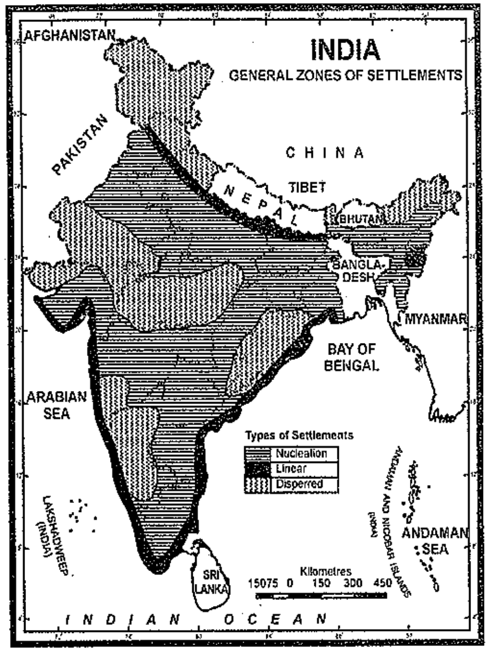

FIG. 13.14. India : General Zones of Rural Settlements

(*v*) Wheat and sugarcane producing areas of Punjab and Haryana.

(*vi*) Western Malwa plateau.

(*vii*) Along small water bodies in West Bengal.

(*viii*) Thar desert, Bikaner, Jaiselmar, Barmer of Rajasthan and adjoining parts of Gujarat.

(*ix*) Hilly areas in Odisha.

It is worth noting that the isolated settlements consisting of one house or farmstead are rarely found in India. Most of dispersed settlements consist of 2 to 5 or 10 huts.

2. Nucleated Settlements

Nucleated settlements are found in most parts of India. The largest concentration of such settlements is found in the northern plain of India consisting of Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal and the Brahmaputra valley of Assam. Level land, fertile soil, water resources, cooperation and interdependence in agricultural operations, small and fragmented agricultural fields, caste and clan considerations, social and economic cohesion, religion and orthodoxy and security considerations in the past are the main factors contributing to the growth of nucleated settlements. Nucleated settlements of Rajasthan are due to agricultural land, pastures, availability of water at a few selected places and security requirements. Nucleated settlements here appear to be in response to peoples' reaction to political instability and social insecurity which had been prevailing for so many centuries. Here the villages are of larger size and are distant apart. The average distance between these settlements in Jaiselmar is about 10 km which is the largest distance in the whole of Rajasthan.

In south India, the Malwa plateau has nucleated settlements of larger size whose average population varies from 500 to 5000. Sehore, Indore and Betul districts of Madhya Pradesh have still larger settlements with populations varying from 5,000 to 10,000. In certain areas semi-nucleated settlements are also found. Bundelkhand and Baghelkhand also have nucleated settlements of larger size. Settlements of Bundelkhand are comparatively larger and are mostly located near towns. Chhattisgarh plain has comparatively smaller settlements where about two-thirds of the total settlements have population less than 500. In Mayurbhanj, Kendujhar and Sundergarh districts of Odisha, nucleated settlements are found on the valley slopes. Such settlements are found in the Mahanadi basin also. The black cotton soil of Maharashtra also support nucleated settlements. In the Karnataka plateau, the Malnad hills have infertile soil but they are covered with teak, sal and sandal forests. Consequently the nucleated settlements of this area are of small size. But the northern plain of Karnataka has larger settlements having population varying from 2,000 to 10,000. Andhra Pradesh, Telangana and Tamil Nadu also have nucleated settlements of varying sizes. Kerala has the unique distinction of having settlements of large sizes where more than two-thirds of the settlement have population over ten thousand.

3. Liner Settlements

These are elongated settlements with larger length and minimum breadth. Such settlements usually develop along a road, a canal, a river, embankments made by the old course of a river or along the sea coast. In Assam, Tripura, West Bengal and Odisha, linear settlements can be seen stretching for miles together along both the banks of rivers and canals. Houses in these settlements face the sea water front and face each other across the water course. In West Bengal, linear settlements along the courses of the dead rivers in Murshidabad, Nadia, as well as in North and South Twenty Four Parganas can still be seen. Odisha (Balasore), Tamil Nadu (Thanjavur, Ramnathpuram, Tirunelveli) and some parts of Maharashtra also have linear settlements. Over six thousand kilometre long coastline of India is dotted with thousands of fishermen's villages most of which present linear pattern. Deltas and estuaries of big rivers have long queues of linear settlements. In north India, there is continuous belt of linear settlements along the footbills of the Himalayas stretching over the states of Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Uttar Pradesh, Bihar and Sikkim.

Regional Distribution of Rural Settlements

From the physiographic point of view, India can be divided into four major divisions *viz*. The Himalayas, the Northern plains, the Paninsular plateau and the coastal areas and the distribution of rural settlements can be described on the basis of these physiographic divisions.

1. Rural Settlements in the Himalayan Region. The type of rural settlements in the Himalayas region varies according to altitude, slope and general relief of the land as well as on the climatic conditions. In the inter-mountain valleys such as those of Kashmir, Kullu-Manali and Dun valley most of the settlements are either compact or semi-compact. At higher altitudes, the undulating topography, cold climate and shortage of agricultural land favour dispersed or scattered settlements. Some of the migratory tribal people like Gujjars and Bakarwals of Kashmir, Bhutias of Himachal Pradesh and Uttarakhand and Lepthas of Sikkim practise *transhumance i.e.* they move to higher areas in summer to graze their animals and come back to lower areas to avoid severe winter conditions of the higher areas. Thus they are forced to have houses in both the areas. They build permanent houses in lower areas where they spend their winter season and are engaged in agriculture and temporary houses in the alpine pastures at higher altitudes where they graze their animals in summer.

In the Eastern Himalayas, a number of states like Arunachal Pradesh, Nagaland, Mizoram and Tripura

have small and widely dispersed settlements. This is due to typical physical and social environment of this region which is reflected by rugged topography, heavy rainfall, dense forests and multiplicity of tribes with different traditions and dialects. In Nagaland, most of the villages are found on the flat tops of hills, spurs and ridges located at altitudes varying from 1,000 to 2,000 metres above sea level. Such sites are selected from the point of view of security against invaders. In Manipur, Kukis tribal people are engaged in shifting agriculture locally known as ***Jhuming*** and construct their temporary huts in Jhum fields. However, some permanent houses may also be found. In Mizoram, linear settlements are found in valleys, on hill tops and along the roads. These settlements are built by the Lushai tribes. The Chakma tribes of Tripura build settlements which are similar to those build by the Lushais of Mizoram. In the Khasi and Jaintia hill regions of Meghalaya, the settlements range from isolated homesteads to dispersed and semi-compact settlements. These settlements are generally located along the hill slopes near springs and other water bodies.

2. Rural Settlements in the Northern Plain of India. The Northern Plain of India has been formed by the depositional work of mighty rivers like the Indus, the Ganga, the Brahmaputra and hundreds of their tributaries. As such, this is one of the most fertile plain of the world which has been intensively cultivated for the last several centuries. People lead settled life and have built permanent settlements. The plain of Punjab, Haryana and western part of Uttar Pradesh has large sized compact settlements which are uniformly spaced. The *Bhangar* tracts are free from floods and have compact and semi-compact settlements while the *Khadar* and *Bet* lands are flooded almost every year during the rainy season and most of the settlements in these areas are semi-compact or scattered. The eastern part of Rajasthan, adjoining Punjab and Haryana also has compact settlements of large size. But the western parts of Rajasthan, to the west of the Aravali range, particularly Jaiselmer and Barmer, are characterised by aeolian topography, especially the sand dunes. Therefore most of the settlements here are of semi-compact type.

In Uttar Pradesh and Uttarakhand, there is terai tract to the south of the Bhabar belt extending in the east-west direction. This tract is marked by marshy lands seasonal floods and thick forests (many of them have been cleared for agriculture). Under these circumstances, the rural settlements in this tract are largely semi-compact and are of medium size.

Most of the rural settlements in the Middle Ganga Plain are semi-compact and are of small size. But since the land is fertile and can support higher density, the settlements in this area are closely spaced. In the Lower Ganga Plain, the types of rural settlements are controlled by the hydrological characteristic and a variety of rural settlement patterns may be noticed. However, scattered settlements are very common in the *Duars* and *Sundarban Delta*.

In the Brahmaputra valley, the villages are of small size and are generally oriented along the river levees and transport routes. The houses are separated by bamboo fences. The low lying areas are prone to annual floods where boat is the only mode of transport during the rainy season. Therefore the *Machan* type of houses are constructed on wooden pillars.

3. Rural Settlements in Peninsular India. Peninsular India is one of the oldest land masses of the world and is characterised by a greater diversity of topography. Therefore, this part of the country has a large variety of rural settlements. The Aravalli Hills receive scanty rainfall and the rocky terrain does not support high density of population and human settlements. Thus the settlements are small and are widely dispersed. Mewar and Alwar have dissected hills where isolated farmsteads are dotted along the narrow valleys. These are called ***Dhanis*** in the local language. Jaipur and its neighbouring areas have compact and semi-compact settlements. In the Udaipur division of Rajasthan, there is preponderance of isolated and dispersed settlements. Settlements of Bundelkhand are by and large scattered.

In Chotanagpur plateau of Jharkhand, there are clustered and semi-clustered rural settlements whereas the settlement of Baghelkhand are largely compact. Compact settlements are also found in the lava plateau of black soils in Maharashtra where most of the settlements are located near the source of water. But the tract between Pune and Solapur is dotted with semi-compact and dispersed settlements.

In Karnataka, the Maidan region had widely spaced compact settlements whereas hilly areas of Malnad has semi-compact settlements. In Andhra Pradesh, the coastal and Rayalseema regions have compact settlements while Telangana has compact and semi-compact settlements. The higher parts of whole of Sahyadris stretching from the Tapi valley in the north to Kanniyakumari in the south is dotted with isolated settlements.

4. Rural Settlements in the Coastal Regions. The entire length of Indian coast-line is dotted with villages of fisherman of varied shapes and sizes. However, there is some difference between the settlements of the east coast and those of west coast. In the east coastal region compact settlements have come up on the elevated basin of deltas of large rivers like the Mahanadi, the Godavari, the Krishna and the Kaveri. These compact settlements are the result of intense cultivation on the fertile lands of these deltas. Since these settlements are located on the elevated levees, they do not seen the danger of flood.

Along the western coast those is Rann of Kachchh in the north where there are semi-compact and scattered settlements of small sizes. The Konkan coastal region is marked by compact and semi-compact settlements. The Malabar coast of Kerala is unique in the sense that it has compact settlements of very large size. However scattered and dispersed settlements are also found in plantations of coconut and cashew nut.

Density of Rural Settlements

Density of rural settlements is defined as the number of village per 100 square kilometres of land area. A look at **table 13.1** reveals that average density of rural settlements in India is 19 villages per 100 sq. km. Among the larger states Bihar has the highest density of 48 villages per 100 sq km. This is followed by Uttar Pradesh and West Bengal (45 each) and Jharkhand (41). These states are said to have some of the highest densities in India. Next in order are Himachal Pradesh (37), Assam (34), Odisha (33) and Uttarakhand (31). The lowest densities of less then ten villages per hundred sq km are found in Jammu and Kashmir (3), Kerala (3), Sikkim (6), Arunachal Pradesh (7), Tripura (8), Mizoram (8), Gujarat (9) and Andhra Pradesh including Telangana (10). The rest of the states have moderate densities varying from 11 to 30 villages per 100 sq km. Among the Union Territories, Lakshadweep has the highest density of 65 villages per 100 sq km which is the highest in the whole of India. The lowest is found in the Union Territory of Chandigarh where there are only 4 villages per 100 sq km.

Morphology of Rural Settlements

Morphology of rural settlements is concerned with their internal and external structure and identification, classification, regionalisation and analysation of its components. Thus rural morphology tries to find answers to meaningful basic questions like what is, where and why ? **Carl Sauer** opines that rural morphology is based on three postulates *viz.* (*i*) organic or quasi-organic, (*ii*) functional equivalent and (*iii*) agglomeration and placement of structural elements. Thus rural morphology deals with the study of built up area consisting of houses and streets etc. and the open land surrounding the built up area where agriculture or some other primary activity is carried on. The famous settlement geographer **C.A. Doxiadis** has suggested four main parts of a rural settlements (**Fig. 13.16**) :

(*i*) Homogenous part, agricultural fields etc.

(*ii*) Central part, built up area of *Basti*.

(*iii*) Circulatory part, roads, streets, footpaths, etc.

(*iv*) Special part, school, temple, mosque, church, *panchayat-ghar*, cultural place, etc.

The built-up area consists of houses, bazars (shops), streets, roads, schools, religious places, cultural places, *panchayat-ghar*, etc.

Almost all the rural settlements have built-up area at the centre which is surrounded by agricultural land or grazing land. These two types of areas are connected to each other by *Chak-roads*, footpaths, etc. Normally the nucleus of the settlement is located on a higher site which is occupied by the first settler (normally people belonging to upper castes or landlords locally known as ***Zamindars***). Once the nucleus is properly inhabited, the village starts expanding around this nucleus with the passage of time. Some hamlets may develop near the main

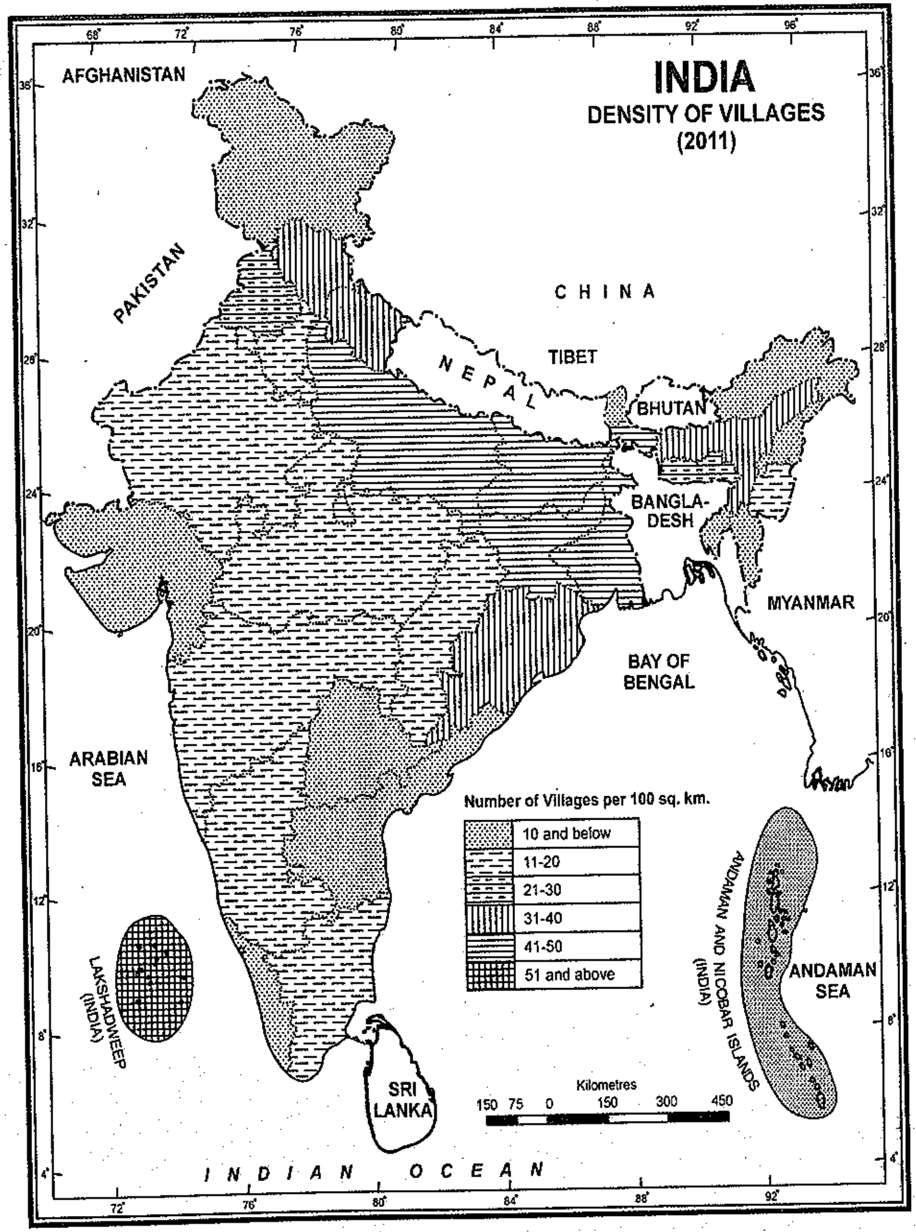

FIG. 13.15. India : Density of Villages (2011)

settlement. Such hamlets are generally inhabited by the people belonging to lower castes and landless agricultural labourers. The socio-economic activities are maximum at the nucleus and their intensity decreases with the increasing distances from the nucleus.

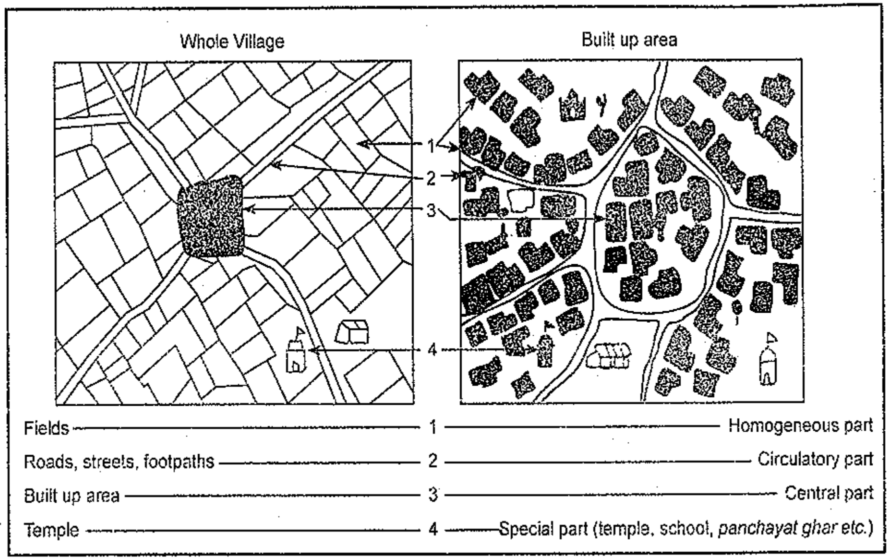

FIG. 13.16. Morphology of an imaginary rural settlement after Doxiadis

Socio-Spatial Structure of Rural Settlements

The socio-spatial morphology of any rural settlement can be explained on the basis of following two concepts :

1. Concept of functional space
2. Concept of social space

According to the views expressed by **Prof. Kashi Nath Singh**, there is almost complete segregation between upper castes (Brahmins, Rajputs, Kayathas) and lower castes (scheduled castes). This segregation is caused due to religious considerations and the distance between two types of castes is maximum. On the contrary, such distances are minimum in a secular set up.

Based on caste considerations, people belonging to upper castes occupy the best site at the central place. Their houses are very large in which each married women is provided with a separate apartment. Such houses have spreading courtyards also. On the contrary, the lower castes, especially the scheduled castes, are generally poor and have a single room hut/house which is share by all the family members. Sometimes the family members have to share these small huts with domestic animals also. These huts are invariably made of locally available cheap materials. Normally houses of low castes are located on the peripheries of the village at a certain distance from the houses of the upper castes. Hamlets of lower castes are called ***Purvas*** which are known by different names in different parts of the country. *Ahyiron, Chamarkheda, Jatvara, Ladhian, Posiwada, Machpara* etc. are some of the common names for ***Purvas***. The hamlets and their inhabitants are closely linked with the main site of the village under *Jajmani* system and act like a single functional unit. Prof. Kashi Nath Singh found both concepts of social discrimination and functional unity in his Socio-Spatial Structure of Rural Settlements and propagated two models based on religious-ritual dominance and secular norms which are briefly described as below :

1. The religious-ritual dominance model of distance maximization. The rural Hindu society is dominated by powerful social structure and is divided into a number of castes. Each caste performs a specific socio-economic function. For example, Brahmins perform religious rituals, Kshatriyas are responsible for security, Vashyas are engaged in trade, commerce and agriculture, and Shudras are supposed to provide low grade services to the other castes. They are debarred from several ritual privileges which are enjoyed by the upper castes. The entire rural society is divided into upper castes and

lower caste due to caste system prevailing there which has resulted in the concept of purity-pollution and untouchability. The concept of purity and untouchability led to the growth of *purvas* of lower castes. These *purvas* were separated from the upper castes more by social space them by any appreciable barrier. Normally the *purvas* of low castes are located in the south-east or east of the main settlement because this direction is less conductive for wind movement. This was because it was believed that even air gets polluted after coming in contact with *Shudras* body.

2. Secular Norms as a Model of Distance Minimization. In a secular model, as proposed by Prof. Kashi Nath Singh, people belonging to different castes construct their houses closer to each other due to economic considerations. The upper caste landholders have to depend on lower caste landless labourers to work in their agricultural fields and the lower caste labourers heavily depend on the upper caste landlords for their livelihood. Thus there is inter-dependence between upper and lower castes and the distance between two sections of society is minimized. This leads to the emergence of a compact, nucleated and unified settlement. **Fig. 13.17** shows the religious-ritual model and secular dominance model as proposed by Prof. Kashi Nath Singh. However, it is observed that the power enjoyed by a person in the rural society is not always by the upper castes *i.e.* Brahmins, but by the person who owns land. According to **Oscar Lewis** (1965; 81) "While the land owners are generally of higher caste in Indian villages, it is their position as land owners, rather than caste membership what gives them power and status." For example if *Brahmin* is a land owner in a village, then *Brahmins* will get the place of honour, but if a *Thakur* is the land owner, then *Thakurs* will get the place of honour and they will provide livelihood to *Brahmins* along with other castes.

Both the above mentioned models leave their own impact on the morphology of Indian village independently. But it is the joint impact of these models which gives a distinct morphology to a village. The old socio-economic system is gradually giving way to the new one and *Jajmani* system is becoming a thing of the past. The rigid caste system is losing its grip and new socio-economic structure is coming up. With the spread of education and general awareness, the *Dalits* and other backward classes have become conscious of their rights and the old caste system is crumbling.

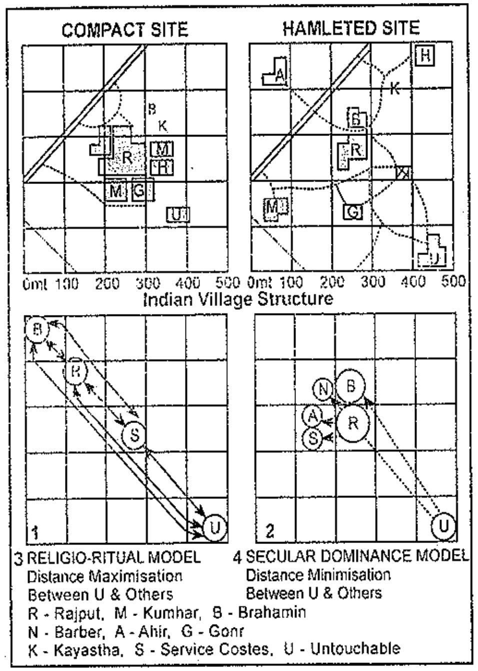

FIG. 13.17. Hypothetical Socio-Spatial Structure of Rural Settlement (After Kashi Nath Singh)

Rural Houses and House Types

House is a shelter built by man to protect himself from the vagaries of climate and to meet the basic physiological requirements of the body. Thus the house is a universal feature of the inhabited world.

Structurally, a house consists of a roof, supported by walls with a door. The census of India defines a 'census house' as a building or a part of a building having a separate main entrance from the road, common courtyard or staircase, etc. used or recognised as a separate unit.

Almost everywhere in rural India, the houses are made of locally available building materials such as stones, mud, unburnt bricks, bamboos, wood reeds, leaves, grasses, etc. This is more true of the poor people who cannot afford the luxury of building materials other than the locally available ones. These are invariably ***kutcha houses.*** However, some rich people in the rural areas can afford to build houses using burnt bricks and cement. These are called ***pucca houses.***

According to Census of India, houses have been classified as *Pucca*, *Semi-pucca*, and *Kutcha* according to the types of materials used in the construction of walls and roof of the house. For the purpose of this classification, the criteria adopted by National Building Organisation has been made use of. The basis of the classification is as below :

Those houses which have both wall and roof made of pucca materials are classified as *pucca*. When both wall and roof are made of kutcha materials, the house is classified as *kutcha*. If either wall or roof is made of pucca material and the other of kutcha material, then the house is classified as *semi-pucca*.

TABLE 13.3. House types and building materials

Category	Materials used for construction
	Wall
Pucca	Burnt bricks, G.I. sheets or other metal sheets, stone, cement, concrete.
Kutcha	Grass, leaves, reeds, bamboo, mud, wood, un-burnt bricks.
	Roof
Pucca	Tiles, slate, shingle, corrugated iron, zinc or other metal sheets, asbestos, cement sheets, bricks, lime and stone, stone and RBC/RCC, concrete.
Kutcha	Grass, leaves, reeds, bamboo, thatch, mud, un-burnt bricks, wood.

URBAN SETTLEMENTS AND TRENDS IN URBANISATION

What is an Urban Place ?

It will be pertinent to know and understand an urban place before one proceeds to discuss trends in urbanization for which defining an urban place is most essential. What constitutes an urban place and how does it differ from a rural place ? How does one define the boundary separating urban from rural areas. At the outset, these questions might appear trivial and one may not consider them worthy of proper attention. But it is not as easy to precisely define an urban place, as it appears to be at the first instance. Everybody seems to know what a city is, but no one has given a satisfactory definition although several scholars, both in India and abroad, have tried to define an urban place in their own way. There seems to be rural-urban continuum and the boundary separating urban from rural is often vague and ill defined. It is practically not possible to point out the disappearance of urbanity or the beginning of rurality. Despite widespread use of the terms 'urban' and 'rural' for centuries, they continue to remain vague and elusive, lacking precise definition. Even if we accept the rural-urban dichotomy, it does not in itself, provide us with an adequate frame of reference for defining and identifying urban places. It is almost universally accepted that a single criterion is not enough to define an urban place and the issue has to be settled on the basis of a set of suitable criteria. The multi-dimensional character of urban areas creates hindrance in giving a precise definition for them. The criteria for defining urban areas, in general, fall into five categories : (*a*) demographic, (*b*) economic, (*c*) social, (*d*) morphological, and (*e*) functional.

The census of India has used the above mentioned criteria for defining an urban area. However, there have been changes in the definition given by the Census of India from one census year to another, particularly in the first half of the 20th century. According to the 1901 census, towns included (*a*) every municipality, (*b*) all civil lines not included within the municipal limits, (*c*) every cantonment and (*d*) every other collection of houses inhabited by not less than 5,000 persons that the census superintendent may decide to treat as a town for census purposes. At the 1911 census, the capitals of the princely states of India, irrespective of being urban or not, were adopted as urban. The census operations upto 1951 continued with the same definition of a town. After Independence, the former princely states were mostly merged to form large unions and their erstwhile capitals were not treated as towns in 1951 if they did not possess the requisite urban characteristics. The 1961 census adopted a strict definition which has been applied more rigorously and uniformly and has been followed in the consequent census years of 1971, 1981 and 1991.

The only exception related to the exclusion of certain economic activities like fishing, livestock, logging, plantations, orchards, etc. in 1981 from the category of non-agricultural activities for computing the percentage of male workers engaged in such activities. In 2001 census of India the definition of urban area adopted is as follows :

(*a*) All places with a municipality, corporation, cantonment board or notified town area committee, etc.

(*b*) All other places which satisfy the following criteria :

(*i*) a minimum population of 5,000;

(*ii*) at least 75 per cent of male working population engaged in non-agricultural pursuits; and

(*iii*) a density of population of at least 400 persons per sq km (1000 per sq mile).

Besides, the Directors of Census Operation in States/Union territories were allowed to include, in consultation with the State Governments/Union Territory Administrations and the Census Commissioner of India, some places having distinct urban characteristics as urban, even if such places did not strictly satisfy all the criteria mentioned under category (*b*) above. Such marginal cases include major project colonies, areas of intensive industrial development, railway colonies, important tourist centres, etc.

The definition of urban areas has been refined in 2011 according to which urban areas are comprised of two types of administrative units—Statutory Towns and Census Towns.

(*a*) Statutory Towns. All administrative units that have been defined by statute as urban like Municipal Corporation, Municipality, Cantonment Board, Notified Town Area Committee Town Panchayat, Nagar Palika etc., are known as Statutory Towns.

(*b*) Census Towns. Administrative units satisfying the following three criteria simultaneously are treated as Census Towns:

(*i*) It should have a minimum population of 5,000 persons*;

(*ii*) At least 75 per cent of the male main working population should have been engaged in non-agricultural pursuits; and

(*iii*) It should have a density of population of at least 400 persons per sq km (1,000 per sq mile).

*For the purpose of identification of places that qualify to be classified as 'Census Towns', all villages with a population of 4000 and above as per the Census 2001, a population density of 400 persons per sq km and having at least 75 per cent of male main working population engaged in non-agricultural activity were considered.

Source : Census of India, 2011, Tables on Houses, Household Amenities and Assets, Series 1, p. lix.

(*c*) City. Towns with population of 1,00,000 and above are categorised as cities.

Out Growth. An Out Growth (OG) is a viable unit such as a village or a hamlet or an enumeration block made up of such village or hamlet and clearly identifiable in terms of its boundaries and location. Some of the examples are railway colony, university campus, port area, military camp, etc., which have come up near a statutory town outside its statutory limits but within the revenue limits of a village or villages contiguous to the town. While determining the outgrowth of a town, it has been ensured that it possesses the urban features in terms of infrastructure and amenities such as pucca roads, electricity, taps, drainage system for disposal of waste water etc. educational institutions, post offices, medical facilities, banks etc. and physically contiguous with the core town of the UA. Each such town together with its outgrowth(s) is treated as an integrated urban area and is designated as an 'urban agglomeration'. In Census 2011, 474 UAs with 981 OGs were identified as against 384 UAs with 962 OGs in Census 2001.

Urban Agglomeration

Each town together with its outgrowth(s) is treated as an *urban agglomeration*. Thus the concept of *Town Group*, which was adopted in 1961 to obtain a broad picture relating to urban spread, was refined and replaced by the concept of *urban agglomeration in 1971* to obtain better feed back in regard to urban contiguity, process and trends of urbanization.

other related matters. An "urban agglomeration" denotes *a continuous urban spread and normally consists of a town and its adjoining urban outgrowths (OGs), or two or more physically contiguous towns together with contiguous well recognised outgrowths, if any, of such towns.* This concept has remained operative in the later censuses without any change or modification.

For the purpose of delineation of Urban Agglomerations, following criteria are taken as pre-requisites :

(*a*) The core town or at least one of the constituent towns of an urban agglomeration should necessarily be a statutory town.

(*b*) The total population of all the constituents (*i.e.* towns and outgrowths) of an urban agglomeration should not be less than 20,000 (as per 2001 Census). In varying local conditions, there were similar other combinations which have been treated as urban agglomerations satisfying the basic conditions of contiguity. Examples are Greater Mumbai UA, Delhi UA etc.

With the above mentioned basis two criteria having been met the following are the possible different situations in which Urban Agglomerations should be constituted :

(*i*) a city or town with one or more contiguous outgrowths

(*ii*) two or more adjoining towns with their outgrowth

(*iii*) a city and one or more adjoining towns with their outgrowths all of which form a continuous spread.

Although big towns and cities stand conspicuously, anomalies do arise in the population size band of village: 5,000 to 10,000 and above, and towns : less than 5,000 to 20,000 in the whole settlement pattern ranging from the smallest village to the largest metropolitan city. According to Prakasa Rao, it could be hypothesized that some of the accessible large villages (5,000-10,000 size class) are more urban than some of the equally accessible small towns (less than 10,000) which are more rural. Rural settlements with population size ranging from 5,000-10,000 and above, and small towns with a population size ranging from less than 5,000 to 20,000 could be classified as *urban* settlements: semi-rural and semi-urban. The definition given by the Census of India has some inherent weakness so far as marginal settlements are concerned. Part (*a*) of the definition includes all places which have a legal/administrative status and are called ***statutory towns***. These towns may not satisfy the criteria listed in part (*b*) of the definition. In particular, a legal/administrative town may have a population of less than 5,000 persons. On the other hand, hundreds of revenue villages satisfied the criteria listed in part (*b*) of the definition, but were not legally/administratively recognised as towns. According to 2001 census figures, there were about two thousand places with 10,000 or more persons which were identified as rural.

The second criterion given by the Census is that 75 per cent of male working force should be engaged in non-agricultural pursuits. Surprisingly, the Census data reveal that at least 25 per cent of the Census towns have agriculture as the dominant activity. **R. Ramachandran** has suggested that all places with 50 per cent or more workers in non-agricultural activities should be treated as urban. Further it is not clear as to why female workers are not considered by the Census of India while suggesting this criterion.

The third criterion relates to the density of population, according to which all places having minimum density of 400 persons per sq km are to be treated as urban. This is indeed an unrealistically low density value in the Indian context. The average density of population in India in 2011 was 382 persons per sq km and 14 states and union territories had densities well over 400 persons per sq km According to the Census criteria, all these states and union territories should be treated as urban which is far from the ground reality. In the opinion of R. Ramachandran, a much higher value of around 1,000 persons per sq km would be more appropriate in the Indian situation.

Besides, the Census of India has given wide powers of discretion to the Directors of Census Operations in States/Union Territories which is totally illogical and unscientific. This leads to some element of subjectivity as some officers exercise their discretion in an arbitrary manner. Consequently, the comparisons of the number of towns and the total urban population in different states becomes misleading.

While the Census definition of a town is standardized and is a welcome move, its rigidity leads to both declassification and re-classification of villages and towns. Application of different criteria as mentioned in the definition given by the Census of India as well as the use of discretionary powers by the Directors of Census of States/Union Territories leads to sudden increase or decrease in the number of towns in different states, from one census to the next as several towns are classified and declassified at each census enumeration. Certain places are treated as new towns by virtue of their being qualified to be treated so due to statutory notification or due to attainment of the minimum population size, density and required proportion of male working population engaged in non-agricultural pursuits and are added to the existing list. Simultaneously, some urban places which either lose their civic status due to statutory notification or fail to qualify the prescribed eligibility tests are deleted from the said list besides the merger of certain adjoining rural-urban areas due to extension of statutory limits of the existing places. For example, there were 4,029 towns in India as per 1981 census. Out of these 93 towns were declassified and 103 towns were fully merged with other towns by statutory notifications of the concerned State/Union Territory Governments during 1981-91. As many as 856 new towns (277 statutory and 579 census towns) were added to urban frame of the 1991 census.

Number of statutory towns, census towns, urban agglomerations and outgrowth in 2011 and 2001 is given in **Table 13.4.**

TABLE 13.4. Number of UAs/Towns and Out Growth (OGs)

Type of Towns/UAs/OGs	Number of Towns	
	2011 Census	2001 Census
1. Statutory Towns	4,041	3,799
2. Census Towns	3,892	1,362
3. Urban Agglomerations	474	384
4. Out Growths	981	962

Source : *Census of India 2011*, Tables on Houses, Household Amenities and Assets, Series 1, p. ix.

Metropolitan Cities. Cities with population of one million and over are known as ***metropolitan cities***. The main activities in these cities are industries, trade, commerce, transport, cultural and political. The number of metropolitan cities increased from 12 in 1981 to 53 in 2011.

Mega Cities. Cities with population of 5 million and above are known as mega cities according to Census of India. But United Nations consider mega cities as those that have a population of 10 million and above. In India, Greater Mumbai, Kolkata and Delhi are examples of mega cities.

Conurbation. This term was coined by Patrick Geddes. It comes into being by coalescence of urban settlements which were separated by open space in the past. The coalescence usually occurs through Ribbon Development along the main inter-urban transport routes. Mumbai, Delhi and Kolkata are good examples of conurbation in India.

Megalopolis. It is a Greek word which is derived by combining two terms 'great' and 'city'. It is just like conurbation and is formed when a large city sprawls and brings into its fold, the smaller adjacent towns and cities. This term was first used by **Gottman** in 1964 to describe the urban scene of the north-eastern board of the U.S.A. He identified a large conurbation like mass of linked built-up areas (and yet containing much more open land) extending over 960 km (600 miles) from north of Boston to Norfolk in Virginia.

Size Class of Cities. The Census Department of Government of India has classified the urban places under the following six categories :

Size class	Population
I	100,000 & above
II	50,000-99,999
III	20,000-49,999
IV	10,000-19,999
V	5,000-9,999
VI	Less than 5,000

Urban Growth and Development in India

1. Cities of Ancient and Medieval Periods. India has a long history of urbanization. The first phase of urbanization is traced in the Indus valley which is associated with the Harappa urbanism. The cities of Harappan civilization flourished for about 600 years, between 2350 B.C. and 1750 B.C. Two major towns of the Indus civilization *viz.* Harappa and Mohenjodaro are in Pakistan now. Important towns of the Harappan culture located in India are Lothal, Surkotada, Rangpur and Rojdi (Gujarat), Kalibangan (Rajasthan), Banwali (Haryana) and Rupar (Punjab). This period was followed by a prolonged period of about one thousand years in which there is no evidence of urbanization. From around 600 B.C. onwards, towns and cities grew in association with two cultural streams *viz.* the Aryan civilization in the North and the Dravidian civilization in the South. The major cities which grew during this period were Hastinapur, Mathura, Ayodhya, Kapilavastu, Kusinagar, Vaishali, Patliputra, Varanasi, Rajgir and Champa in north India and Ujjain, Mahishamati, Nagarjunakonda, Kancheepuram, Puhar, Uraiyur, Madurai, Korkai and Vanji in south India. Cities grew both in number and size during the Mauryan and post Mauryan periods (from 300 B.C. to A.D. 600) in north, as well as in south India. Northern part of the country saw a decline in urban growth during the post-Gupta period from A.D. 600 to about A.D. 1000. Later on, the invasion of Turks followed by the Sultanate rule helped in revival of urban development in India. This phase started around 11th century A.D. and continued with some changes till the fall of the Mughal Empire *i.e.* till the 17th century A.D. The cities which grew and flourished during this period are Ludhiana, Hisar, Bikaner, Jaipur, Jodhpur, Udaipur, Kota, Chittaurgarh, Moradabad, Agra, Jaunpur, Ahmedabad, Indore, Raipur, Aurangabad, Ahmadnagar, Pune, Gulbarga, Bijapur, Vijaynagar, Hyderabad (Golcunda) and Mysore.

2. Cities of British Period. With the arrival of the British East India Company, the nature of urbanization process changed remarkably. The major contribution of the British to the Indian urban scene were : (1) the creation of three metropolitan port cities of Mumbai (Bombay), Kolkata (Calcutta) and Chennai (Madras), (2) creation of a chain of hill stations in the Himalayan region and in South India, (3) the modification of the urban landscape of the existing cities with the introduction of civil lines and cantonments, (4) the introduction of railways and modern industry, and (5) the improvements in urban amenities and administration. Some of the major towns that came up during the British period are :

Hill stations. Shimla, Mussoorie, Dehradun, Almora, Nainital, Darjeeling and Shillong in the north and Ooty, Kodaikanal in the south.

Port cities. Mumbai, Panaji, Marmagao, Cannanore, Alleppey, Karaikal, Puducherry, Chennai and Kolkata.

Industrial cities. Kanpur, Dhanbad, Jamshedpur, Asansol, Bhadravati.

Transportation cities. Bhusawal, Jalgaon, Siliguri.

Other cities. Sriganganagar, Bhilwara, Ranchi.

It may be mentioned here that all the above cities were not built by the Britishers alone but were the result of efforts made by the Britishers, the Portuguese, the Dutch, the French and the Indians.

It is clear from the above discussion that urbanization in India passed through different phases of history and around the year 1800, India had 16 cities with a population of one lakh or more and about 1,500 towns. About 11 per cent of the total population of the country lived in urban areas at that time. At the time of first Census in 1872, the urban population declined to 8.7 per cent. The number of cities with a population of one lakh or more still remained at 16 and only 43 places had a population of 50,000 or more. Thus major part of the 19th century was marked by stagnation or decline in urbanization in India. This was primarily due to the lack of interest on the part of Britishers and ushering of the *Industrial Revolution in England* in the latter half of the 18th century. As a matter of fact, the cities of Kolkata, Mumbai and Chennai built by the Britishers showed remarkable growth while most of the pre-British cities desperately declined.

3. Cities of Post-Independence Period. After India got Independence in 1947, a greater need for economic development was felt and efforts were made for the overall growth of the country. This naturally called for establishing new towns and cities and growth of the pre-existing cities. The central and state governments made strenuous efforts to set-up new towns. Many new states were created and such states preferred to have new planned cities as their capitals. Chandigarh is the best example of such cities. Gandhinagar, Itanagar, Dispur, and Bhubaneshwar are other examples of capital cities. The industrial sector also progressed rapidly after

Independence and many industrial towns come up after Independence. Iron and Steel Industry gave birth to new towns of Durgapur, Rourkela, Bhilai and Bokaro. Vishakhapatnam and Vijaynagar (Hospet) also grow due to growth of iron and steel industry.

Noonmati, Barouni, Haldia, Digboi, Koyali etc. are some of the towns which originated or grew because of oil refineries. Pinjore in Haryana owes its origin and growth to Hindustan Machine Tools. Some of the towns and cities have a large number of industries working simultaneously. The list of such towns and cities is very large. However, names of Sundri, Chittaranjan, Nangal, Neyveli, Modinagar, Ghaziabad, Faridabad, Yamunagar, Dalmiapuram, Pimpri, Namrup etc. are worth mentioning. Some of the old towns have grown in due course of time around metropolitan cities and are known as satellite towns. Ghaziabad, Faridabad, Gurgaon, Noida, Bahadurgah, Sonipat around Delhi are some of such satellite towns. Towns of small and medium size have developed in almost all parts of the country.

Urbanisation

The process of society's transformation from a predominantly rural to a predominantly urban population is known as '***urbanisation***'. It includes two things—an increase in the number of people living in urban settlements, and an increase in the percentage of the population engaged in non-agricultural activities, living in such places.

Trends in Urbanisation. Trends in urbanistion in India from 1901 to 2011 are shown in **Fig. 13.15** and **13.16** and are further elaborated in **table 13.5**. This table shows that the number of towns/urban agglomerations increased by more than four times from 1,915 in 1901 to 7,935 in 2011. There was steady increase in number of towns till 1951, but due to more rigorous tests applied in 1961 to determine whether a place qualified to be treated as a town or not, many urban places were declassified and hence, the number of towns declined from 3,035 in 1951 to 2,657 in 1961.

Table 13.5 also shows that the total population living in urban areas as well as the percentage of urban population to total population of India had been gradually increasing since 1901. For example, only 25.94 million people lived in towns till 1911 and by 2011 the urban population of India increased by more than fourteen times to 377.11 million. At the time of the first census after Independence *i.e.* 1951, the population living in towns was 62.44 million. Since the 1961 census, however, the urban population and number of towns/urban agglomerations had increased steadily. There has been more than three times growth in urban population in four decades which increased from 109.11 million in 1971 to 377.11 million in 2011.

The percentage of urban population to total population has also recorded a gradual increase from one decade to another with the only exception of a decline from 10.84 per cent in 1901 to 10.29 per cent in 1911. This decline is largely attributed to the devastating plague epidemic of 1911 which spread mainly in urban areas and brought an exodus of urban population to rural areas. On the other hand, the World War II (1939-45) and partition of the country in 1947 were mainly responsible for a sudden spurt in

TABLE 13.5. Urbanization in India, 1901-2011

Year	Population (in million)		Urbanisation rate (per cent)	No. of cities/towns	Decadal growth
	Total	Urban			
1901	238.40	25.85	10.84	1915	—
1911	252.09	25.94	10.29	1864	0.35
1921	251.32	28.09	11.18	2018	8.27
1931	278.98	33.46	11.99	2188	19.12
1941	318.66	44.15	13.86	2392	31.97
1951	361.10	62.44	17.29	3035	41.42
1961	439.09	78.94	17.97	2657	26.41
1971	548.23	109.11	19.91	3081	28.23
1981	683.33	159.46	23.34	3981	46.14
1991	846.39	217.55	25.70	4615	37.52
2001	1028.61	286.12	27.82	5161	31.52
2011	1210.19	377.11	31.16	7935	31.80

Notes 1. As the 1981 census was not conducted in Assam, the 1981 total and urban population figures for India include interpolated figures for that state.

2. The 1991 census was not held in Jammu and Kashmir. The 1991 total and urban population figures for India include the interpolated figures for that state.

Source : (*i*) Premi (2012 : 69); (*ii*) Census of India 2011, Series 1, India, *Provisional Population Totals*, Paper 2 of 2011.

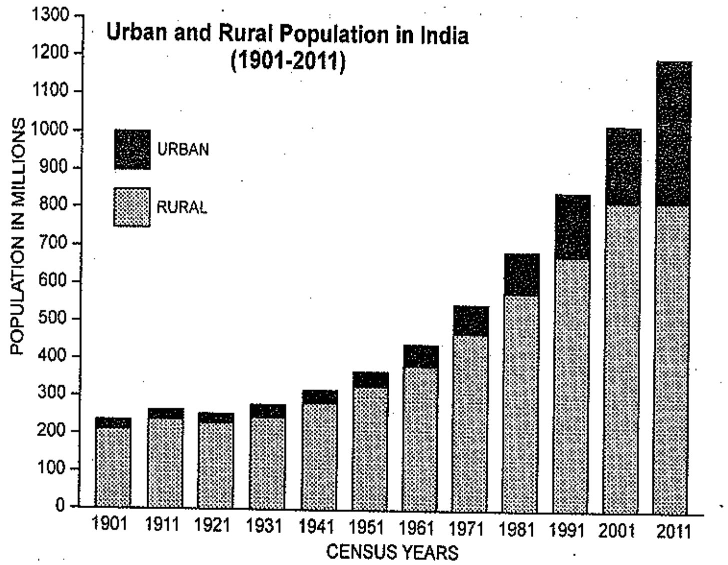

FIG. 13.18. Urban and Rural Population in India (1901-2011)

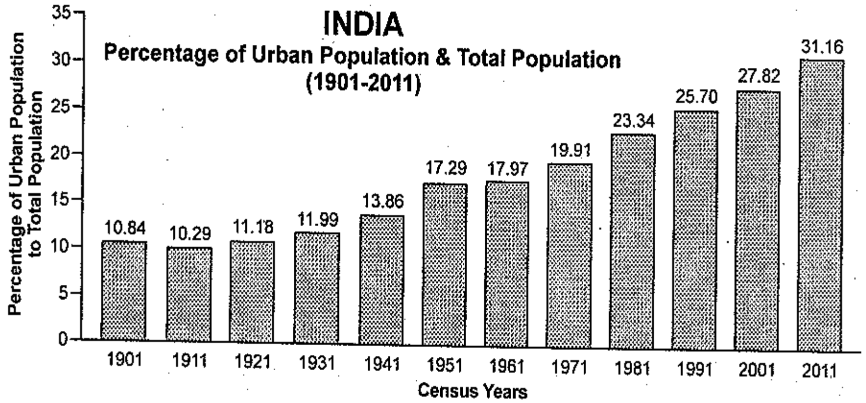

FIG. 13.19. Percentage of Urban Population to Total Population

urban growth during 1931-41 and 1941-51. Partition of the country resulted in a massive influx of refugees into India from West Pakistan (now Pakistan) and East Pakistan (now Bangladesh). Refugees from West Pakistan settled down mainly in Delhi and Punjab (including present Haryana) and to a lesser extent in western Uttar Pradesh, while those from East Pakistan found their way in Kolkata and its suburbs as well as in Assam and Tripura. In all, 14 new towns were built to accommodate refugees migrating from Pakistan. In addition, refugee colonies (new townships) were established near existing cities. As many as 19 places in Punjab, Haryana and Delhi were selected for locating these townships (generally called Model Towns). However, the pace of urbanization slowed down during 1951-61 as a result of declassification of large number of towns. The percentage of urban population to total population increased only by 0.68 per cent from 17.29 percent in 1951 to 17.97 per cent in 1961. As mentioned earlier, the number of towns/urban agglomerations actually declined during this period. Further, it is worth

mentioning that the pace of urbanization slowed down during 1981-91. The decennial growth rate had declined from 46.14 per cent in 1971-81 to 37.52 per cent in 1991. According to 2011 census, 377.11 million persons or 31.16 per cent of the total population of India is termed as ***urban***.

In spite of the above mentioned developments, India is still one of the least urbanised countries of the world. Only 31.16% of India's population (census 2011) is urban whereas world's 48% population (according to 2004 figures) lives in urban areas. India was previously more urbanised than China where 21% population was urban. But that country has left India far behind with 41% of its population as urban. Even Pakistan has 34% of its total population living in urban areas and is more urbanised than India. India's less than one-third of urban population is no comparison with 79% of the USA, 78% of Japan, 74% of European countries, 73% of Russia, 78% of New Zealand and 91% of Australia.

India is still considered to be a country of villages. But **R. Ramachandran** (1995) holds altogether a different view. According to him, "India is often portrayed as a land of villages and hamlets, nevertheless, in reality, it is equally a land of towns and cities. With over 12,000 settlements with populations of 5,000 persons or more, India has an urban infrastructure of gigantic magnitude". In terms of absolute numbers, India's urban population far exceeds the total population of the U.S.A. which is the third most populous country of the world. Further, it may be mentioned that India's urban population is the world's second largest after that of China.

Table 13.5 shows that there had been gradual growth of urban population before independence. The decennial growth rate was at a very low level of 0.35 per cent in 1901 which shot up to 41.42 per cent in 1951. Thereafter, varying trends have been observed with respect to growth rates. The maximum 46.14 per cent in 1981 which declined to 31.80 per cent in 2011. However, such percentages can be misleading because the total urban population was much less in the pre-independence period as compared to the post-independent period.

The number of cities/towns increased rapidly from 1,864 in 1911 to 3,035 in 1951. But this number fell sharply to 2,651 in 1961 due to declassification of several towns. Thereafter, there has been steep rise in the number of cities/towns and the time of 2011 census, there were as many as 7,935 cities/towns in India.

The forgoing discussion brings us is the conclusion that where have been three distinct phases of urban growth in India.

1. Period of Slow Urban Growth (before 1931). The period of 50 years extending from the first complete census in 1881 to 1931 is considered as the period low urban growth in India. In 1881, only 9.3 per cent of India's population was living in urban areas which slowly increased to 11.99 per cent in 1931. Thus the growth rate during the first fifty years of census increased only by 2.69 per cent which is negligibly small as compared to the later increase in growth rates. This slow rate of urban growth is attributed to a large number of factors, but natural disasters like drought, floods, famines, epidemics had been the major causes. These factors led to high mortality rate and retardation of urban growth.

2. Period of Medium Growth Rate (1931-61). Period of thirty years from 1931 to 1961 is termed as period of medium growth. There was more than two-fold increase in urban population from 33.46 million in 1931 to 78.94 million in 1961 and the percentage of urban population to total population also increased from 11.99 to 17.97 during the same period. This was because of major thrust given by the Government of India and many industrial towns and state capital towns came up immediately after Independence. World War II (1939-45) and partition of the Indian subcontinent in 1947 gave a major thrust to urbanisation in India. Several new towns were set-up to accommodate displaced persons from Pakistan. As a result of declassification of several towns in 1961, the number of towns fell from 3035 in 1951 to 2657 in 1961. Therefore *1951-61 is termed as inactive decade from urbanisation point of view*.

3. Period of Rapid Growth (1961-2011). During the period of 50 years from 1961 to 2011, India witnessed rapid growth in urbanisation and urban centres. The urban population saw more than four-fold increase from 78.94 million in 1961 to 377.11 million in 2011 and the percentage of urban population also shot up from 17.67 in 1961 to 31.16 in 2011. The number of towns which fell from 3,035

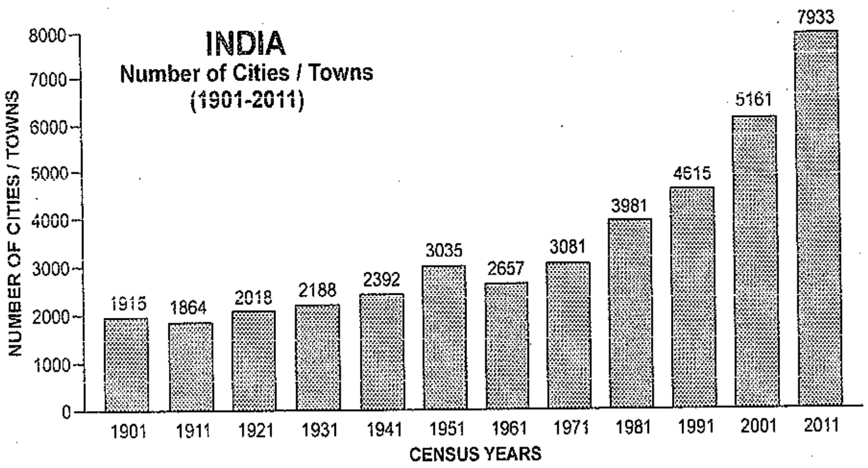

FIG. 13.20. India : Number of Cities/Towns

in 1951 to 2,657 in 1961 sharply increased in to 7,933 in 2011. This is a reflection of India's economic growth history and a major change in the demographic set up of the country as a large number of people are migrating from rural to urban areas in search of livelihood and better quality of life.

Spatial Patterns of Level of Urbanisation

Table 13.6 and **Fig. 13.21** show that the level of urbanisation varies widely among the states. Goa is the most urbanised state where 62.17 per cent of the population lives in urban areas. This is followed by Mizoram where 51.51% of total population of the state lives in towns/cities. Among the larger states Tamil Nadu with 48.45 of its urban population is the most urbanised state. This state is followed by Kerala (47.7%), Maharashtra (45.23%), Gujarat (42.58%), Karnataka (38.57%) and Punjab (37.49%). The other states with percentage of urban population more than the national average of 31.16 are Haryana, West Bengal and Andhra Pradesh. On the other end of the scale, Himachal is the least urbanised state where 10.04 per cent of the population lives in urban areas. The other states where level of urbanisation is below 20 per cent are Bihar (11.30%), Assam (14.08%), and Odisha (16.68%). The other states with level of urbanisation below the national average are Jammu and Kashmir, Uttar Pradesh, Sikkim, Arunachal Pradesh, Nagaland, Tripura, Meghalaya, Chhatisgarh and Madhya Pradesh.

Among the Union Territories, Delhi is the most urbanized where 97.50 per cent of the population is classified as urbanised. Next in order of level of urbanisation are Chandigarh (97.25%), Lakshadweep (78.08%), Daman and Diu (75.16%), Puducherry (68.31%) and Dadra and Nagar Haveli (46.62%). The Union Territories of Andaman and Nicobar Islands is the least urbanised where only 35.67% of the population lives in urban areas.

Of the total urban population of India, more than one-half lives in just five states. These states are Maharashtra (50.8 million), Uttar Pradesh (44.5 million), Tamil Nadu (34.9 million), West Bengal (29.1 million) and Andhra Pradesh (28.4 million). The other five states of Madhya Pradesh, Gujarat, Karnataka, Bihar and Rajasthan, account for one fourth of India's total urban population. Thus, the total for these two sets of states comes very high—over three-fourths of the total urban population of India. It is interesting to note that U.P. figures in this list, although it is one of the least urbanised states of India with only 22.28 per cent of its population living in urban areas. This happens because its size of urban population is very large (44.5 million) even though its urban percentage is low. One may compare Uttar Pradesh with Maharashtra where the degree of urbanisation is one of the highest in the country but its absolute urban population (50.8 million) is slightly more than that of Uttar Pradesh.

TABLE 13.6. Spatial patterns of urbanisation in India

State/UT Code	India/State/Union Territory#	Population 2011			Percentage share of Total Population 2011		Percentage Decadal Growth 2001-2011		
		Total	Rural	Urban	Rural	Urban	Total	Rural	Urban
	INDIA	**1,210,193,422**	**833,087,662**	**377,105,760**	**68.84**	**31.16**	**17.64**	**12.18**	**31.80**
01	Jammu & Kashmir	12,548,926	9,134,820	3,414,106	72.79	27.21	23.71	19.77	35,66
02	Himachal Pradesh	6,856,509	6,167,805	688,704	89.96	10.04	12.81	12.50	15.64
03	Punjab	27,704,236	17,316,800	10,387,436	62.51	37.49	13.73	7.58	25.72
04	Chandigarh#	1,054,686	29,004	1,025,682	2.75	97.25	17.10	–68.51	26.86
05	Uttarakhand	10,116,752	7,025,583	3,091,169	69.45	30.55	19.17	11.34	41.86
06	Haryana	25,353,081	16,531,493	8,821,588	65.21	34.79	19.90	10.00	44.25
07	NCT of Delhi#	16,753,235	419,319	16,333,916	2.50	97.50	20.96	–55.61	26.56
08	Rajasthan	68,621,012	51,540,236	17,080,776	75.11	24.89	21.44	19.05	29.26
09	Uttar Pradesh	199,581,477	155,111,022	44,470,455	77.72	22.28	20.09	17.81	28.75
10	Bihar	103,804,637	92,075,028	11,729,609	88.70	11.30	25.07	23.90	35.11
11	Sikkim	607,688	455,962	151,726	75.03	24.97	12.36	–5.20	153.43
12	Arunachal Pradesh	1,382,611	1,069,165	313,446	77.33	22.67	25.92	22.88	37.55
13	Nagaland	1,980,602	1,406,861	573,741	71.03	28.97	–0.47	–14.59	67.38
14	Manipur	2,721,756	1,899,624	822,132	69.79	30.21	18.65	10,58	42.74
15	Mizoram	1,091,014	529,037	561,977	48.49	51.51	22.78	18.20	27.43
16	Tripura	3,671,032	2,710,051	960,981	73.82	26.18	14.75	2.13	76.08
17	Meghalaya	2,964,007	2,368,971	595,036	79.92	20.08	27.82	27,04	31.03
18	Assam	31,169,272	26,780,516	4,388,756	85.92	14.08	16.93	15.35	27.61
19	West Bengal	91,347,736	62,213,676	29,134,060	68.11	31.89	13.93	7,73	29.90
20	Jharkhand	32,966,238	25,036,946	7,929,292	75.95	24.05	22.34	19.50	32.29
21	Odisha	41,947,358	34,951,234	6,996,124	83,32	16.68	13.97	11.71	26.80
22	Chhattisgarh	25,540,196	19,603,658	5,936,538	76.76	23.24	22.59	17.75	41.83
23	Madhya Pradesh	72,597,565	52,537,899	20,059,666	72.37	27.63	20.30	18.38	25.63
24	Gujarat	60,383,628	34,670,817	25,712,811	57.42	42.58	19.17	9.23	35.83
25	Daman & Diu #	242,911	60,331	182,580	24.84	75.16	53.54	-40.18	218.37
26	Dadra & Nagar Haveli#	342,853	183,024	159,829	53.38	46.62	55.50	7.64	216.73
27	Maharashtra	112,372,972	61,545,441	50,827,531	54.77	45.23	15.99	10.34	23.67
28	Andhra Pradesh (including Telangana)	84,665,533	56,311,788	28,353,745	66.51	33.49	11.10	1.64	36.26
29	Karnataka	61,130,704	37,552,529	23,578,175	61.43	38.57	15.67	7.63	31.27
30	Goa	1,457,723	551,414	906,309	37.83	62.17	8.17	-18.56	35,15
31	Lakshadweep#	64,429	14,121	50,308	21.92	78.08	6,23	-58.08	86.55
32	Kerala	33,387,677	17,455,506	15,932,171	52.28	47.72	4.86	-25.96	92.72
33	Tamil Nadu	72,138,958	37,189,229	34,949,729	51.55	48.45	15,60	6.49	27.16
34	Puducherry#	1,244,464	394,341	850,123	31.69	68.31	27.72	21,07	31.07
35	Andaman & Nicobar Islands#	379,944	244,411	135,533	64.33	35.67	6.68	1.86	16.64

Source : Census of India 2011, Paper 2, Volume 1 of 2011, India Series 1, pp. 2, 8.

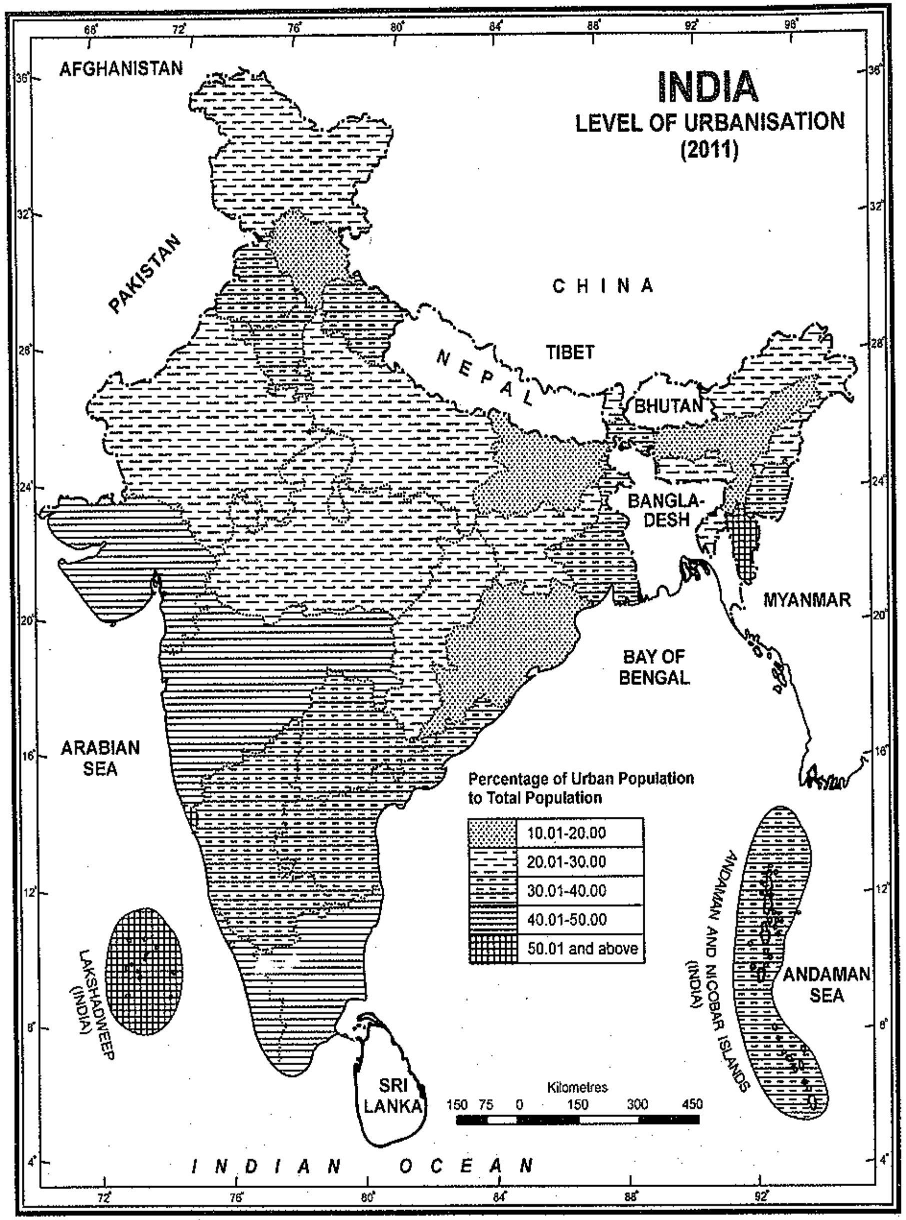

FIG. 13.21. India : Level of Urbanisation (2011)

Table 13.7 gives an idea of distribution of statutory and census towns in 2001 and 2011, new towns in 2011 as well as denotified/declassified towns in 2011. It is obvious that Tamil Nadu has the largest number of 1097 towns among the big states. This means that over 13.8 per cent of India's towns are in Tamil Nadu alone. This state is followed by Uttar Pradesh (915), West Bengal (909), Maharashtra (535)

TABLE 13.7. Statewise distribution of 2001 and 2011 censuses, new towns of 2011 census and denotifies/declassified towns in 2011

State/ Union Territories	2001 Number of Towns			2011 Number of Towns			New Towns in 2011 census		2011 towns minus new towns		Denotified/ declassified towns		
	Total	S	C	Total	S	C	S	C	S	C	Total	S	C
India	**5,161**	**3,799**	**1,362**	**7,935**	**4,041**	**3,894**	**289**	**2,740**	**3,752**	**1,154**	**255**	**47**	**208**
Big States													
Andhra Pradesh (including Telangana)	210	117	93	353	125	228	19	159	106	69	35	11	24
Assam	125	80	45	214	88	126	8	86	80	40	5	0	5
Bihar	130	125	5	199	139	60	17	56	122	4	4	3	1
Chhattisgarh	97	75	22	182	168	14	93	10	75	4	18	0	18
Gujarat	242	168	74	348	195	153	41	106	154	47	41	14	27
Haryana	106	84	22	154	80	74	11	52	69	22	15	15	0
Himachal Pradesh	57	56	1	59	56	3	0	3	56	0	1	0	1
Jammu & Kashmir	75	72	3	122	86	36	14	33	72	3	0	0	0
Jharkhand	152	44	108	228	40	188	2	:07	38	81	33	6	27
Karnataka	270	226	44	347	220	127	4	94	216	33	21	10	11
Kerala	159	60	99	520	59	461	0	362	59	0	1	0	1
Madhya Pradesh	394	339	55	476	364	112	26	64	338	48	8	1	7
Maharashtra	378	251	127	535	256	279	7	171	249	108	21	2	19
Odisha	138	107	31	223	107	116	0	86	107	30	1	0	1
Punjab	157	139	18	217	143	74	7	60	136	14	7	3	4
Rajasthan	222	184	38	297	185	112	0	80	184	32	6	0	6
Tamil Nadu	832	721	111	1097	721	376	0	272	721	0	1	–16	17
Uttar Pradesh	704	638	66	915	648	267	9	208	639	59	6	–1	7
Uttarakhand	86	74	12	116	74	42	0	31	74	11	1	0	1
West Bengal	375	123	252	909	129	780	5	537	124	243	8	–1	9
Small States													
Arunachal Pradesh	17	0	17	27	26	1	10	1	16	0	1	–16	17
Goa	44	14	30	70	14	56	0	26	14	30	0	0	0
Manipur	33	28	5	51	28	23	0	19	28	4	1	0	1
Meghalaya	16	10	6	22	10	12	0	6	10	6	0	0	0
Mizoram	22	22	0	23	23	0	1		22	0	0	0	0
Nagaland	9	8	1	26	19	7	10	7	9	0	0	–1	1
Sikkim	9	8	1	9	8	1	0	1	8	0	1	0	1
Tripura	23	13	10	42	16	26	3	23	13	3	7	0	7
Union Territory													
A & N Islands	3	1	2	5	1	4	1	2	0	2	1	1	0
Chandigarh	1	1	0	6	1	5	0	5	1	0	0	0	0
D. & N. Haveli	2	0	2	6	1	5	0	5	1	0	1	–1	2
Daman and Diu	2	2	0	8	2	6	0	6	2	0	0	0	0
Lakshadweep	3	0	3	6	0	6	0	3	0	3	0	0	0
NCT of Delhi	62	3	59	113	3	110	0	55	3	55	4	0	4
Puducherry UT	6	6	0	10	6	4	0	4	6	0	0	0	0

Note: S—Statutory. C—Census.
Source **:** Mahendra Premi and Dipendra Nath Dass (2012 : 93-95)

and Kerala (520). Thus more than half the towns are located in just five states. Kerala has 520 towns although it is comparatively small state with respect to area when compared with other large states.

As expected, small states have lesser number of towns. Among the small states Goa has the maximum number of 70 towns while Sikkim has to content with only 9 towns of small sizes.

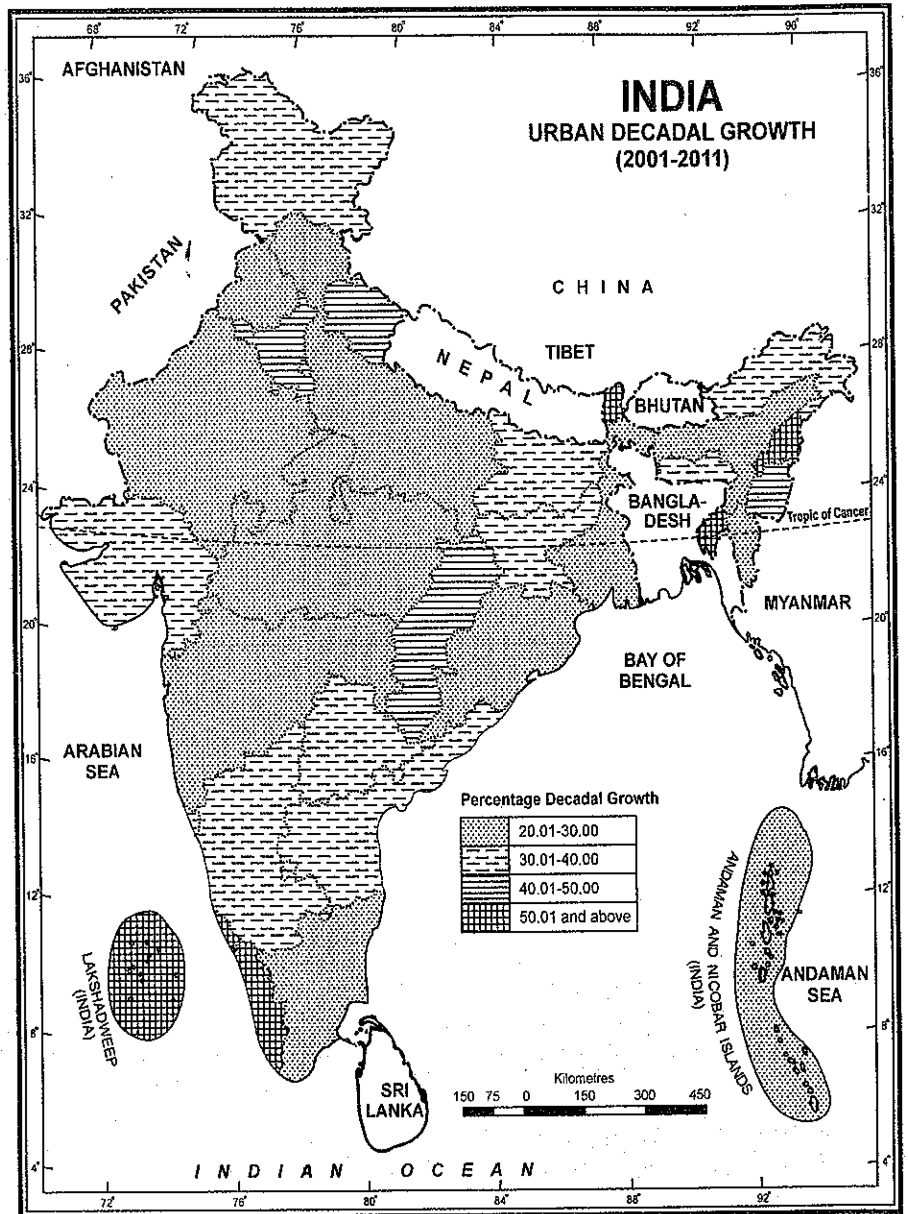

FIG. 13.22. Urban Decadal Growth

Statutory Towns and Census Towns. Census of India had classified Indian towns into two broad categories *viz.* statutory cities of towns and census towns. According to Census of India, statutory towns are those towns which have a local self government like municipal corporation, municipal committee/board, contonment board, notified area committee, town (nagar) panchayat etc. established by the local self government of the state after testing for the requirements laid down in their respective Acts in this regard. Besides, there are a number of other urban settlements that meet certain criteria specified by the census organisation on the eve of a particular census.

According to 2011 census, there is a net addition of 2,774 towns in India between 2001 and 2011. Out of these 2,774 towns, 242 are statutory towns and the remaining 2,532 are census towns. West Bengal tops the list with 537 towns followed by Kerala (362), Tamil Nadu (272) and Uttar Pradesh (208). The recognition of these new towns has resulted in the accelerated rate of urbanisation and have changed the urban map of some states substantially.

Table 13.7 also reveals that 47 statutory towns have been denotified and 208 census towns have been declassified on the eve of 2011 census. Of these 27 towns each belong to Jharkhand and Gujarat and 24 towns to Andhra Pradesh. However this has not affected the urban scene of the concerned states to any great extent.

Decadal Growth (2001-2011). Table 13.6 shows that at all India level, there has been 31.80 per cent growth in the urban population in contrast to only 12.18 per cent in the rural population during 2001 and 2011. This phenomenal growth in the urban population is largely attributed to migration of a large number of people from rural to urban areas. Great regional variations are noticed in the decadal growth of urban population during 2001-11. Among the states, Sikkim has recorded maximum decadal urban growth of 153.43 per cent. This phenomenal growth seems to be the result of mass migration of people from rural to urban areas because this state recorded negative growth rate of 5.20 per cent in the rural population. Similar is the case with Nagaland which recorded 67.38 per cent growth in urban and –14.59 per cent growth in rural population. In the south, Kerala has recorded 92.72 per cent growth in the urban and –25.46 per cent growth in its rural population. The other states with high growth rate in urban population are Tripura (76.08%), Haryana (44.25%), Manipur (42.74%), Uttarakhand (41.86%) and Chhattisgarh (41.83%).

The other states which recorded decadal growth rate higher than the national average of 31.80% are Jammu and Kashmir, Bihar, Arunachal Pradesh, Jharkhand, Gujarat, Andhra Pradesh and Goa. Among all the states, Himachal Pradesh has recorded the minimum growth rate of 15.64% and this is also the least urbanised state in India. The other states with less than the national growth rate are Punjab, Rajasthan, Uttar Pradesh, Mizoram, Meghalaya, Assam, West Bengal, Odisha, Madhya Pradesh, Maharashtra, Karnataka, and Tamil Nadu.

Among the Union Territories, Daman and Diu as well Dadra and Nagar Haveli have recorded exceptionally high growth of 218.37 and 216.73% respectively. This is largely due to large scale migration of the people from rural to urban areas both from within these territories and from the surrounding areas. Lakshadweep has also recorded very high growth rate of 86.55 per cent. Puducherry had recorded below national average growth rate. In the north Chandigarh and Delhi have recorded low percentage of growth rates of 26.86% and 26.56% respectively which may be due to larger number of people already living in these union territories. Andaman and Nicobar Islands have recorded the lowest urban growth rate of 16.64 per cent. **Fig. 13.22** shows the areal variations in the urban decadal growth rate.

METROPOLIZATION (OR METROPOLITANIZATION)

Metropolization refers to the growth of metropolitan centres rooted in industrial and tertiary economic base. A metropolis is a distinct form of settlement, charateristically with sprawling of its built-up area and includes its inter-dependent nearby villages and even towns. The metropolitan centres are a class by themselves, characterized by large scale consumption and a large quantum of flows of people, goods, services and information (Prakasa Rao, 1983). According to **R. Ramchandran** (1995), "Metropolization is essentially a product of the centralization of administrative, political and economic forces in the country at the national and state capitals. Metropolization is also a product of intense interaction between cities and the integration of national economy and urban centres into a viable inter-dependent system". The pace of metropolization depends upon the rate of direct migration of rural folk to metropolitan cities as well as from the smaller towns. In fact migration constitutes the very foundation of the process of urbanization and is recognised as the chief mechanism by which urban centres continue to grow. One view is that urbanization stops when migration to urban centres stops (Prakasa Rao, 1983). However, natural growth cannot be overlooked. Sixty per cent of the urban growth during 1981-91 is attributed to the factor of natural increase (Premi, 1991).

The Census of India has defined metropolitan *as an urban agglomeration/city having a population of one million and above*. These are also called the *million plus cities*. Metropolization in India is primarily a phenomenon of the post-independence era. In 1901 Kolkata (Calcutta) was the only metropolitan city in the whole of India. In 1911, Mumbai (Bombay) joined Kolkata. The number of such cities remained at 2 for another three decades till 1941. But at the time of the first census after independence in 1951 their number increased to 5 with population of Delhi, Chennai (Madras) and Hyderabad crossing one million mark. In the next 30 years from 1951 to 1981, the cities which joined the million plus group of cities were Ahmedabad and Bangalore in 1961, Kanpur and Pune (Poona) in 1971 and Lucknow, Nagpur and Jaipur in 1981. Thus the number of million plus cities rose to 7 in 1961, 9 in 1971 and 12 in 1981. The decade 1981-91 recorded a phenomenal growth and the number of such cities rose to 23 in 1991. The growth of metropolitan cities was further accelerated in the decade 1991-2001 and the number of metropolitan cities stood at 35 in 2001 (**Table 13.8**). Obviously these cities are characterised by high concentration of population. Together, these cities provided home to 107.88 million people in 2001 which accounted for about 37.81 per cent of the total urban population of India. The average population per urban agglomeration/city of million plus category has almost doubled from 1.51 million in 1901 to 3.08 million in 2001. The decadal variation had also changed largely from 8.86 per cent in 1931 to 121.32 per cent in 1951. The exceptional increase in 1951 is

TABLE 13.8. Urban Agglomerations/Cities having Population of more than a Million, 1901-2001

Census Year	Number of metropolitan cities	Population (in million)	Average Population per UA/city (in million)	Population of million plus urban agglomerations/cities as percentages of India's urban population	Decadal variation of population (per cent)
1901	1	1.51	1.51	5.84	—
1911	2	2.76	1.38	10.65	83.02
1921	2	3.13	1.56	11.14	13.24
1931	2	3.41	1.70	10.18	8.86
1941	2	5.31	2.65	12.02	55.79
1951	5	11.75	2.35	18.81	121.32
1961	7	18.10	2.59	22.93	54.10
1971	9	27.83	3.09	25.51	53.75
1981	12	42.14	3.51	26.41	51.35
1991	23	70.66	3.07	32.54	67.76
2001	35	107.88	3.08	37.81	58.83
2011	53	—	—	—	—

attributed to influx of refugees from West Pakistan (now Pakistan) and East Pakistan (now Bangladesh) to metropolitan cities of Mumbai, Kolkata and Delhi.

According to 2011 Census, India has 53 metropolitan cities. They are, in descending order, Greater Mumbai, Delhi, Kolkata, Chennai, Bengaluru, Hyderabad, Ahmedabad, Pune, Surat, Jaipur, Kanpur, Lucknow, Patna, Nagpur, Ghaziabad, Indore, Coimbatore, Kochi, Kozhikode, Bhopal, Thrissur, Vadodara, Agra, Vishakhapatnam, Malappuram, Thiruvananthapuram, Kannur, Ludhiana, Nashik, Vijaywada, Madurai, Varanasi, Meerut, Rajkot, Faridabad, Jamshedpur, Srinagar, Jabalpur, Asansol, Allahabad, Dhanbad, Vasai-Virar, Aurangabad, Amritsar, Jodhpur, Ranchi, Raipur, Kollam, Gwalior, Durg-Bhilainagar, Chandigarh, Tiruchirapalli and Kota. As many as 160 million people are living in these 53 metropolitans (Census 2011). Greater Mumbai tops the lists with 18.4 million people and Delhi stands at second position with 16.3 million population. It was quite surprising to find the Kolkata and Mumbai are the slowest growing metros. Conversely, smaller metropolitan cities such as Malappuram, Thrissur, Kannur, Kollam, Kozhikode and Thiruvananthapuram (all in Kerala), Ghaziabad (Uttar Pradesh), Visal-Virar (Maharashtra), Dhanbad (Jhakhand), Surat (Gujarat) and Raipur (Chhattisgarh) are galloping ahead in quest for expansion. Cities with most rapidly growing municipal corporations include Vasai-Virar, Dhanbad, Surat, Bengaluru and Hyderabad. The slow growth of some of the largest metropolitans of India shows that the big infrastructure was never meant to cater to the needs of such a huge inflow of migrants. Very little town planning has been involved, so even the existing infrastructure is rapidly crumbling under the weight the multitudes that are flocking to the metros. Gurgaon has been cited as another urban catastrophe by centre for Policy Research. According to its finding, "The Millennium City has walls but no commensurate parking, it is residential hub but lacks proper drainage system and social waste management. The best corporate addresses are located here, yet they run on generators and packaged water and even major roads get water-logged after a few showers."

According to projections made by the Census Department, India will have 87 metropolitan cities in 2039 in which 255 million people will be living. In 2011, India's top ten metropolitan cities had 93 million people and this figure is likely to be 149 million in 2039.

MORPHOLOGY OF INDIAN CITIES

The term 'morphology' has been derived from two Greek words which literally means, "to describe the shape or layout." According to **L.D. Stamp** (1961), "Morphology is the science of form and structure and development which influence the form. **R.E. Murphy** (1966) suggests, "In morphological studies the form elements of the urban area are of chief concern; the arrangement of streets and rail-roads, the form of building, infact, the whole urban landscape." These introductory definitions of morphology help us to conclude that morphology includes three major constituents : (1) internal layout and external shape, (2) internal functional structure or land use and (3) demographic structure. Thus there are three forms of urban morphology. Prof. Enayat Ahmed (1957) has rightly described the urban morphology when he says "from the view point of morphology we are mainly concerned with the ground plan built and aspect of town...... Plan may be viewed from two angles, many concentrate on the internal plan pattern of the town by which is meant the relative arrangements of streets and built-ground. We may also concentrate on the external outline of the plan." In short urban morphology comprises the structure of the city, residential areas, industrial estates, central business district (main market), open space, down town (old city), railways, roads and streets, parks and play grounds, cultural centres water bodies, etc. Prof. Enayat Ahmed has attached great importance to morphology of towns. According to him "The morphological aspect is highly important and diagnostic. As geomorphic landscape is function of structure, process and stage, the morphology of a town is largely the function of site factors, historical viscissitutes, impact of successive cultures and economic settings and development".

Morphology of Indian towns and cities has changed considerably with reference to time and space. In fact no two towns have same morphology and morphology of the same town changes with the passage of time. For sake of simplicity, the morphological study of Indian towns can historically be described in the following three phases :

1. Morphology of Ancient Towns. Most of the ancient towns of India are associated with the Indus Valley Civilization, ample proof of which is available from the excavations of Harappa and Mohenjodaro. Towns of Indus valley civilization has gridiron type of morphology which is also known as chequer board morphology. In this type of morphology, the main streets are parallel to one another and meet at right angles. They are generally oriented north-south and east-west direction and the town is generally of rectangular shape. These roads divide the town into different rectangular blocks of almost equal sizes and buildings are constructed on both sides of the roads. The rectangular plan of the towns was designed to meet the needs some sort of ceremony—religious or secular or both in which the terrace or terraces played a significant role, and to which the professional access was required. This type of morphology can be seen in towns like Ayodhya, Kanchipuram, Lumbini, Madurai, Mathura, Rajgir, Varanasi and Ujjain.

This type of morphology has its merits and demerits. The greater merit is that all the roads receive almost equal amount of air and sun-shine. Since the roads are parallel to and intersect each other at right angles, it requires lots of time and labour to reach from one place to another. Visibility at the road crossings is limited and accidents occur frequently. Sometimes diagonals are used across the rectangles. This provision increases visibility but the shape of buildings is distorted and they often become triangular in shape.

2. Morphology of the Medieval Towns. In majority of the medieval towns, the grid-pattern of the ancient towns was adopted in which forts, city walls, markets, religious places to water bodies and *chowks* were added. This morphology is found in cities of Agra, Ahmedabad, Ahmadnagar, Aligarh, Aurangabad, Bijapur, Bulandshahr, Delhi, Chittaurgarh, etc.

3. Morphology of Modern Towns. Rapid pace of industrialisation and urbanisation in India after Independence gave birth to a large number of new towns and changed the landscape of several pre-existing towns. Large scale migration from rural to urban areas in search of livelihood drastically changed the morphology of the Indian towns. Many old cities became over-crowded and rich people from old cities constructed their houses in the peripheral areas to escape over-crowding in the centre and to enjoy the open environment which the peripheries offered them. The negative impact of rural-urban migration was the growth of slum and squatter colonies in different parts of the cities and disparity between the rich and poor become quite conspicuous. The British rulers built many towns reflecting British architect and after Independence, these towns grew according to Indian architect. Thus, these towns reflect a mixture of British and Indian architect. Unplanned and unchecked growth of some cities has led to degradation of urban life and different parts of such cities are marked by narrow tortuous lanes often with blind curves.

The most outstanding feature of cities built by the Britishers is the Central Business District (CBD). CBD is also known as ***Central Traffic District, Down Town Commercial Core, City Centre*** etc. It lies at the heart of the city where one finds the greatest concentration of offices and retail stores reflected in the city's highest land values and tallest buildings. This is also the chief focus of transport routes. Different floors of the multi-storeyed buildings are used for different purposes. The ground floor is invariably used by the retailers while other floors may be used by wholesalers, offices and even for residential purposes. There is almost a complete absence of independent residential buildings and permanent population. This *area throbs with activity during the day time and is a dead heart at night.* Usually the CBD is at the centre of the city but growth of city in due course of time may result in location of CBD at a place other than its centre. Thus CBD should not necessarily to be located at the centre of the city but should be the business centre of the city. Most of the million cities to have more than one CBD. For example, Connaught Place, Karol Bagh and Chandni Chowk can be treated as three different CBDs of Delhi.

CHIEF CHARACTERISTICS OF CBD

- Dominance of trade
- Concentration of transportation routes
- Concentration of offices
- Multi-storey buildings
- Different use of each floor of multi-storey buildings
- High land values
- High intensity of land use
- Absence of manufacturing industries, residential buildings and permanent population

The British ruler built in or near the pre-existing towns several features such as cantonments, civil lines, educational institution, hospitals, railway colonies, barracks, big bungalows, residential quarters, etc. These were well planed and equipped with modern facilities available at that time. Such structures clearly left the impact of the British architect. Since these towns have both the Indian and the British architect, a greater variety is noticed in their morphology.

Morphology of Allahabad. Located the confluence of the holy rivers of the Ganga and the Yamuna in Uttar Pradesh, this cultural, education and administrative urban centre was known as ***Prayag*** in the ancient time and this name is still popular with many social and religious organisations. Prayag became an important city in the third century B.C. The construction of the present city was initiated by Akbar in the last quarter of the 16th century. However, the actual development of the present city began in the 19th century during the British rule. This city progressed very fast when it became capital of United Provinces of Agra and Awadh in 1858. Establishment of High Court in 1868 further boosted its growth. New colonies come up after Independence and the city expanded considerably. It now covered an area of more than 85 sq km and is the home of more than one million people.

Following are some of the important functional zones of this city (**Fig. 13.23**).

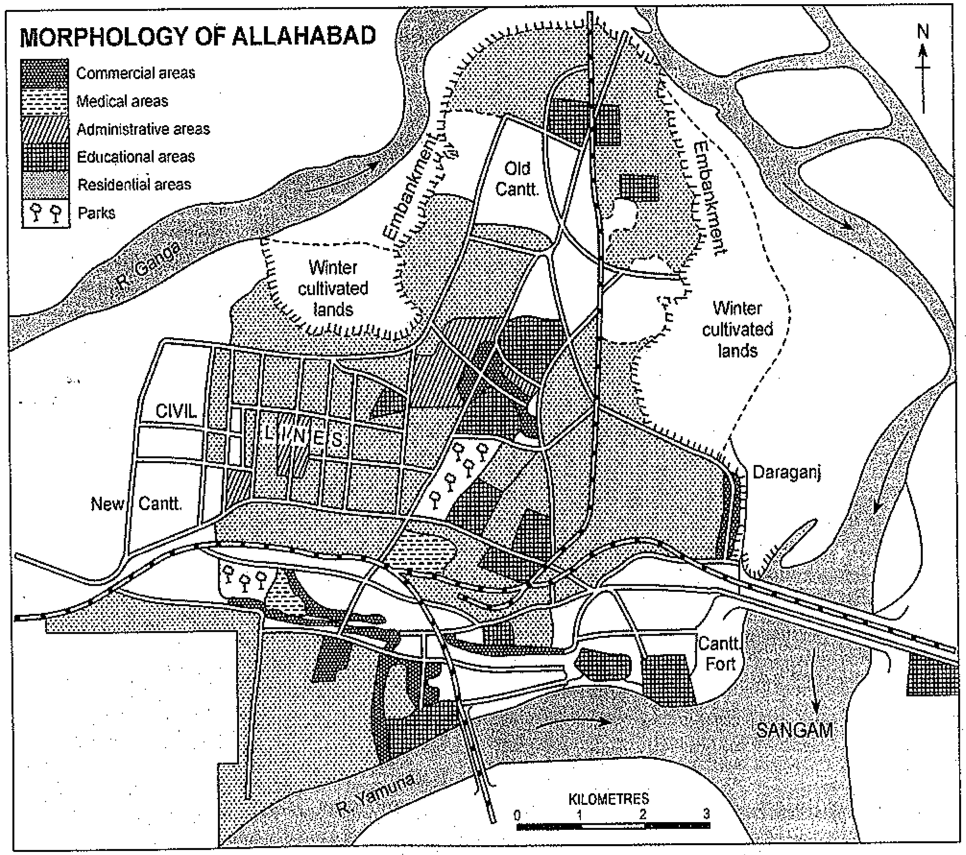

FIG. 13.23. Morphology of Allahabad

1. Commercial Area. Locally known as ***Chowk Area***, the commercial area of Allahabad is located around clock tower (Ghantaghar) along the Grand Trunk (G.T.) Road. This area may be called the Central Business District (CBDF) of Allahabad. Roads radiate in all directions from the Chowk area. Shops and business establishments are located along the roads and in the area between the roads. Civil Lines business area is about 3 km north-west of Chowk area. Another business area, known as ***Katra***, lies at a distance of about 3 km north-east of Civil Lines. The expansion of city has given birth to additional business area like Phaphaman grain market and Transport Nagar. Business areas on a small scale have come up in the residential areas such as Allahpur, Teliarganj, Rajapur, etc.

2. Residential Area. The main residential area of Allahabad is in the old city. This is an over-crowded area with very high density of population. On an average, more than 10 inhabitants live in one house and more than 40 per cent households live in one room only. Some new colonies have been built, particularly between the Ganga and the Yamuna rivers. Of these, Civil Lines is a planned area which provides most of the facilities required for a reasonably good living. However, most of the new colonies have been built in an unplanned and haphazard manner and lack the basic facilities of markets, schools, hospitals, play grounds, parks, parking areas for vehicles, wide roads and open space, community centres, etc.

3. Educational Area. Allahabad holds a position of pride in the field of education, and educational institutes cover a substantial part of urban land-use of the city. Almost all important educational institutes are located in the eastern part of the city extending from Phamphamau in the north to Naini in the south. The major institutions located in this area University of Allahabad, Engineering College, I.E.R.T. Medical College, Purushotam Das Tandon Open University, Agricultural Institute, Indian Institute of Information Technology and a number of degree colleges, intermediate colleges, training institutes and high schools.

4. Administrative Area. Allahabad is an important centre of administration where several offices of the state and central government are located. The main administrative area lies in the western part of the Civil Lines. This area hosts the Allahabad High Court, Board of Revenue, Offices of the Accountant General, Director of Education, Intermediate Board, Higher Education Commission, etc. Some of the administrative areas are in the northern and eastern sides of old city also. Besides, these are offices of Nagar Nigam, Divisional Police Superintendent, P.W.D., etc. Main branch of State Bank of India is also located here. Some of the district level offices are also located here.

5. Industrial Area. Allahabad proper does not have well defined industrial area although some industries are located in Naini, in the trans-Yamuna area. Some of the important industries located here are glass, textiles, telephone. Ayurvedic medicine, machines and tool making. In the Multhiganj and Chowk areas, there are food processing industries such as pulse mills, flour mills, oil mills, etc. A considerable number of printing press industries are scattered in different parts of the city.

FUNCTIONAL CLASSIFICATION OF INDIAN CITIES

No two cities are identical in the world. All cities are different from one another with respect to their size, location, population, architect and function. Cities can be classified on the basis of their size, location, population, morphology, formation, etc. But from the geographic point of view, functions performed by a city are of paramount important for classifying cities. According to **R.E. Dickinson**, "Functions are the driving force of city life, and influence to a very large extent its growth and morphology. It is the function of the town, rather than its size, which provides some basis for comparison.

Classifying cities on the basis of their functions is a very difficult task because people performing different functions live in almost all the cities. Cities are often classified on the basis of the most important function performed by them. For example, Chandigarh is an administrative city, while Gurgaon is an industrial city and Kurukshetra is a city of religion, culture and education. But this type of classification is not based on some scientific method, rather it is based on general observation. There is need to apply some scientific methods so that a clear picture of functional classification of cities emerges.

Methods used to classify towns on the basis of functions performed by them are categorised into following three classes :

1. Empirical or Qualitative Methods
2. Empirical-cum-Statistical Methods
3. Pure Statistical or Quantitative Methods

1. Empirical or Qualitative Methods

This category of methods denote the initial stage for classifying urban centres on the basis of their functions. M. Aurousseau (1921) was perhaps the first to use empirical method and recognised six classes of towns according to their functions described as under :

1. **Administration Towns :** Capital cities and revenue towns.
2. **Defence Towns :** Fortress, garrison, and naval towns.
3. **Cultural Towns :** University, cathedral, art, pilgrimage and religious towns.
4. **Production Towns :** Manufacturing towns.
5. **Communication Towns :** Collection, transfer and distribution towns.
6. **Recreation Towns :** Health resorts, tourist resorts, holiday resorts and hill stations.

Following Aurousseau, R.D. Mackenzie (1925) classified American communities into four broad categories : (*i*) primary service community, (*ii*) commercial community, (*iii*) industrial community, and (*iv*) other communities.

James divided Indian towns into six categories : (1) capital towns, (2) religious centres, (3) army centres, (4) market, (5) industrial towns, and (6) port towns. **V. Nath** divided Indian towns into eight categories in his essay on "Urbanization in India with special reference to Growth of Cities." But this division was based on the economic aspect of towns.

2. Empirical-cum-Statistical Methods

Also known as Semi-quantitative methods, these methods are mixture of empirical or qualitative methods on one hand and pure statistical or quantitative methods on the other hand. As such, these methods symbolize a transition phase between the earlier empirical and later quantitative methods.

Ogburn (1937), presented a functional classification of towns on the basis of percentage of population engaged in trade, manufacturing and transportation. **Chancy D. Harris** (1943) presented "A Functional Classification of Cities of the United States" in which he recognised nine functions performed by towns. He argued that all cities were more or less multi-functioal and based his classification of the cities on the function of the greatest importance. Each of the nine principal types was designated by a latter : (*i*) Manufacturing cities (M' and M), (*ii*) Retail centres (R), (*iii*) Diversified cities (D), (*iv*) Wholesale centres (W), (*v*) Transport centres (T), (*vi*) Mining towns (S), (*vii*) University towns (E), (*ix*) Resort and retirement towns (X), (*x*) Other towns including political (P). He fixed varied minimum percentages of workers for different functional groups. For example, a city was considered ***manufacturing*** if atleast 60 per cent of the total employees are engaged in manufacturing. For retail centre at least 50 per cent of the total employment should be in retail business. If the employment is less than 60% in manufacturing, 20% in wholesale and 50% in retail, the town is considered to be multi-functional.

Harris method was followed with some modifications by **Kneedler Ohlson** (1945), Victor Jones (1954) and Hart (1955).

The greatest disadvantage of these methods is that the parameters adopted are arbitrary and are not applicable in all the circumstances.

3. Pure Statistical or Quantitative Methods

As their name indicates, these methods are dependent purely on statistical analysis and are used for each type of cities. Statistical methods are fixed, reliable and easy to understand and have become very popular by virtue of these qualities. Although attempts to use these methods were made earlier also, the first popular attempt was made by **L.L. Pownall** in 1953 for studying the functions of New Zealand towns. He classified towns into six functional groups : (*i*) manufacturing, (*ii*) building and construction, (*iii*) primary industry, (*iv*) transport and communications, (*v*) distribution and financial, and (*vi*) personal services.

The most popular scheme was put by **Howard J. Nelson** when he present his scheme, "A Service

Classification of American Cities" in 1955. He based his classification on the data derived from the 1950 census and selected 897 towns each with population over 10,000. He recognised 24 different activities and divided them into 9 major functional groups. The percentage of the total labour force in each of the 897 cities was calculated and thus, arithmetic mean was determined for each functional group for all the cities together. The average employment in different groups ranged from 1.62 per cent for mining to 27.07 per cent for manufacturing. He selected **standard deviation (S.D.)** and calculated S.D. from the mean for each of the nine functional groups. In this way cities were grouped in their appropriate categories : Nine functions recognised were (*i*) mining, (*ii*) manufacturing, (*iii*) transport and communication, (*iv*) wholesale trade, (*v*) retail trade, (*vi*) finance, (*vii*) insurance and real estate, (*viii*) personal service, and (*ix*) professional service and public administration.

Contribution of Indian Geographers

Indian geographers have made their own contribution in classifying Indian cities. Some of the outstanding contributions are briefly described as under :

V.A. Janki (1954) in essay on "Functional Classification of Urban Settlements in Kerala" divided urban settlements into five categories : (*i*) Administration Towns, (*ii*) Commercial and Industrial Towns, (*iii*) Trade Towns (centre for collection and distribution of agricultural products), (*v*) Religious Towns and (*v*) Plantation Towns. Following Nelson **Kashi Nath Singh** (1959) presented "Functional Classification of Towns of U.P. in which many towns remained unclassified the to shortcomings in the methodology. **Amrit Lal** (1959) adopted a new technique while presenting his essay on "Some Aspects of Functional Classification of Cities and Proposed Scheme of Classifying Indian Cities." He used location quotient (LQ) method for functional classification of Class I cities of India and concluded that most of Class I cities of India are multifunctional. **V.L.S. Prakash Rao** (1965) used "Least Square Regression" method for classifying towns. **A. Ramesh** (1965) adopted Nelson's method for classifying towns of Tamil Nadu. **Quazi Ahmed** (1965) used 62 variables for classifying 102 Indian cities according to functions performed by them. **S.M. Raffullah** (1965) adopted a new technique and methodology and suggested that cities perform not one function but many functions simultaneously. Therefore, cities should be classified not on the basis of just one function, rather the classification should be based on a number of functions performed by the cities. He suggested that functions can be categorised into a number of classes : (*i*) Monominal function, (*ii*) Binominal function, (*iii*) Trinominal function, (*v*) Quadrinominal function, and (*v*) Polynominal function. **M.P. Saxena** (1966) presented a new formula for classifying towns of the Yamuna-Hindon region. He based his classification on Census 1961 data and divided the functions into nine classes and presented four combinations of those nine classes. They are: (*i*) primary, (*ii*) trade, (*iii*) industry and (*iv*) miscellaneous. **Onkar Singh** (1967) also used 1961 Census data and expressed the view that urban function are : (*i*) isolated and (*ii*) integrated. He used the functional index and specialisation index as explained below :

$$\text{Functional Index} = \frac{P \times P}{MP}$$

$$\text{Specialisation Index } \sum \left[\frac{P \times P}{MP}\right] \div 100$$

where P = No. of workers in a particular function in the city

MP = No. of workers in a particular function in all the cities.

Om Prakash Singh (1968) followed Nelson's method for classification of towns of Uttar Pradesh. He introduced following two formulae :

(*i*) Functional Specialization Index or F.S.I.

$$= \frac{Cs \times 100}{Rs} \times Mf$$

(*ii*) Functional Centrality Index or F.C.I.

$$= \frac{Cf \times 100}{Rf}$$

where Cs = Total population of the town

Mf = Mean functional percentage of the function of all towns in the region

Rs = Total population of the region

Rf = Population of the region engaged in the same function.

Ashok Mitra (1971) also used 1961 Census data for classifying towns of India. Census of India gives details of population engaged in nine different types of functions. Ashok Mitra excluded first two functions in his classification of towns because they are concerned with agriculture and agricultural labourers which are purely rural functions. He considered the remaining seven functions *viz.* (3) lumbering, fishing, mining, plantation, (4) house-hold industry, (5) manufacturing industry, (6) construction, (7) trade and commerce, (8) transport and communication, and (9) service. Considering the number of people engaged in these seven functions to be 100, calculation for people engage in each function was made. Based on these calculations he classified 2462 towns/cities of India. According to his findings 83 were mining and plantation towns, 496 were household industry towns, 374 were manufacturing towns, 24 were construction towns, 244 were trade and commerce towns, 78 were transport towns and 1163 were service towns.

V.P.P. Sinha (1976) recognised the significance of regional elements while classifying the towns of the Chhotanagpur Plateau. **R.N. Singh** and **Saheb Deen** (1976) successfully removed the shortcomings of Nelson's method in their essay entitled "A Functional Typology of Urban Centres of Eastern Uttar Pradesh." **Ram Pyare** (1980) followed more or less similar methodology in his article entitled "Functional Classification of Towns of Bundelkhand." Like Ashok Mitra he based his classification on nine functions suggested by Census of India and used the Functional Specialization Index (Si) = 100 *e*/*w* where *e* is the number of people engaged in one function and *w* is the number of total workers in the town. Based on his calculations, he classified 37 towns of Bundelkhand. He used index for different classes of towns explained as follows : A = Agriculture, M = Mining, H = House-hold industry, Mf = Manufacturing, C = Construction, Tc = Transport and communication, T = Trade.

On the basis of different methodologies suggested by different scholars, following simple functional classification of Indian cities is suggested :

1. Administrative Cities. The main function of an administrative city/town is to administer a given area which may be a district, a state or the whole country. From this point of view all the state capitals in India are administrative cities. Some of the district headquarters may also fall in the category of administrative city. In India, New Delhi is the largest administrative city because it is the capital of the whole country. At the state level, Chandigarh, Bengaluru, Chennai, Hyderabad, Jaipur, Lucknow, Mumbai, Patna, Bhopal, Gandhinagar, Itanagar, Dispur, Jaipur, Aizawl, Kohima, Raipur, Panaji, Ranchi, Thiruvananthapuram, Imphal, Shillong, Shimala, Bhubaneshwar, Gangtok, Agartala, Kolkata are important administrative centres.

2. Production Centres. Cities/towns associated with industrial production are often referred to as production centres. Since they are concerned with industrial production they are popularly known as ***industrial cities/towns***. These towns are well connected with their surrounding areas because industries depend on raw materials and transport facilities. Indian industries have progressed a lot after Independence and a large number of industrial towns have come up in the post-Independence era. Ahmedabad, Jamshedpur, Durgapur, Rourkela, Bhilai, Bokaro, Bhadravati, Sindri, Coimbatore etc. are important industrial towns of India.

3. Transport Centres. These centres develop at the following locations :

(*i*) Where rail transport ends and road transport starts. Most of such towns are located up the foothills of the Himalayas. Kalka, Rishikesh, Kotdwar, Kathgodam, Tanakpur are examples of such towns.

(*ii*) Where sea route ends and inland water or land route starts. These towns have facilities of loading and unloading and are equipped with godowns. Mumbai, Kolkata, Chennai, Kandla, Calicut, Vishakhapatnam etc. are cities of this type.

(*iii*) Where inland transport routes converge for example Agra, Dhulia, Mughalsarai, Itarsi, Katni, etc.

4. Trade Centres. Trade centres primarily depend upon trade for their growth. India has hundreds of big and small towns/cities which can be termed as ***trade centres***. Small towns depend on agricultural commodities and develop as grain markets. Big cities carry on various types of trade. Mumbai is the largest trade centre and is known as the '*Commercial Capital*' of the country. Kolkata, Chennai, Bengaluru, and a large number of other cities are popular as trade centres.

5. Mining Towns. Many towns have developed due to mining and are known as ***mining towns***. For example, Jharia, Raniganj, Singrauli, etc. have developed due to coal mining. Digboi, and Ankleshwar due to oil drilling and Khetri due to copper mining.

6. Defence Towns. The main function of defence towns is to provide security and arrange for defence of the country. In the mediaeval period Mughals and Rajputs had built castles for defence purposes, and those castles developed into towns at a later stage. Chittaurgarh, Ajmer, Jodhpur, Ranthambhor, Gwalior, Chanderi etc. are example of fort towns. If a town has '*garh*' attached to its name, then if must be fort town because 'garh' in Hindi is used for a fort.

Latter on British rulers had set-up a large number of contonments for defence purposes. Then came the age of air battles and air-fields in various parts of the country were built. In addition harbours and navel headquarters were also built to strengthen the defence preparedness of the country. Ambala, Jalandhar, Ferozepur, Meerut, MOHO, Pathankot, Udhampur, Adampur, Halwara, Jamnagar, Vishakhapatnam, etc. are some of the examples of defence towns.

7. Education Centres. Some towns grow due to educational facilities and become popular because they import quality education. Roorkee, Varanasi, Aligarh, Pilani, etc. are famous as educational centres.

8. Religious and Cultural Centres. Some towns/cities are famous for religious, culture and spirituality and attract devotees even from far-off places. Even during the ancient period, towns have been built around religious places like temples, mosques and churches. Some towns have come-up near *gurudwaras* also. Some of the major places of religious importance are Hardwar, Rishikesh, Mathura, Vrindavan, Allahabad, Varanasi, Dwarka, Rameshwaram, Ayodhya, Badrinath, Kedarnath, Kurukshetra, Ajmer, Pushkar, Nashik, Amritsar, Bodh-Gaya, etc.

9. Tourist Resorts. Tourist resorts are generally located in areas of healthy climate, natural beauty or some man-made features which provide facilities for enjoyment, fun and sports. Such places are usually found in hilly areas or on the bank of a water body. Among the hill stations, Srinagar, Pahalgam, Gulmarg, Dalhousie, Dharamsala, Leh-Ladakh, Kullu, Manali, Nainital, Darjeeling, Gangok, Shimla, Ooty, Mt. Abu, Panchmadhi, Ranikhet, Khandala, Matheran, Mahabaleshwar, etc. are important. On the sea coast of India there are beautiful beaches at Gopalpur, Chennai, Goa, and Mumbai.

10. Residential Towns. Some of the town are developed with the primary purpose of providing residential accommodation to urban people. A large number of colonies and satellitic towns have been built to accommodate the growing population of big cities like Delhi, Mumbai, Kolkata, Chennai, Bengaluru, Hyderabad, etc. Panchkula and Mohali near Chandigarh and Partapur near Meerut are primarily residential towns.

11. Seaports. Seaports are developed to facilitate imports and exports. Kandla, New Mangalore, Kochi, New Tuticorin, Paradweep etc. are some of the examples of seaports.

12. Multifunctional Cities. Most cities of India are performing more than one or two functions simultaneously and are termed as multifunctional cities. For example a capital city may also be a centre for trade and commerce, industry, transport, tourism, Big cities like Delhi, Mumbai, Kolkata, Chennai, Bengaluru, Hyderabad, etc. are performing highly diversified functions and are known as multifunctional cities.

CONURBATIONS

As mentioned earlier in this chapter, the term conurbation was coined by Patrick Geddes in 1915 for an extensive urban area, usually resulting from the coalescence of several originally separate expanding towns or urban nuclei. This coalescence is usually along the main inter-urban transport routes. The term conurbation perhaps has been formed by compounding two words 'continuous' and 'urbation'. Thus a conurbation means a continuous stretch of urban development over a considerable area. According to **Mayer and Kohn** (1967), "Tentacles of urbanization, in many areas, have reached towards one another, and numerous cities have converged into larger masses, conurbation or megalopolitan concentrations. **C.B. Fawcett** devoted much attention

to the studies of conurbation during his studies of population of Britain on the basis of 1921 and 1931 census figures. According to his definition "A conurbation is an area occupied by continuous series of dwellings, factories and other buildings, harbours and docks, urban parks and playing fields etc., which are not separated from each other by rural land; though in any cases in this country such an area includes exclosures of rural land which is still in agricultural occupation."

Currently different expressions are used to express large urban area in view of the rapidly increasing urban sprawl. These terms are ***'urban agglomeration', 'urban aggregate', 'urban complex', 'metropolitan area', 'megalopolis', 'metropolitan labour area', 'conglomeration', 'urban region', 'town aggregate', 'urban tract'***, etc. However, the term conurbation is commonly used only for that group of contiguous towns or cities which are under separate civic administrations.

Process of formation of conurbation. Conurbation is an indication of climax in the growth of an urban area. There is rapid growth of industries, trade, transportation and economic activities with the development of science and technology and growth as well spread of urban areas is a natural sequel. Interaction between two neighbouring cities increases and distance between them is reduced. There comes a time when continuity between the neighbouring cities is complete and there is practically no agricultural rural land in-between them. Normally a conurbation is formed under the following three situations :

1. When only one city expands and encompasses the neighbouring rural and urban areas, for example London.
2. When two neighbouring cities expand and meet each other leaving practically no open space between the two, for example Hyderabad-Secunderabad and Kolkata-Haora.
3. When more than two cities expand and meet one another, for example Delhi, Faridabad, Ballabhgarh, Palwal, Gurgaon, NOIDA.

A.E. Smailes has termed these conurbations as uninuclear, binuclear and polynuclear (**Fig. 13.24**).

The world's first and the largest conurbation is in the eastern sea-board of the USA which represents the

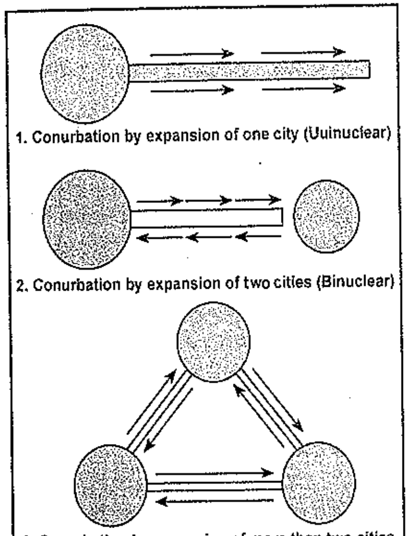

FIG. 13.24. Origin and Growth of Conurbation

coalescence of million cities of Portland, Boston, New Haven, New York, Philadelphia, Baltimore, Washington D.C., New Port, Columbia, Richmond and Columbus.

Conurbations in India

With only 31.16 per cent of her total population as urban as per 2011 census figures, India is considered to be one of the least urbanised countries of the world. But her massive urban population of over 377 millions is more than the total population of any country of the world except that of China and India boasts of her 53 million cities. As such, it is but natural to expect the growth of conurbations in different parts of the country. One such conurbation has developed in West Bengal along the banks of the Hugli river where Kolkata is the main city. Most of the cities of this conurbation are based on jute industry. Most of the jute mills of West Bengal are located in a narrow belt about 100 km long and 3 km wide. Besides Kolkata, Haora, Titanagar, Jagatdol, Budge Budge, Bhadreshwar, Rishra, Bansbaria, Shamnagar, Naihati, etc. are other important cities of this conurbation (**Fig. 13.25**). Group of experts making geographical study of this conurbation have taken into account the administrative units while demorcating the boundaries of the conurbation. This group has also considered the villages located in the non-municipal corporation for this purpose. Accordingly Kolkata conurbation embraces 30 municipal corporations, 2 corporations, 2 contonment areas and 2 areas without contonment spread in four districts.

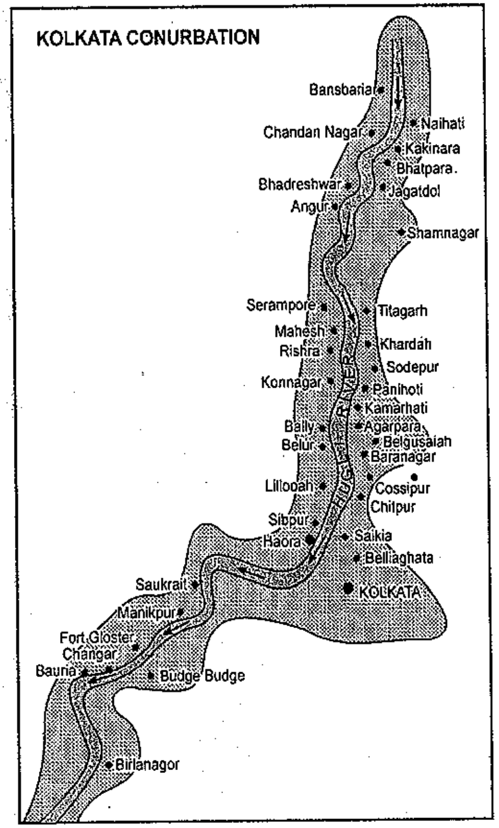

FIG. 13.25. Kolkata Conurbation

A similar conurbation is coming up in the north-western part of India. It extends from Agra in the south to Delhi in the north. At Delhi it is bifurcated into two branches. One branch goes via Meerut and Muzaffarnagar to Saharanpur in U.P. and to Dehra Dun in Uttarakhand while the other branch goes to Ambala in Haryana. At Ambala it is further bifurcated in two sub-branches, one sub-branch goes to Amritsar through Ludhiana and Jalandhar and the second sub-branch goes to Chandigarh and Kalka. Currently these cities/towns appear to be at certain distances and some agricultural land is also seen between them. But these towns/cities are fast spreading and are likely to form a very big conurbation in the near future (**Fig. 13.26**)

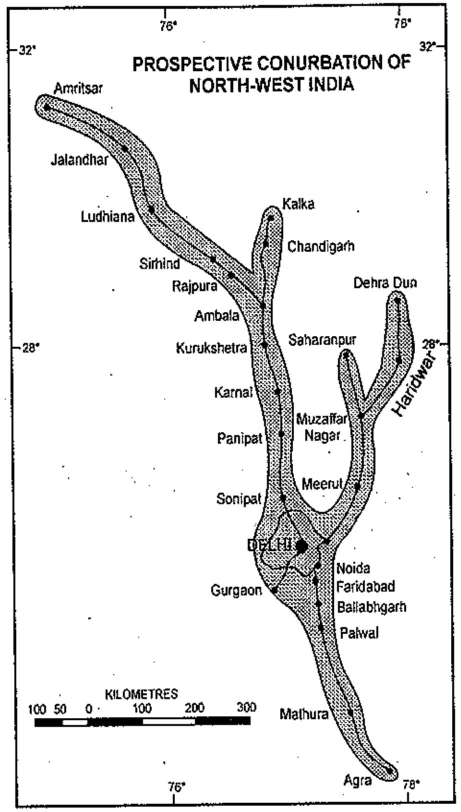

FIG. 13.26. Prospectus Conurbation of North-west India

Problems of Conurbation

1. Most of the conurbations are growing at an alarming rate and the growing population puts great pressure on the urban infrastructure. The basic facilities are not available to the people and life in conurbation is less enjoyable and more tense.
2. There is unplanned growth of urban areas due to large scale rural to urban migration of the people. This process creates lots of problems for the urban people.
3. Most of the people who migrate from rural to urban areas are unskilled and semi-skilled who often fail to find a reasonably good place to live in. Consequently there is rapid growth of slums and squatters and life becomes miserable in these areas.
4. There are growing trends of poverty, unemployment, insecurity and crimes among the conurbation dwellers due to rapidly increasing population.
5. Sphere of influence of the neighbouring cities/towns often overlap which creates serious problems of administration. Criminals cross the territory of sphere of influence of one city and enter the sphere of another city. Thus taking proper action against the criminals becomes difficult.
6. Because of large size and high population density of conurbation, there is always shortage of water, electricity as well as facilities of transport, sewer, open space and the problem of environmental pollution becomes acute.

Metropolitan Regions of India

Metropolitan region is a vast urbanised region which consists of a large city and its surrounding or accompanying towns or suburbs. It is till now an obscure, unclear and loosely used term because no precise parameters have been fixed to define and delineate such regions in India. However, this term is used in the U.S.A. which may be treated as equivalent to a conurbation.

Three metropolitan cities of India, namely Mumbai, Kolkata and Chennai were developed on the Indian sea coast by the British rulers for their own benefit. They used these three cities as ports for international trade. Britain used to carry raw materials from India to Britain and send back the manufactured goods from Britain to India. As a result of the trade benefits, these three port cities become the economic hubs of the country in the beginning of 19th century and ruled over the economic scene of the country till the beginning of 20th century. In the year 1911, the British rulers shifted British India's capital from Kolkata to New Delhi and this city soon became the largest centre of political, economic and social activities in India. In fact Delhi recorded the growth rate which was much faster than any other large city of India and today it overshadows the remaining three coastal metropolitan cities of the country. Thus, at present there are four metropolitan cities in India which together, account for over 85 per cent of the richest people of the country. They cover all the four directions of the country. In the north is Delhi, in the south there is Chennai, the west is dominated by Mumbai and east is served by Kolkata. These four cities are indicators of India's accelerated rate of urbanisation and economic growth. The areas of influence of these four major cities are determined on the basis of the following four parameters and are shown in **Fig. 13.27.**

1. Air travel.
2. Railway passengers and commodity flow.
3. Long distance telephone calls.

However, the landline phones have lost much of their relevance as the mobile phones are becoming more popular.

1. Delhi. Being the capital of India, Delhi is the largest centre of politics and administration. Its economic influence is also felt over large areas of north-western and in some parts of central India. It covers the whole of Jammu and Kashmir, Punjab, Haryana, Himachal Pradesh, Uttarakhand and large parts of Rajasthan, Madhya Pradesh and Uttar Pradesh.

2. Mumbai. This is the largest city of India and is popular as the commercial capital of the country. This metropolitan region covers the whole of Maharashtra, Gujarat and Goa, southern part of Madhya Pradesh and contiguous parts of Chhattisgarh, Karnataka and Rajasthan.

3. Kolkata. This is the first city which was developed by the East India Company and remained the capital of British India upto 1911. This was the first city of India to cross one million mark at the time of 1901 census and remained the largest city of India till 1981 after which it was superseded by Mumbai. The Kolkata metropolitan region covers most parts of East India which encompasses all the north-eastern states (Sikkim, Assam, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Bihar, Jharkhand, West Bengal, Odisha and eastern parts of Uttar Pradesh and Chhattisgarh.

4. Chennai. Chennai is the fourth largest city of India which is on the eastern coast of the peninsular India. Its metropolitan region covers five southern states of Tamil Nadu, Andhra Pradesh, Telangana

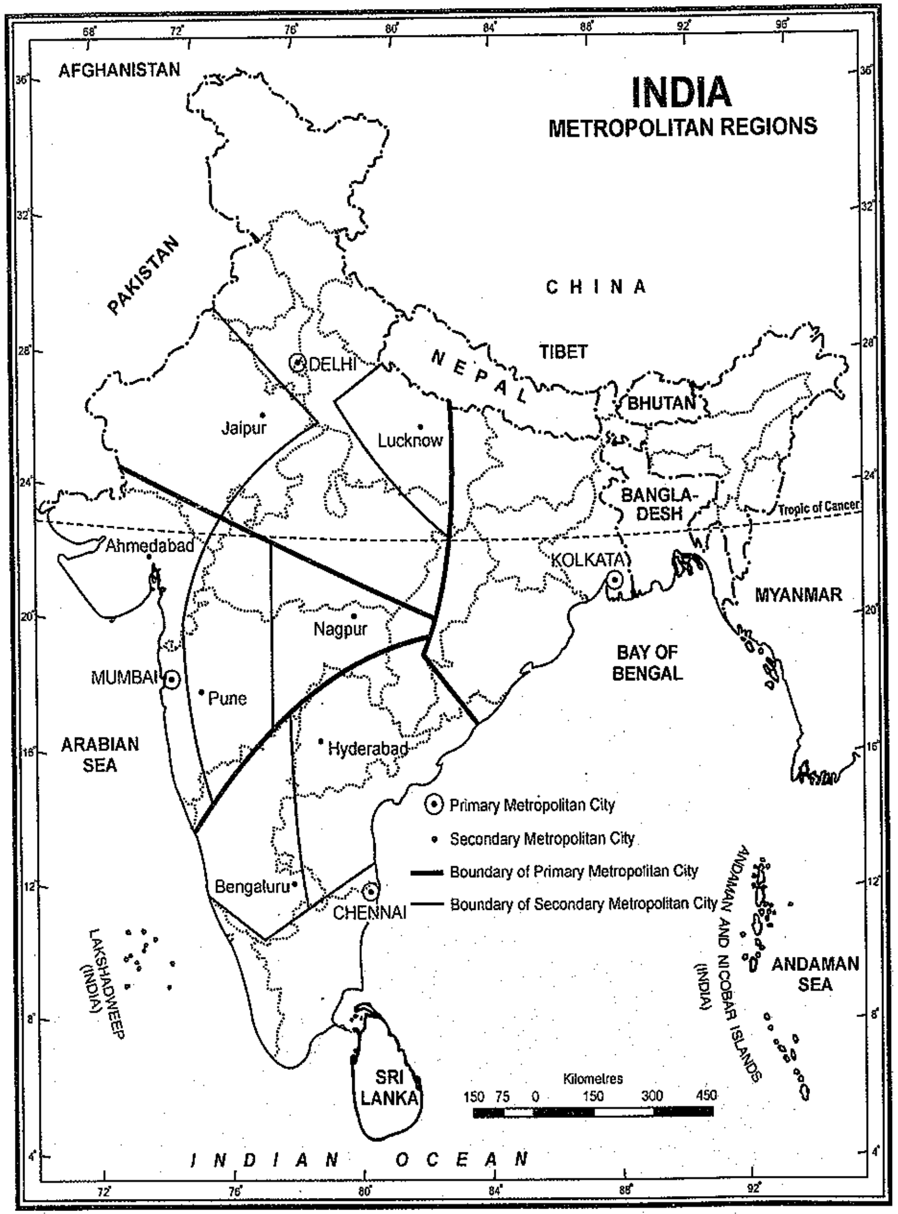

FIG. 13.27. India : Metropolitan Regions

Karnataka and Kerala as well as southern tips of Chhatisgarh and Odisha.

Within the above mentioned four primary metropolitan areas, there are several secondary metropolitan areas also. For example Delhi primary metropolitan area has Lucknow and Jaipur secondary metropolitan area. Similarly Mumbai has Nagpur, Pune and Ahmedabad, and Chennai has Bengaluru and Hyderabad secondary metropolitan areas (**Fig. 13.27**)

Urban Sprawl

Growth in population and areal expansion of a city in the countryside is known as ***urban sprawl.*** Almost all the cities of the world grow, both with respect to population and area with the passage of time making urban sprawl more or less a continuous process. Following three factors are responsible for urban sprawl.

1. Natural growth of population (difference between birth rates and death rates).
2. Large scale migration of the people from rural to urban areas.
3. Migration of the people from small towns to big cities.

The above mentioned three factors cause rapid increase in population and area of cities and often these factors work in combination. However, there are temporal and spatial variations in the relative importance of these factors. In certain cities, natural growth of population may be the dominating factor but in most of the cities it is the migration of the people from rural to urban areas which plays a significant role in the process of urban sprawl.

The first large flow of migration from rural to urban areas was during the "depression" of late 1930s when people migrated in search of jobs. Later, during the decade 1941-51, another one million persons moved to urban places in response to wartime industrialisation and partition of the country in 1947. During 1991-2001, well over 20 million people migrated to cities. The greatest pressure of the immigrating population has been felt in the central districts of the city (the "old city") where the immigrants flock to their relatives and friends before they search for housing. Population densities beyond the "old city" decline sharply. **Brush** (1968) has referred to this situation in the central parts of the cities as ***"urban impulsion"*** which results from concentration of people in the centre of the city close to their work and shopping. Incidentally many of the fastest growing urban centres are large cities. This is due to the fact that such large cities act as magnets and attract large number of immigrants by dint of their employment opportunities and modern way of life. Such ***hyperurbanisation*** leads to projected cities sizes of which defies imagination. Delhi, Mumbai, Kolkata, Chennai, Bengaluru, etc. are examples of urban sprawl due to large scale migration of people from the surrounding areas.

In several big cities wealthy people are constantly moving from the crowded centres of the cities to the more pleasant ***suburbs*** where they can build larger houses and enjoy the space and privacy of a garden around the house. In some cities, the outskirts are also occupied by squatters who build makeshift shacks on unused land although they have no legal right to the land. The difficulty of restricting town growth in either case is immense and most

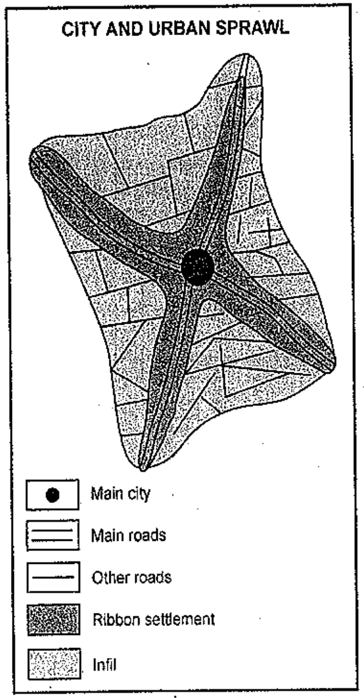

FIG. 13.28. Urban Sprawl

towns and cities are surrounded by wide rings of suburbs.

Historically suburbs have grown first along the major roads leading into the town. This type of growth is known as ***ribbon settlement.*** Such sites are first to be developed because of their location near the road gives them greater accessibility. But soon the demand for suburban homes causes the land between ribbon settlements to be built and made accessible by constructing new roads. This type of development is known as ***'infil'.*** Simultaneously small towns and villages within the commuting distance of major cities are also developed for residential purposes. In this way towns are continuously growing and in some areas the suburbs of a number of neighbouring towns may be so close together as to form an almost continuous urban belt which is called ***conurbation.*** Urban sprawl is taking place at the cost of valuable agricultural land.

Urban sprawl has its own advantages and disadvantages. Whereas urban sprawl provides livelihood and shelter to lakhs of people, the problems created by urban sprawl are complicated and solving such problems is an uphill task. Some of the problems created by urban sprawl are briefly described below :

1. Urban sprawl is generally caused by large scale immigration which leads to steep rise in land prices. People with moderate income are unable to afford high land prices and their life becomes troublesome.
2. There is heavy pressure of population on the infrastructure facilities such as water, electricity, transport, sewerage, education and health services, etc. and people have to face multiple problems in their daily life.
3. Most immigrants come to big cities in search of jobs. They often fail to find suitable jobs and add to the problem of unemployment.
4. Slums and squatter settlements come up in different parts of cities. This leads to environmental degradation and lower standard of living.
5. Unemployment, particularly among the youngsters, leads to several social evils like thefts, decoities, kidnappings, murders, rapes, etc. which creates many problems for the common man.
6. Valuable fertile agricultural land is encroached upon by urban sprawl.
7. Increasing urbanisation is also associated with industrialisation and both of them lead to environmental degradation and environmental pollution.

Slums and Squatter Settlements

The natural sequel of unchecked, unplanned and haphazard growth of urban areas is the growth and spread of slums and squatter settlements which present a striking feature in the ecological structure of Indian cities, especially of metropolitan centres.

The rapid urbanisation in conjunction with industrialisation has resulted in the growth of slums. The proliferation of slums occurs due to many factors, such as, the shortage of developed land for housing, the high prices of land beyond the reach of urban poor, a large influx of rural migrants to the cities in search of jobs etc. In spite of several efforts by the Central and State Governments to contain the number of slum dwellers, their growth has been increasing sharply exerting tremendous pressure on the existing civic amenities and social infrastructure.

In India slums have been defined under section 3 of Slum Areas (Improvement and Clearance) Act 1956 as

(*i*) Area in which buildings are of poor quality.

(*ii*) Area in any respect unfit for human habitation.

(*iii*) Area by reason of dilapidation, overcrowding, faulty arrangement and design of such buildings, narrowness or faulty arrangement of streets, lack of ventilation, light, sanitation facilities or any combination of these factors, which are detrimental to safety, health and morals.

The following criteria characterises an area as slum :

(*i*) All areas notified "Slum" by state govt. under any Act.

(*ii*) All areas recognised as slum by state govt. which have not been formally notified as slum under any Act.

(*iii*) A compact area of at least 300 population or about 60-70 households of poorly built congested tenements in unhygienic environment usually with inadequate infrastructure and lacking in proper sanitary and drinking water facilities.

Census of India defines a slum as "residential areas where dwellings are unfit for human habitation" because they are dilapidated, cramped, poorly ventilated unclean or "any combination of these factors which are detrimental to safety and health."

Socially, slums tend to be isolated from the rest of the urban society and exhibit pathological social symptoms (drug abuse, alcoholism, crime, vandalism and other deviant behaviour). The lack of integration of slum inhabitants into urban life reflects both, the lack of ability and cultural barriers. Thus the slums are not just huts and dilapidated buildings but are occupied by people with complexities of social-networks, sharp socio-economic stratification, dualistic group and segregated spatial structures.

In India, slums are one or two-room hutments mostly occupying government and public lands. The houses in slums are built in mud or brick walls, low roofs mostly covered with corrugated sheets, tins, bamboo mats, polythenes, gunny bags and thatches, devoid of windows and ventilators and public utility services. Slums have invariably extreme unhygienic conditions. They have impoverished lavatories made by digging shallow pit in between three or four huts and with sackcloth as a curtain, hanging in front. When the pit overflows excreta gets spread over the surrounding area and is rarely cleaned. The children cultivate the habit of defecating anywhere in the slum area. Slums have practically no drains and are marked by cesspools and puddles. Piped water is not available to slum dwellers and they mainly depend upon shallow handpumps for water supply. Such handpumps are generally dug in the middle of a stale dirty pool. People wash their clothes and utensils under the handpumps. The entire muck around the handpump percolates into the ground and contaminates the ground water. This contaminated ground water is taken out through the handpump which adversely affects the health of the slum dwellers. Consequently people suffer from water-borne diseases like blood dysentery, diarrhoea, malaria, typhoid, jaundice, etc. These diseases stalk the people all the year round. Children with bloated bellies or famished skeletons, many suffering from polio, are a common sight. Most of the slums are located near drains (*Nullahs*) which contain filthy stagnant water. Billions of flies and mosquitoes swarming over these drains cause infectious diseases. These drains are used as open lavatories by the inhabitants and are always choked. Such drains (*Nullahs*) pose serious threat to health of the people.

Slums are known by different names in different cities. They are called *bustees* in Kolkata, *jhuggi-jhoparies* in Delhi, *Jhoparpattis* or *Chawl* in Mumbai and *Cheri* in Chennai.

Squatter Settlements

No clear-cut distinction can be drawn between slums and squatter settlements in practice except that slums are relatively more stable and are located in older, inner parts of cities compared to squatter settlements which are relatively temporary and are often scattered in all parts of the city, especially outer zones where urban areas merge with their rural hinterland. Normally, squatter settlements contain makeshift dwellings constructed without official permission (*i.e.*, on unauthorised land). Such settlements are constructed by using any available material such as cardboards, tin, straw mats or sacks. Squatter settlements are constructed in an uncontrolled manner and badly lack essential public services such as water, light, sewage. Such an environment leads to several health problems. Determining size of squatter settlement is a difficult job. Some may occur singly or in small groups of 10-20 dwellings while others occur in huge agglomerations of thousands of houses. They can occur through organised rapid (almost overnight) invasions of an area by large number of people or by gradual accretion, family by family.

Squatter settlements have following three characteristics in common.

Physical Characteristics : Due to inherent 'non-legal' status, a squatter settlement has services and infrastructure below the adequate minimum levels. As such water supply, sanitation, electricity, roads, drainage, schools, health centres, and market places are either absent or arranged informally.

Social Characteristics : Most of the squatter households belong to lower income group. They are predominantly migrants, but many are also second or third generation squatters.

TABLE 13.9. Number of Town and Households—2011

State Code	India/State/ Union territory #	Number of towns			Urban households	Slum households	
		Total	Statutory	Slum reporting		Absolute	Percentage
1	2	3	4	5	6	7	8
	INDIA	7,933	4,041	2,543	78,865,937	13,749,424	17.4
01	Jammu & Kashmir	122	86	40	517,168	96,990	18.8
02	Himachal Pradesh	59	56	22	166,043	14,240	8.6
03	Punjab	217	143	71	2,094,067	296,482	14.2
04	Chandigarh #	6	1	1	228,276	22,080	9.7
05	Uttarakhand	115	74	31	592,223	89,398	15.1
06	Haryana	154	80	75	1,751,901	325,997	18.6
07	NCT of Delhi #*	113	3	22	3,261,423	383,609	11.8
08	Rajasthan	297	185	107	3,090,940	383,134	12.4
09	Uttar Pradesh*	915	648	260	7,449,195	992,728	13.3
10	Bihar	199	139	71	2,013,671	194,065	9.6
11	Sikkim	9	8	7	35,761	8,612	24.1
12	Arunachal Pradesh	27	26	5	65,891	4,005	6.1
13	Nagaland	26	19	7	115,054	15,268	13.3
14	Manipur	51	28	NS	171,400	NS	NS
15	Mizoram	23	23	1	116,203	16,240	14
16	Tripura	42	16	15	235,002	33,830	14.4
17	Meghalaya	22	10	6	116,102	10,936	9.4
18	Assam	214	88	31	992,742	48,122	4.8
19	West Bengal	909	129	122	6,350,113	1,393,319	21.9
20	Jharkhand	228	40	31	1,495,642	79,200	5.3
21	Odisha	223	107	76	1,517,073	350,306	23.1
22	Chhattisgarh	182	168	94	1,238,738	395,297	31.9
23	Madhya Pradesh	476	364	302	3,845,232	1,086,692	28.3
24	Gujarat	348	195	96	5,416,315	360,291	6.7
25	Daman & Diu #	8	2	NS	47,631	NS	NS
26	D & N Haveli #	6	1	NS	37,655	NS	NS
27	Maharashtra	534	256	187	10,813,928	2,449,530	22.7
28	Andhra Pradesh and Telangana	353	125	124	6,778,225	2,421,268	35.7
29	Karnataka	347	220	206	5,315,715	728,277	13.7
30	Goa	70	14	3	198,139	4,846	2.4
31	Lakshadweep #	6	0	NS	8,180	NS	NS
32	Kerala	520	59	19	3,620,696	54,849	1.5
33	Tamil Nadu	1,097	721	504	8,929,104	1,451,690	16.3
34	Puducherry #	10	6	6	206,143	35,070	17
35	A & N Islands #	5	1	1	34,346	3,053	8.9

Note : 'NS' indicates slum not reported.

***Delhi includes 19 Census towns and Uttar Pradesh includes 1 Census Town.**

Source : Census of India 2011, Housing Stock, Amenities and Assets in Slums, Series 1, p. ci.

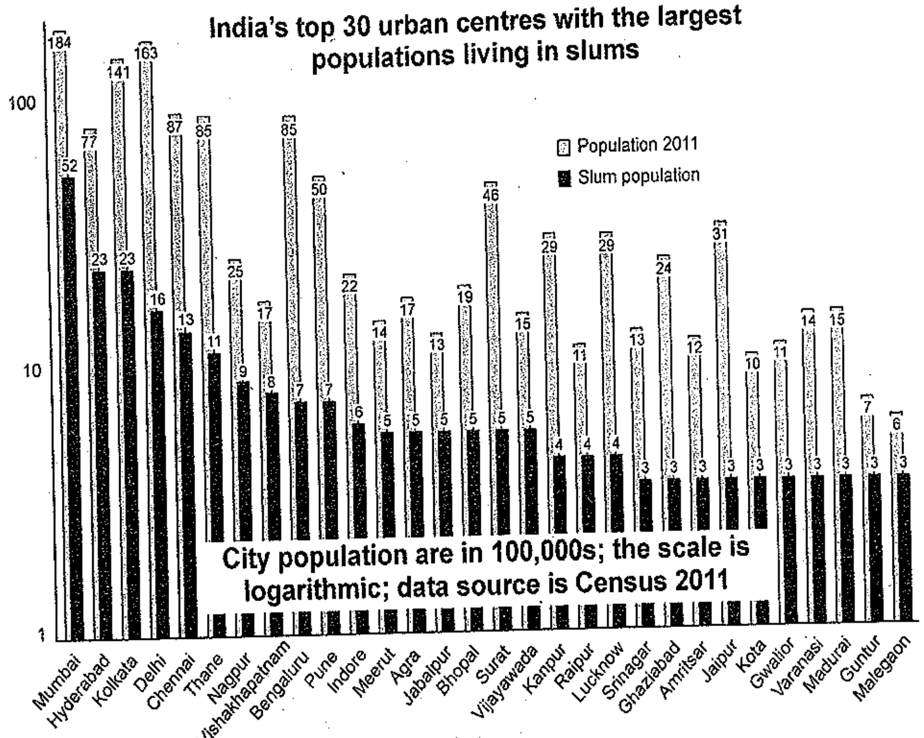

FIG. 13.29. India's to 30 urban centres with the largest populations living in slums

***Legal Characteristics* :** Such settlements lack land ownership.

From the above discussion it is clear that *squatter* refers to legal position of the settlement and *slum* refers to the condition of a settlement.

A distinction has to be drawn between squatter settlements and *shanty towns*. Illegality of tenure is the hallmark of the squatter settlement but shanti huts or mean dwellings are defined by their fabric. *Shanty* towns result mainly from massive rural-urban migration and from the inability of city authorities to provide sufficient housing facilities and employment for the vast influx of people from rural to urban areas.

Indian cities abound with slums which have been termed as ***'eyesores'***, a ***'rash'*** on city landscape, 'a blot on civilization' etc. But actually they are much more health hazards for its unfortunate poverty stricken inhabitants and also for the city as a whole. The most shocking aspect is that slums are growing at an accelerated rate.

CAUSES OF SLUM GROWTH

- Rapid growth of urban population.
- Unemployment in rural areas.
- Mass migration of unskilled and semi-skilled workers from rural to urban areas.
- Limited employment opportunities to immigrant rural population in urban areas.
- Limited land and high land values in urban areas.
- Shortage of cheap residential accommodation in urban areas.

Census of India, for the first time in 2001, came out with detailed data on slum population in India. According to data released by Census of India 2011. types of households has been considered as an important criteria for evaluating the position of slum dwellers in 2011 census. Out of a total of 788.66 million households, as many as 13.75 million households or 17.4% of the total have been reported as slum households. Maharashtra had reported maximum of 2.45 million slum households followed

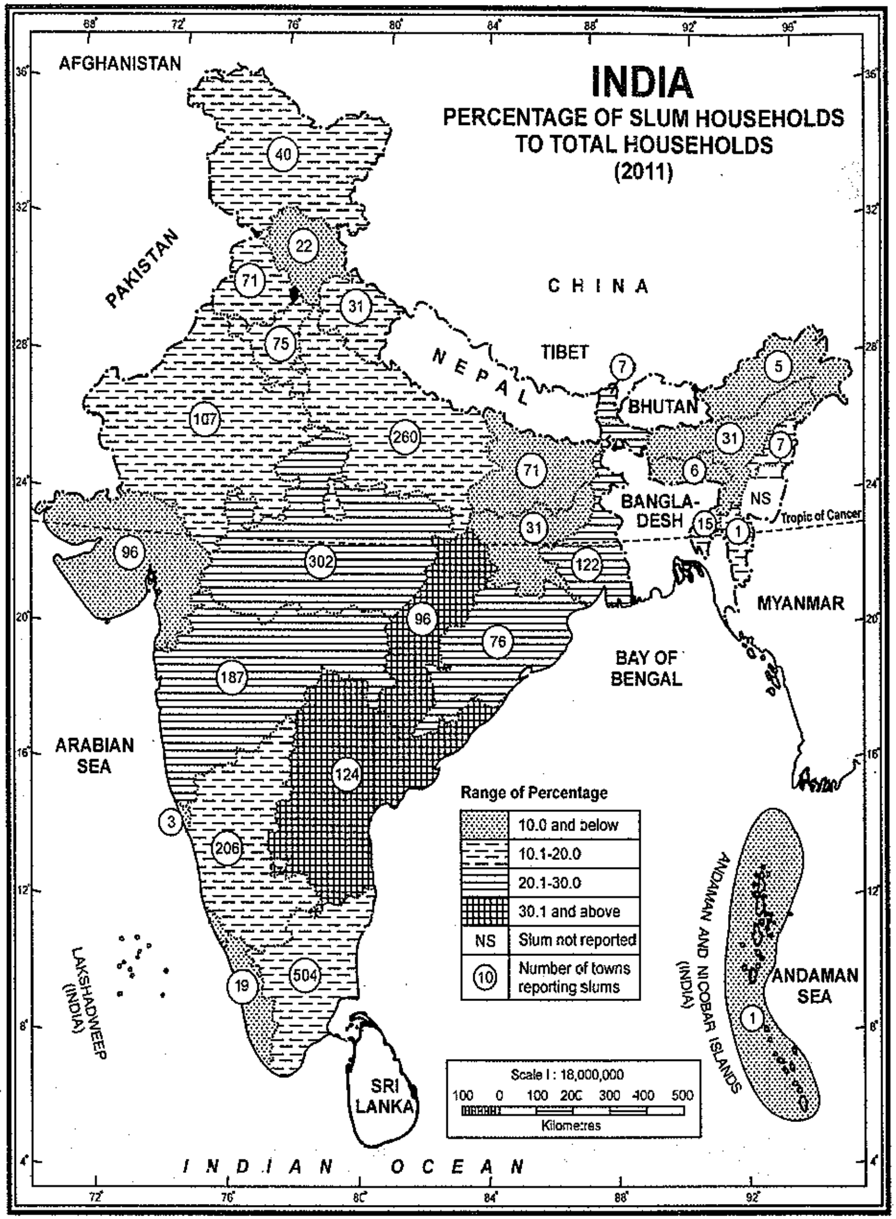

FIG. 13.30. Slum Population, 2001

by Andhra Pradesh and Telangana (2.42 million), Tamil Nadu (1.45 million) and West Bengal (1.39 lakh). State of Manipur and union territories of Daman and Diu, Dadra and Nagar Haveli and Lakshadweep have not reported any slum households (**Table 13.9 and Fig. 13.30**). Entirely different picture emerges if we consider the percentage of slum households to total households at the state/union territory levels. The

CHIEF CHARACTERISTIC FEATURES OF SLUMS

- Slums grow illegally on government land.
- Slums are almost invariably occupied by poor people belonging to lower strata of society.
- Houses in slum areas are very small and most of them consist of one room without separate toilet and kitchen.
- Houses are constructed with poor materials consisting of mud or bricks with thatched roofs or roofs covered with corrugated sheets, tins, bamboo mats, polythenes, gummy bags etc.
- Houses badly lack in ventilation and sanitation.
- Public latrines are practically absent and people, especially children defecate anywhere in the slum area.
- Infrastructural facilities such as electricity, piped (running water), sewage, garbage removal and roads are almost completely absent.
- Hand-pumps are used for water supply.
- People take bath and wash their clothes and utensils with water obtained from the hand-pumps.
- Muck around hand pumps percolates into the ground and contaminates ground water. People fall ill after consuming this water.
- There is shortage of education and health facilities and most people are illiterate and have poor health.
- Sex ratio is low in slum areas.
- There is obnoxious smell in the surroundings.

highest percentage (35.7%) of slum households are in Andhra Pradesh including Telangana. This is followed by Chhattisgarh (31.9%) and Madhya Pradesh (28.3%). The lowest percentage of 1.5% has been reported by Kerala.

Figure 13.29 shows that Mumbai has the largest number of 52 lakh slum dwellers which is 28.26 per cent of the total population of city's Municipal Corporation population. This is followed by Hyderabad (23 lakh), Kolkata (23 lakh), Delhi (16 lakh) and Chennai (13 lakh). If we consider the percentage of population living in slums to the total population of the concerned cities, then Hyderabad is at the top where 29.87 per cent population is living in slum areas. This is followed by Mumbai (28.26%), Kolkata (16.31%), Chennai (14.94%) and Delhi (9.8%). Slum population of the remaining big cities can be seen from **Fig. 13.29**. **Dharavi** slum in Central Mumbai is the second largest slum of Asia. Earlier Dharavi of Mumbai was the largest slum of Asia, but according to Human Development report released by the United Nations Development Programme (UNDP) in 2009, 'Orangi in Karachi' is the largest slum of Asia. Here some of the side allays and lanes are so narrow that not even a bicycle can pass. The whole neighbourhood consists of tenement buildings, two or three storey high with rusty iron stairways to the upper part, where a single room is rented by a whole family, sometimes twelve or more people. In this place of shadowless, treeless sunlight, uncontrolled garbage, stagnant pools of foul water, the only non-human creatures are the shining black crows and long gray rats. Dharavi was an arm of the sea, that was filled by waste, largely produced by the people who have come to live there.

SOME GLARING FACTS ABOUT SLUMS IN INDIA

- 17 per cent of India's urban population lives in slums.
- Maharashtra accounts for 23 per cent of total slum population followed by Andhra Pradesh and West Bengal.
- Half of slum population lives in 53 million plus cities.
- Maharashtra, Karnataka and Andhra Pradesh have largest number of slums.
- Slum population has risen from 52 million in 2001 to 65 million in 2011 and is expected to rise to 104 millions in 2017.

However the UN-HABITAT report entitled "*State of the World Cities 2010/2011, Bridging the Urban Divide*" released at the World Urban Forum in Rio de Janeiro in March, 2010 has shown a silver lining. According to this report, China and India have lifted at least 125 million people out of slum condition. Out this, 59.7 million people are in India and the rest are in China.

The Census of India 2011 report released on March 21, 2013, had pointed a very bright picture of living conditions in slum areas of some major cities. The report says that living conditions in slums are no different from that of non-slums. In fact there are great similarities as far as access to basic amenities like drinking water and electricity is concerned. India's first-ever census of household amenities and assets in slums has revealed that slum dwellers are also spending more on TV sets, computers and mobile phones rather than sanitation.

TABLE 13.10. Comparison of slums and non-slum households with respect to basic amenities in some selected cities of India (2011)

City (Figures in %)	Tap Water		Toilet		Electricity		Cell Phone	
	S	NS	S	NS	S	NS	S	NS
Delhi	86.7	89.9	50.6	95.8	97.8	99.6	66.1	63.4
Kolkata	90.8	87.0	92.0	96.2	95.5	96.5	70.1	63.5
Greater Mumbai	96.1	97.3	32.8	75.1	95.6	98.3	76.6	53.5
Bengaluru	84.3	80.2	86.8	97.8	96.6	98.4	71.0	66.5
Ahmedabad	88.2	86.6	61.3	94.6	91.5	98.9	48.8	63.1
Pune	98.8	98.4	35.8	90.6	96.2	98.9	73.4	62.0
Chennai	78.2	83.7	91.0	97.4	98.4	99.3	70.0	59.2

S = Slum house, NS = Non-slum household.
Source : Census of India 2011.

In 2011, of the 13.7 million slum households, 74% have access to tap water as against 70% in non-slums. As many as 90% have access to electricity as against 92% in non-slums. Also more slum dwellers—77% have access to permanent houses. The figures indicate the narrowing gaps between slums and non-slums.

In an indication of an increase in purchasing power, the report also reveals that 70.2% of slum families own their houses at compared to 69% in non-slum households. Further 70% of slum families have TV sets, 63% have mobile phones and 10.4% computers.

Overall there are 19 million plus cities where more than 25% households live in slums.

Highlights about slums according to provisional figures released by Census of India 2011 in 2013

- 13.71 million urban households live in slums which is 17.4 per cent of total households in the country.
- There are 19 million plus cities where more than 25 per cent households live in slums.
- 35 per cent of India's slum households are in Maharashtra and Andhra Pradesh.
- Maharashtra has 2.45 million slum households which is two times more than 1.19 million slum households in Uttar Pradesh and Bihar put together.
- 64 per cent of India's slum households live in five states *viz.* Maharashtra, Andhra Pradesh, Tamil Nadu, West Bengal and Madhya Pradesh.

TOWN PLANNING

Introduction and Necessity of Town Planning

Urbanisation has increased at rapid pace during the last few decades and size as well as number of cities have increased at an unprecedented rate. This phenomenon has resulted into a large number of complex problems in urban areas. Uncontrolled, unplanned and haphazard growth of cities has led to tremendous pressure of population on the basic infrastructural facilities such as housing, transport, sewer, education, health, water, electricity, etc. and the city dwellers have to face a lot of problems, some of which have really become very complicated. With the increasing number of vehicles, slums and squatter settlements, industries, urban environment has become polluted beyond the permissible limits which has made life of the urban people miserable. Keeping in view these problems, town planning has become of paramount importance. Its implies that new towns should be dwelled in a planned way and proper plans should be made to improve the condition of old cities. By town planning, we will not only make life of the present generation comfortable but will secure the life of the future generations also. From the historic point of view, it is very aptly said that town planning is as old at towns themselves. Romans planned city of Rome more than two thousand years ago and this city has the pride privilege of being the first planned the city of the world. The present day problems of towns have made town planning as the foundation of towns

on which the infrastructure rests and the future prospects of towns depend.

Definition of Town Planning

Town planning is a multi-disciplinary subject and specialises from different fields make their respective contribution to the process of town planning. For example sociologists, economists, geographers, artists, politicians, engineers, demographers, etc. view town planning from their respective angles. The role of geographers in town planning has become very important during the last few decades and many geographers have become professional town planners in India. In fact, *town planning is an art of which geography is a science*. Several geographers have defined town planning in their own way (see box).

1. "The underlying idea of Town Planning is the welfare of the citizens and raise the standard of living of the people." —**L.D. Stamp**
2. "Town and country planing is concerned with the use and development of land." —**Jackson**
3. "The touchstone of planning is the accommodation of several units to make a complete and harmonious whole." —**H.M. Mayer**
4. "City planing is simply the exercise of such foresight as will promote the orderly and sightly development of a city and its environs along rational lines with due regards for health, amenity and convenience and commercial and industrial advancement." —**Nelson, P. Lewis**

Aims and Objectives of Town Planning

There can be several aims and objectives of town planning but for the sake of convenience, three objectives are considered important : (1) beauty, (2) health, and (3) convenience.

1. ***Beauty*** of a town implies that the town should look beautiful and attractive and its beauty should not fade away with the passage of time. To maintain the beauty of a town, there should be proper provision for cleanliness, drainage, light, roads, buildings, etc. The initial beauty of a town quickly fades away if proper arrangements for maintaining this beauty are not made.

2. ***Health*** of the inhabitants of a town is the main pillar on which the town's progress depends. People need pollution free environment and nutritious food to maintain good health. Industries and other polluting establishments should be placed in such a corner of the city that they cause least harm to the people living the town. Wind rose diagrams can be great help in this regard.

3. ***Convenience*** is an important need of man and all activities are performed according to man's convenience. If a town looks beautiful and proper provision for the people's health is also taken care of the town cannot be termed as planned town if convenience of the people is ignored. For example, if an industrial worker has to spend 1-2 hours to reach his place of work from his place of residence, it will be very inconvenient for him. Things can become very convenient for him, if arrangement for his residence is made near the factory or if proper arrangements for cheap and efficient transport are made.

Thus beauty, health and convenience are three basic components of a planned town. Chief aims and objectives of town planning can be summed up as follows :

1. Proper plan should be made for the chronological growth of the town so that there is no obstacle in the future urban sprawl.
2. Land surrounding the town should be included in the plan of the town so that town can spread depending upon the nature of land.
3. Buildings should be planned according to convenience of the people and there should be no scope for unplanned buildings.
4. Growth of town should be planned according to civilizations, culture, rituals or social structure of its inhabitants.
5. There should be proper provision for trade, commerce and other economic activities so that town could be provided with a socio-economic base.
6. Requirements for the coming at lest fifty years should be considered while preparing a plan for a town.
7. Roads and buildings should be specious and there should be open space at the corners.

8. The buildings should be designed in such a way that fresh air and sufficient light can enter in the building. These things are essential for maintaining good health.
9. Due consideration must be given to convenience, comfort and health of the people while preparing plan for a town.

Subject and Scope of Town Planning

Number of size of towns is fast increasing all over the world including India which has increased the importance of town planning considerably. Therefore, it is necessary to know the subject matter of town planning. The subject and scope of town planning has become very vast with the increasing trend in urbanisation. A Augiston of France has mentioned four main elements of town planning. (1) trade, (2) industry, (3) administration and (4) residence. Thus, according to him, a town should be planned in such a way that it is capable of providing scope for growth in trade and industries, its administration base is solid and it provides sufficient scope for residential areas. This plan has not mentioned anything about facilities of health and education which are essential parts of urban life. Arthur B. Galion has divided the subject matter of town planning into two broad classes. (1) *Planning for land-use* which is concerned with the use of land for residence, trade, industry open spaces, etc. Density of land use is determined according to houses and population. (2) *Planning for transport and communication* which requires proper plans for highways and other roads, railways, airports, water-ways and communication network.

Special attention is to be paid to the convenience of the inhabitants and possibilities of future growth of the town. Department of Town and Country Planning has prepared master plans for several towns in India. According to the views expressed by Indian town planners, land use map must be prepared to begin with and then the town plan should be proposed according to the problems of the concerned town. Following are the special features of town planning :

1. Special attention is to be paid to the physical growth of the town.
2. Town plan should have proper consideration for future growth.
3. It should have a broad base.
4. The present population should find it convenient and comfortable to live in the town.

Principles of Urban Planning

Town planning is always bound by certain principles, some of them are briefly described below :

1. Provision for separate area for industries. There is a close relationship between industrialisation and urbanisation and both go hand-in-hand with each other. In some of the towns, industries are set-up in residential areas which is against the principle of town planning. Industries should be located in such an area which is accessible from other parts of the town and at the same time it has least effect of air, water, land and sound pollution.

2. Division of town into functional zones. The whole town is divided into functional zones and each zone is meant for a particular function. Thus there are residential zones, industrial zones, trade and commerce zones, medical zones, educational zones, etc. They are located in such a way that they are complimentary to rather than competitive against each other.

3. Planning for transport. Transport is the main artery and forms the life-line of a town which facilitate the movement of people and goods from one part of the town to another. Therefore, meticulous planing of transport system of a town is of paramount importance. Roads should be broad and clean and there should be separate lanes for separate modes of transportation. Pedestrians need special attention because they are the first victims in any road accident. The road network should be planned in such a way that people do not find much difficulty in travelling from one part of the town to another. Roads coming in and going out of the town are to be properly planned so that greatest accessibility is achieved. Removal of unwanted speed breakers, provision of traffic signals, fly-overs, under-passes, etc. can go a long way in the smooth flow of traffic in big cities.

Local railways also play a significant role in big cities like Mumbai, Delhi, Kolkata, Chennai etc. Mumbai has the best network of local railways in India, but even there, one finds that local trains are unable to meet the increased pressure of traffic and

are almost invariably over-crowded. Delhi metro rail has brought much needed relief to commuters and the success of this railway has encouraged many of the million cities to develop their metro rail system.

4. Slums and Squatter Settlements. Slums and squatter settlements grow in towns and cities when unskilled and semi-skilled workers migrate from rural to urban areas and do not find a suitable job there. Under the plan, the slum dwellers are provided with free or heavily subsidised alternate residential accommodation. In certain cases where it is not possible to remove slums and squatter settlements, basic facilities like water, electricity, roads, sewer, garbage disposal etc. should be proved so as to enable the slum dwellers to lead a reasonably good life.

5. Provision for Public Places. Any good town plan is expected to make provision for public places like parks, play grounds, clubs, community centres, religious places so that people, particularly children and senior citizens can walk, play and spend their free time.

6. Stratified Residential Areas. Normally three types of people live in towns which are labelled as upper class, middle class and lower class according to their financial status. Each class should be allotted separate residential area so that people belonging to one class are able to mix with one another and enjoy the community life.

7. Green Belt. Green belt is usually provided to check the uncontrolled and irregular growth of a town. Usually it is circular area which surrounds the town from all sides and acts as a buffer area between urban and rural land use. In addition to check the uncontrolled, unplanned and irregular growth of the town, green belt also helps in providing pleasant and healthy environment to the people. Scope for future planned growth of the town is also there in the green belt **(Fig. 13.31)**.

8. Land Use. In a planned town, specific piece of land is earmarked for a specific purpose and it is assured that the land is actually used for the purpose for which it is allotted. Height, spacing and design of buildings is also fixed and is strictly adhered to.

9. Open Spaces. Open spaces are needed by all sections of society. Therefore, distribution of parks and playgrounds is planned in such a way that everyone is able to lead the life of virtue.

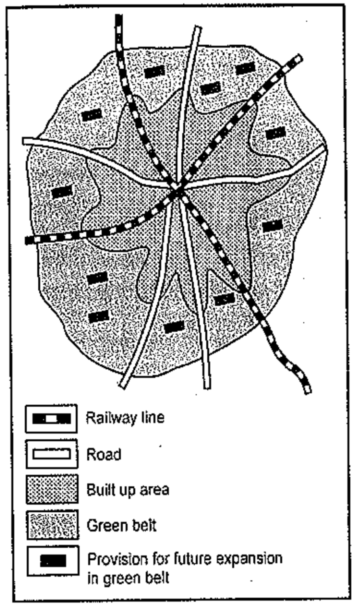

FIG. 13.31. Green Belt

10. Urban Decentralisation. Satellite towns are developed around big cities to decentralise urban population so that high concentration and overcrowding in the city centre is reduced. Satellite towns are new, open and cheaper and act as great mechanism for decentralisation.

11. Renewal of Cities. This is a very important aspect of town planning according to which master plan for 10-20 years is prepared and old land use is improved upon. Currently work is going on Delhi Master Plan 2021.

12. Rehabilitation and re-development. This principle is used for improving old towns. Under this principle, old buildings are improved. Critically old buildings, which are dangerous, are demolished and new buildings are constructed in their place.

13. Development of City Centre. City centre which is usually located at the centre of the city is called the Central Business District (CBD). This area is characterised by tall buildings, high density of land use, convergence of transport routes, high concentration trade and overcrowding. Such a situation leads to a large number of problems. Under the planned development, ways means are devised to solve these problems.

14. Provision for future growth of towns. Plan for future growth and sprawl of urban areas is prepared under this principle. While preparing the plan for future growth of the city, direction and limit of growth are fixed for residential, industrial and commercial areas and priorities for different varieties of land use are also fixed. For metropolitan cities like Delhi, Mumbai, Kolkata, Chennai etc. plans for future development of satellite towns, linear towns, dispersed towns and radial towns are prepared.

TOWN PLANNING IN INDIA

India has a long tradition of town planning. Our old scriptures have many references of planned towns wherein markets, roads, streets, temples, public buildings, residential places, secretarial centres, parks etc. have been mentioned as parts of planned towns. Excavations of Harapa and Mahenjodaro in the Indus Valley are solid proofs of town planning of higher level in India. Four main roads and several other roads and streets of Mohenjodaro meet at right angles giving a typical rectangular shape to the town. The width of main road and the other roads was 10 and 7 metres respectively.

Several towns were developed during the *Vedic* period. Some of the important town built during this period are Kanauj, Ayodhya, Mathura, Janakpuri, Hastinapur, Vaishali, Patliputra, Madurai, Sanchi, Kanchipuram, etc. Majority of these towns were the capitals of their respective kingdoms and were built very meticulously in a planned way. Different parts of the towns were used for different purposes and division of land use pattern was planned in a scientific way. The length and breadth of Ayodhya at that time was 600 and 1500 yards respectively. The town contained beautiful roads and houses and provision for drinking water was made throughout the town.

Patliputra (present Patna) is another example of town planning in ancient time. It was 12 miles (20 km) long and 2 miles (3.2 km) wide and had one fort with 60 doors. The King's palace was in the centre of the city and this palace was surrounded by parks, fountains, ponds, etc. which gave esthetic look to the place. The whole city was encircled by a water channel from security point of view.

Delhi had been the target of invaders throughout its history and had the privilege of being the capital of the country a number of times. Its beginning was made at Indra Prastha which had several palaces, parks, gardens, tanks and beautiful buildings. The Mughal emperor Shahjahan built the city of Shahjahanabad on the bank of the river Yamuna which is now known as Old Delhi. Chandni Chowk was at the heart of the city. The town was spread over 1240 acres of land meant for about 60,000 inhabitants. It had a protection wall on all the sides which had four gates. Currently they are known as Delhi Gate, Kashmiri Gate, Ajmiri Gate and Lahori Gate. It had broad roads which were meeting each other at right angles. A large number of mosques, parks, gardens and fountains enhanced the beauty of the city. Other towns built by the Mughal emperors include Srinagar, Agra and Fatehpur Sikri.

Jaipur, the present capital of Rajasthan, built by the Rajput king Maharaja Jai Singh in 1727 is an outstanding example of planned city. Its broad and beautiful roads and beautiful buildings add to the beauty of the city. All buildings of the original city were painted in pink colour and the city has the distinction of being a **Pink City.**

In the 19th century, the British rulers prepared development plans for cities like Mysore, Vadodara, Kolkata, Delhi etc. for their administrative convenience. Most of the plans were prepared by the army engineers and special attention was paid to the convenience of army personnels while preparing the development plans. In 1915 the then governor of Madras invited a great town planner Patreck Geddes to help the Britishers in town planning. He made an indepth study of the Indian towns and gave valuable suggestions for preparing plans for various towns. It gave a new direction to the process of town planning in India. The British rulers could not afford to ignore the strategic importance of Delhi and decided to shift the capital of India from Kolkata (Calcutta) to Delhi in 1916. Plan for developing New Delhi on a piece of land about 5 miles long and 4 miles broad between the Delhi Ridge and the Yamuna river was prepared by Delhi Town Planning Committee in 1912. Lutyans was the chief architect of this plan and New Delhi is still known as Lutyen's Delhi. Delhi has been one of the fastest growing urban areas in the country. From a little over 2 lakhs in 1901 and 4.5 lakh in 1931 the city took a leep to 7 lakh in 1941. In the first four years after partition, it is estimated that about

1,00,000 left for Pakistan but thrice that number came in and by 1951, Delhi's population had doubled. By 1961, the urban area recorded a population of 2.3 million which rose to 16.75 million in 2011. At the initial stage, New Delhi and Old Delhi were separate urban identities and there was a vast open area between the two. Both the areas have widened with the passage of time and at present there is no open space between the two.

In the year 1907 Jamshedji Tata established Tata Iron and Steel Company (TISCO) at Sanchi in Saghbum district of Jharkhand and prepared development plan for the industrial town of Jamshedpur in 1911 which was revised in 1920, 1936 and 1943. According to the plan, the whole town is divided into two parts and 12 zones. One part is industrial area and the other is residential area. According to the plan, houses are not close to each other, rather they are wide apart, separated by sufficient open space. Due provision for entertainment, market, education and medical facilities has been made.

Town Planning in the Post-Independence Period

India witnessed rapid growth of urbanisation after Independence in 1947. Several new towns came up and many old towns were remodeled. New towns

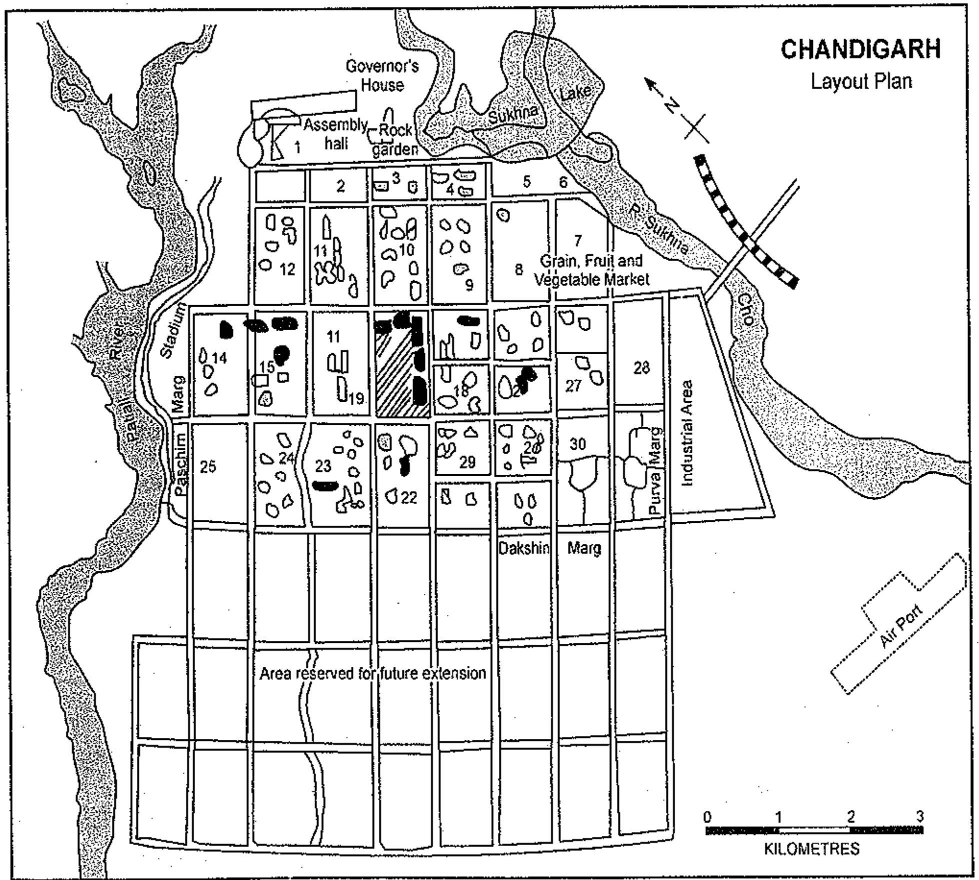

FIG. 13.32. Layout Plan of Chandigarh

were direly needed for immediate settlement of migrants from Pakistan as a result of partition of the country. New colonies named as '*model towns*' were establishes in old towns to provide shelter to the immigrants. A number of industrial towns was also set up to boost the industrial growth. Durgapur, Rourkela, Bhilai, Bokaro, Chittaranjan etc. are examples of such towns. Many new capital towns like Chandigarh, Bhubaneshwar, Gandhinagar, Itanagar were also established for administrative purpose. All these towns have been constructed according to pre-determined plans and they are examples of planned towns in India.

Chandigarh. Chandigarh is the proud city of Independent India and is considered to be one of the most beautiful cities of the world. Need for the new capital of Punjab was felt immediately after partition of the country and its plan was prepared at the initiative of the then chief minister of Punjab, Sardar Partap Singh Kairon. Its construction started in 1952 and it became a union territory and capital of Punjab and Haryana on 1st November 1966 when the erstwhile Punjab was divided into present Punjab and Haryana. It was designed to accommodate 1,50,000 inhabitants but is remained a great attraction for people of the neaghouring states and it is one of the million plus cities of India according to 2011 census.

The city has a rectangular plan in which the roads are designed according to gridiron or chequerboard pattern and they meet each other at right angles (**Fig. 13.32**). According to the original plan, the city is spread on an area of 3642 hectares between Patiali river in the west and Sukhna Cho in the north-east and has 30 sectors, out of which 24 are residential sectors and the remaining six are meant for other purposes. Sector 17 is meant for trade and commerce and may be termed as Central Business District (CBD) of the city. Sector 14 has the campus of Punjab University and sector 11 and 12 host other educational institutes. Important buildings like assembly hall, secretariat, and governor's house are in the northern part of the city. Adjacent to the Sukhna Cho are grain, fruit and vegetable markets while industrial area is in the extreme east corner of the city. Sukhna Lake, Rock Garden, Rose Garden etc. are the main tourist attractions of the city. The southern part of the city has been keep vacant for future expansion of the city.

PROBLEMS OF URBANISATION IN INDIA

Although India is one of the less urbanized countries of the world with only 31.16 per cent of her population living in urban agglomerations/towns, this country is facing a serious crisis of urban growth at the present time. Whereas urbanisation has been an instrument of economic, social and political progress, it has led to serious socio-economic problems. The sheer magnitude of the urban population, haphazard and unplanned growth of urban areas, and a desperate lack of infrastructure are the main causes of such a situation. The rapid growth of urban population both natural and through migration, has put heavy pressure on public utilities like housing, sanitation, transport, water, electricity, health, education and so on. Poverty, unemployment and under employment among the rural immigrants, beggary, thefts, dacoities, burglaries and other social evils are on rampage. Urban sprawl is rapidly encroaching the precious agricultural land. The urban population of India had already crossed the 377 million mark by 2011 which is more than the total population of U.S.A., third most populous country of the world after China and India. By 2030, more than 50 per cent of India's population is expected to live in urban areas. Following problems need to be highlighted.

1. Urban Sprawl

Most cities of India are growing at a rapid pace, both with respect to population and area. This is known as urban sprawl which creates a large number of problems. These problems have already been discussed in this chapter and need not be repeated.

2. Overcrowding

Overcrowding is a situation in which too many people live in too little space. Overcrowding is a logical consequence of over-population in urban areas. It is naturally expected that cities having a large size of population squeezed in a small space must suffer from overcrowding. This is well exhibited by almost all the big cities of India. For example, Mumbai has one-sixth of an acre open space per thousand population though four acres is the suggested standard by the Master Plan of Greater Mumbai. Metropolitan cities of India are overcrowded both in 'absolute' and 'relative' terms.

Absolute in the sense that these cities have a real high density of population; relative in the sense that even if the densities are not very high the problem of providing services and other facilities to the city dwellers makes it so. Delhi has a population density of 11,297 persons per sq km (Census 2011) which is the highest in India. This is the overall population density for the National Capital Territory of Delhi. Population density in central part of Delhi could be much higher. This leads to tremendous pressure on infrastructural facilities like housing, electricity, water, transport, employment, etc. Efforts to decongest Delhi by developing ring towns has not met with the required success.

3. Housing

Overcrowding leads to a chronic problem of shortage of houses in urban areas. This problem is specifically more acute in those urban areas where there is large influx of unemployed or underemployed immigrants who have no place to live in when they enter cities/towns from the surrounding areas. An Indian Sample Survey in 1959 indicated that 44 per cent of urban households (as compared to 34 per cent of rural families) occupied one room or less. In larger cities the proportion of families occupying one room or less was as high as 67 per cent. (Roy Turner, 1962). Moreover, the current rate of housing construction is very slow which makes the problem further complicated. Indian cities require annually about 2.5 million new devellings but less than 15 per cent of the requirement is being constructed.

As per 2011 Census figures, there are 110.1 million houses for a total urban population of over 377 million which means that nearly four persons live in one house. Only 68.5 per cent of the total houses are in good condition and remaining are just livable or dilapidated. **Table 13.11** shows that about two-thirds of the houses are just one room or two room dwellings, many of them without a kitchen or a bathroom. The table also shows that the percentage of houses decreases with the increase in number of rooms.

Several factors are responsible for the above mentioned sad state of affairs with respect to housing problems faced by the urban people. The major factors are shortage of land, building materials and financial resources, inadequate expansion of pubic

TABLE 13.11. Households by Number of Dwelling Rooms

Size of houses	Percentage of the total houses
1. No exclusive room	3.1
2. One room	32.1
3. Two rooms	30.6
4. Three rooms	18.4
5. Four rooms	9.3
6. Five room	3.2
7. Six rooms and above	3.3
Total	100.0

Source : Census of India 2011. Tables on Houses, Household Amenities and Asses, Series 1, p. XIV.

utilities into sub-urban areas, poverty and unemployment of urban immigrants, strong caste and family ties and lack of adequate transportation to sub-urban areas where most of the vacant land for new construction is located.

4. Unemployment

The problem of unemployment is no less serious than the problem of housing mentioned above. Urban unemployment in India is estimated at 15 to 25 per cent of the labour force. This percentage is even higher among the educated people. It is estimated that about half of all educated urban unemployed are concentrated in four metropolitan cities (Delhi, Mumbai, Kolkata, Chennai). Furthermore, although urban incomes are higher than the rural incomes, they are appallingly low in view of high cost of living in urban areas.

One of the major causes of urban unemployment is the large scale influx of people from rural to urban areas. Rural-urban migration has been continuing for a pretty long time but it has not always been as great a problem as it is today. The general poverty among the rural people pushes them out to urban areas to migrate in search of livelihood and in the hope of a better living. But the growth of economic opportunities fail to keep pace with the quantum of immigration. The limited capacity of urban areas could not create enough employment opportunities and absorb the rapid growth of the urban labour force. Efforts made by the central and the state governments to create employment opportunities in rural areas and to check the large scale rural-urban migration have not met with much success.

5. Slums and Squatters

Slums and squatter settlements grow due to unchecked, unplanned and haphazard growth of city and also due to low income levels of the city dwellers. This creates many problems which have already discussed in this chapter.

6. Transport

With traffic bottlenecks and traffic congestion, almost all cities and towns of India are suffering from acute form of transport problem. Transport problems increase and become more complex as the town grows in size. With its growth, the town performs varied and complex functions and more people travel to work or shop. As the town becomes larger, even people living within the built-up area have to travel by car or bus to cross the town and outsiders naturally bring their cars or travel by public transport. Wherever trade is important, commercial vehicles such as vans and trucks will make problem of traffic more complicated.

Since most of the commercial activities of the towns are concentrated in the Central Business District (C.B.D.), the centres are areas of greatest congestion. However, other parts of the town are not free from traffic congestion. Such areas include the roads leading to factories, offices, schools, etc., which will be thronged with people in morning and evening; minor shopping centres which grow up in the suburbs; sporting arenas, entertainment districts which will be busy at night, roads leading to residential and dormitory towns which will be busy when commuters flock to the cities in the morning to work and return home in the evenings. Such congestion becomes greater when the centre is built up in tall skyscraper blocks whose offices sometimes employ thousands of workers, because at the end of the office hours everyone leaves the building within a short span of time to make his way home. This puts tremendous pressure on public transport and causes journeys to take much longer period than they normally would. In most cities the rush hour or peak traffic hour lasts for about two hours and during that period buses and trains are crammed to capacity, roads are overcrowded with vehicles and the movement of traffic becomes very slow.

In other towns, the narrowness of the streets, which were built long before the motorised transport and lack of parking facilities are the main cause of congestion. Cars may be parked along the edges of the roads restricting movement to a narrow lane and the multiplicity of narrow streets, sharp corners and waits to turn into lanes of traffic may slow down the movement and thus create even greater congestion.

The traffic scenario in almost all the Indian cities presents a pathetic picture with Mumbai still having the best city transport system and Chennai, Ahmedabad and Pune being reasonably well served by local transport system. In all other cities, if one does not own a personal vehicle, great hardship is experienced in moving about in the city. Apart from that, the level of incomes and affordability of Indian masses is very low and the citizens are not able to pay an economic fare for use of public transport system. Therefore, all city bus services sustain such heavy losses that they cannot really expand or even maintain a fleet adequately to meet the city needs. Moreover, mixture of vehicles causes uncontrollable chaos on the roads. Free movement of stray cattle and domestic animals on the roads adds to traffic problems and often cause accidents. Heavy traffic and congestion leads to slow movement of traffic, fuel wastage environmental pollution and loss of precious time.

A study of traffic problem in Delhi will aquant us to traffic scenario in the rest of urban India. Already there are more than 82 lakh vehicles on Delhi road (2014). The road length, however has not increased proportionately. The road length per vehicle was 3 km in 1971 which reduced to less than 0.2 km in 2014. Introduction of metro rail eased traffic congestion to begin with but the number of metro rail users is far out pacing the facilities which this mode of transportation is able to provide.

Urban planners say that by 2021, going in a car will take longer time than walking. The guidelines for Delhi Master Plan 2021, allowing mixed land use, multi-storeyed structures and regularisation of 24 industrial estates will add to the city's already congested roads. Disturbing trends have also been indicated in the Status Report for Delhi, 2021 prepared by the Union Ministry of Environment and

Forests. Planning Department of Delhi Government also States that despite roads occupying 21 per cent of the total area of the city, the increase of traffic on arterial roads is resulting in lower speeds, congestion, intersection delays and higher pollution level during peak hours.

Similar conditions prevail in most of the Indian cities. In Kolkata, metro rail and Vivekanand Setu were constructed to ease traffic flow. But traffic congestion in several old localities and near Haora bridge is almost a daily routine. In Ahmedabad, the speed of vehicles comes down to 5 km/hr on Gandhi Marg and several other roads due to congestion and overcrowding.

7. Water

Water is one of the most essential elements of nature to sustain life and right from the beginning of urban civilisation, sites for settlements have always been chosen keeping in view the availability of water to the inhabitants of the settlement. However, supply of water started falling short of demand as the cities grew in size and number. Today we have reached a stage where practically no city in India gets sufficient water to meet the needs of city dwellers. In many cities people get water from the municipal sources for less than half an hour every alternate day. In dry summer season, taps remain dry for days together and people are denied water supply at a time when they need it the most. The individual towns require water in larger quantities. Many small towns have no main water supply at all and depend on such sources as individual tubewells, household open wells or even rivers. Accelerated Urban Water Supply Programme (AUWSP) was launched to provide water to towns with population of less than 20,000. Keeping in view the increased demands for water by the urban population, Central Public Health and Environmental Engineering Organisation (CPHEEO) fixed 125-200 litres of water per head per day for cities with a population of more than 50,000, 100-125 litres for population between 10,000 and 50,000 and 70-100 litres for towns with a population below 10,000. The Zakaria Committee recommended the water requirement per head per day 204 litres for cities with population between 5 lakh and 2 million and 272 litres for cities with population more than 2 million. This amount of water is supposed to be used for drinking, kitchen, bathing, cloth washing, floor and vehicle washing and gardening. Sadly majority of the cities and towns do not get the recommended quantity of water. Gap in demand and supply of water in four metro cities, *viz.*, Mumbai, Kolkata, Delhi and Chennai varies from 10 to 20 per cent. The condition is still worse in small cities and towns. To meet the growing demand for water, many cities are trying to tap external sources of water supply. Mumbai draws water from neighbouring areas and from sources located as far as 125 km in the Western Ghats. Chennai uses water express trains to meet its growing demand for water. Bengaluru is located on the plateau and draws water from Cauvery river at a distance of 100 km. Water for Bengaluru has to be lifted about 700 metres with help of lifting pumps. Hyderabad depends on Nagarjuna Sagar located 137 km away. Delhi meets large part of its water requirements from Tajewala in Haryana. Water is also drawn from Ramganga as far as 180 km. Under the proposed scheme it will meet its growing requirements of water from Tehri, Renuka, and Kishau barrages.

8. Sewerage Problems

Urban areas in India are almost invariably plagued with insufficient and inefficient sewage facilities. **Not a single city in India is fully sewered.** Resource crunch faced by the municipalities and unauthorised growth of the cities are two major causes of this pathetic state of affairs. According to latest estimates, only 35-40 per cent of the urban population has the privilege of sewage system. Most of the cities have old sewerage lines which are not looked after properly. Often sewerage lines break down or they are overflowing. Most cities do not have proper arrangements for treating the sewerage waste and it is drained into a nearby river (as in Delhi) or in sea (as in Mumbai, Kolkata and Chennai), thereby polluting the water bodies.

In most Indian cities, water pipes run in close proximity to sewer lines. Any leakage leads to contamination of water which results in the spread of several water borne diseases.

9. Trash Disposal

As Indian cities grow in number and size the problem of trash disposal is assuming alarming proportions. Huge quantities of garbage produced by our cities pose a serious health hazard. Most cites do not have proper arrangements for garbage disposal and the existing landfills are full to the brim. These landfills are hotbeds of diseases and innumerable poisons leaking into their surroundings. Wastes putrefy in the open inviting disease carrying flies and rats and a filthy, poisonous liquid, called leachate, which leaks out from below and contaminates ground water. People who live near the rotting garbage and raw sewage fall easy victims to several diseases like dysentery, malaria, plague, jaundice, diarrhoea, typhoid, etc.

10. Urban Crimes

Modern cities present a meeting point of people from different walks of life having no affinity with one another. Like other problems, the problem of crimes increases with the increase in urbanisation. In fact the increasing trend in urban crimes tends to disturb peace and tranquility of the cities and make them unsafe to live in, particularly for the women. Growing materialism, consumerism, competition in everyday life, selfishness, lavishness, appalling socio-economic disparities and rising unemployment and feeling of loneliness in the crowd are some of the primary causes responsible for alarming trends in urban crime. Not only the poor, deprived and slum dwellers take to crime; youngsters from well-to-do families also resort to crime in order to make a fast buck and for meeting requirements of a lavish life. Occasional failures in life also drag youngsters to crime. The problem of urban crime is becoming more complicated in the present day world because criminals often get protection from politicians, bureaucrats and elite class of the urban society. Some of the criminals reach high political positions by using their money and muscle power.

According to study made by Dutt and Venugopal (1983), violent urban crimes like rape, murder, kidnapping, dacoity, robbery, etc. are more pronounced in the northern-central parts of the country. Even economic crimes (like theft, cheating, breach of trust, etc.) are concentrated in the north-central region. Poverty related crimes are widespread with main concentration in the cities of Patna, Darbhanga, Gaya and Munger.

However, the latest surveys show that Mumbai and Delhi figure in 35 cities that have high crime rate. As much as 31.8 per cent of citizens in Mumbai and 30.5 per cent in Delhi have been victims of crime. Sexual assault was higher in Mumbai (3.5 per cent) as compared to Delhi (1.7 per cent). Both cities score poorly on corruption, with 22.9% in Mumbai being exposed to bribery as compared to 21% in Delhi.

11. Problem of Urban Pollution

With rapid pace of urbanisation, industries and transport systems grow rather out of proportion. These developments are primarily responsible for pollution of environment, particularly the urban environment. The problem of environmental pollution has already been discussed in details in Chapter 9 and need not be repeated here.

We cannot think of strong India, economically, socially and culturally, when our cities remain squalor, quality of urban life declines and the urban environment is damaged beyond repair. As a matter of fact, cities comprise the backbone of economic expansion and urbanization is being seen in a positive light as an engine of economic growth and agent of socio-political transformation. The share of urban areas in the total national economic income had been estimated at 60 per cent and the per capita income was about three times higher than rural per capita income. But this is not sufficient partly, due to high cost of living and partly, because of growing economic disparity in urban areas. Rich are becoming richer and poor are becoming poorer. Several steps have been initiated to meet the challenges posed by urban crisis but with little or no success. National Commission on Urbanization (NCU) has, in its policy proposal of 1988, stressed the need for (*a*) the evolution of a spatial pattern of economic development and hierarchies of human settlements, (*b*) an optimum distribution of population between rural and urban settlements, and among towns and cities of various sizes, (*c*) distribution of economic activities in small and medium-sized growth centres, (*d*) dispersal of economic activities through the establishment of counter-magnets in the region, and (*e*) provision of minimum levels of services in urban and rural areas. The other major development programmes include (*i*) Urban Basic Services for the Poor (UBSP) programme, (*ii*) the Environmental Improvement of Urban Slums (EIUS) programme, (*iii*) the Integrated Development of Small and

Medium Towns (IDSMT), (*iv*) various housing and infrastructure financing schemes of Housing and Urban Development Corporation (HUDCO), (*v*) the Mega Cities Project, and (*vi*) the Integrated Urban Poverty Eradication Programme (IUPEP). Almost all the major programmes of urban development suffer from the chronic disease of resource crunch. Right from the beginning of the planning period, urban development has been low on the development agenda with only 3-4 per cent of the total plan outlay being allocated to the urban sector. The National Commission on Urbanization recommended in 1988 that at least 8 per cent of the Plan outlay should be dedicated to urban sector.

The Jawaharlal Nehru National Urban Renewal Mission (JNNURM) was launched by the Ministry of Urban Development in 2005 for a seven year period upto March 2012 which was extended to 31st March, 2014. The components under the sub-mission Urban Infrastructure and Governance (UIG) include urban renewal, water supply (including desalination plants), sanitation, sewage and solid waste management, urban transport, development of heritage areas and preservation of water bodies. All the selected 65 cities under the UIG component of JNNURM have prepared comprehensive city development plans (CDPs). The Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT) is a subcomponent of the JNNURM for development of infrastructure facilities in all towns and cities other than the 65 Million cities under UIG. Proposals for bus rapid transit system (BRTS) were approved for Ahmedabad, Bhopal, Indore, Jaipur, Pune-Pimpri, Chhindwara, Rajkot, Surat, Vijayawada, Visakhapatnam, Kolkata, Naya Raipur and Hubli-Dharwar. Metro-rail has been approved for a number of large cities and the work of the metro rail projects in such cities are at various stages of construction.

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CHAPTER 14

Regional Development and Planning

DEVELOPMENT

Development implies overall improvement in economic, social and political conditions of a society. Recently one more dimension of conservation and improvement of environment has been added to the overall gamut of development. The quest for development and strategies for development could be related to :

(*i*) Rapidly increasing population and pressure on physical resources.

(*ii*) Growing demand for food and other necessities of life.

(*iii*) Quest for improving the general standards of living of the people specifically in the less developed parts of the world.

(*iv*) Decolonisation of large number of countries and their consequent emergence as independent countries. For example, India became an independent country in 1947, after which a lot of development has taken place.

(*v*) Reconstruction of former colonies that have become now independent sovereign states.

(*vi*) Regional disparities at the national and international levels.

The concept of development is not only area specific but also time specific. It means that concept of development changes from place to place and from time to time. Thus development process belies any permanent conceptualization. Different disciplines like economics, sociology, political science, history, geography, etc. often deal with development from their own point of view.

The largest contribution to the study of development has been made by economists. An economist looks at development in terms of economic progress. Economic progress is expressed in terms of enhancement in general productivity level, per capita

income, efficiency of a worker, overall improvement in quality of life in general and elimination of poverty in particular. As such the economists have met with greater success in the formulation of theories and models and have earned greater acceptability in policy formulation.

Sociologists, on the other hand, believe that economic development was of little relevance in the absence of social development and social development must precede economic development. The main focus of social development is the development of people in terms of their mental relations and the institutional and structural changes in the society. The two most significant parameters of measuring social development are quality of life (*i.e.* social harmony and social cohesion) and social justice.

Political scientist's, conceptualization of development has its focus on political context. This is justified in view of the increasing role of government not only as promoter but also as the principal planner. Thus, power structure holds the pivotal position in political scientists conceptualization of development.

A historian's concept of development lies in the formulation of theories and models that may explain economic, social and political history. Thus, a historian's focus is upon temporal changes in economic, social and political institutes and models, if any, would be temporal models.

Geography is an integrating discipline and offers a unique synthesis of development of natural and human resources. As such a geographer's conceptualization of development is much more comprehensive. It considers economic progress, social advancement, political development and environmental preservation.

Figure 14.1 gives an idea of geographer's conceptualization of the process of development. The

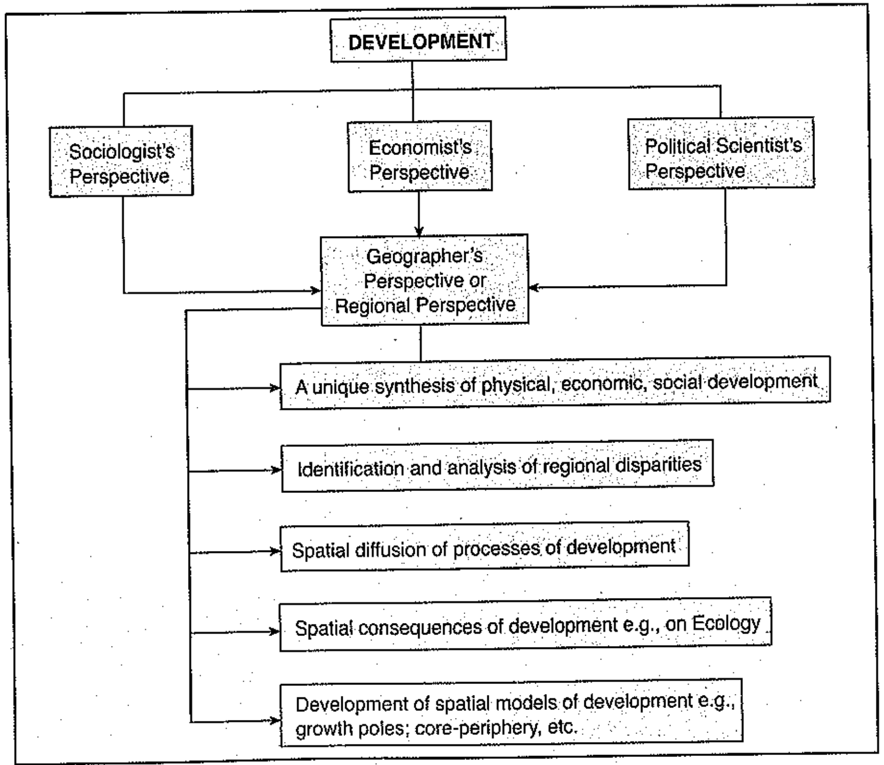

FIG. 14.1. Development

figure shows that each social science such as sociology, economics political science, geography, etc. has its own perception of the process of development. However, geographer's concept offers a unique synthesis of physical, social and economic development. The figure also shows four basic steps in geographic analysis of regional development. These are (*i*) identification and analysis of regional disparities, (*ii*) spatial diffusion of process of development, (*iii*) spatial consequences of development *e.g.* on ecology and (*iv*) development of spatial models of development *e.g.* growth poles, core-periphery, etc.

In the last quarter of 20th century, a growing focus on the behavioural aspect of development has been observed. This is in tune with the behavioural revolution in geography. This thrust was the outcome of geographer's quest for role of human factor in development, more specifically human behaviour.

What is Planning ?

Planning has been defined as "the process of thinking through and implementing a set of appropriate actions to achieve some goals." Generally the goals are economic prosperity and social development. Thus planning is a device with the help of which we can achieve socio-economic prosperity by making optimum use of natural and human resources available to us. In other words, it a process of socio-economic development which can make a place for good living and can help in keeping the ecology and environment in a healthy condition. According to the Planning Commission of India, "Planning involves the acceptance of a clearly defined system of objectives in terms of which to frame overall policies. It also involves the formation of a strategy for promoting the realisation of ends defined. Planing is essentially an attempt at working out a rational solution of problems, an attempt to coordinate means and ends; it is then different from traditional hit and miss methods by which reforms and reconstruction are often undertaken." (First Year Plan, p. 7). In fact, planning is a *process of human thought and action based upon that thought.*

Planning India

The foundation of planning in India was laid much before Independence during the heat of India's freedom struggle by the stalwards of Indian thought and freedom movement like Mahatma Gandhi, Subhash Chandra Bose and Jawaharlal Nehru. The setting up of National Planning Committee in 1938 by the then Indian National Congress marks the beginning of thought for planning in pre-Independence era. As a consequences of this initiative, regular planning was started immediately after Independence.

The Planning Commission was set up by a Resolution of the Government of India in March 1951 in pursuance of declared objectives of the Government to promote a rapid rise in the standard of living of the people by efficient exploitation of the resources of the country, increasing production and offering opportunities to all for employment in the services of the community.

The First Five Year Plan was launched in 1951, *i.e.* within 4 years of Independence. Three basic principles of planning policy of India as enshrined in the country's constitution are as follows :

(*a*) that the citizens, men and women, equally, have the right to adequate means of livelihood.

(*b*) that the ownership and control of material resources of community are so distributed as best to serve the common good; and

(*c*) that the operation of economic system does not result in the concentration of wealth and means of production in a few hands to the detriment of the common man.

First Five Year Plan (1950-51 to 1960-61). Regional and national problems became glaring during the initial phase of planning in India. This plan set out following five objectives for accomplishment :

(*a*) increasing the national income and improving the average standard of living of the people;

(*b*) increasing the pace of industrialisation of both the basic and heavy industry sector;

(*c*) increasing employment potential of various sectors;

(*d*) narrowing down both vertical and horizontal. inequalities; and

(*e*) achieving self-reliance so as minimise dependence on foreign aid.

Since the First Five Year Plan was initiated immediately after Independence and partition of the Indian subcontinent, India faced the following serious problems in the beginning of this plan :

(*i*) resettlement of immigrants from Pakistan due to partition of the country in 1947.

(*ii*) acute shortage of food resulting in large scale import of foodgrains.

(*iii*) Checking the increasing rate of inflation.

Also there was immediate need to reduce the regional imbalances in economy caused by World War II and partition of the country.

Keeping in view above scenario, new towns were planned and old towns were expanded to rehabilitate immigrants from Pakistan. Top priority was given to irrigation and agriculture and establishment of power projects in the form of multi-purpose projects. About 44.6 per cent of the total outlay of ₹ 2,069 crore in the public sector (later raised to ₹ 2,378 crore) was allocated for this purpose. The Plan aimed at increasing the rate of investment form 5 to about 7 per cent of the national income.

The national level problems were very serious and not much attention was paid to regional planning. But all the states were divided into five broad divisions which is considered to be the first step towards regional planning. Although regions were ignored in broad outlines of planning, yet problem areas like Damodar Valley were identified and importance of resource planning at the regional level was recognised.

Second Five Year Plan (1956-57 to 1960-61). The efforts made during the First Five Year Plan helped the country to tide over the economic crisis and increase agricultural production to some extent. Inflation rate was also controlled partially. Therefore, it was felt that industries should be given priority over agriculture. The plan aimed at promoting a pattern of development which would lead to the establishment of a socialistic pattern of society. It aimed at :

(*i*) an increase of 25 per cent in the national income;

(*ii*) rapid industrialization with particular emphasis on the development of basic and heavy industries;

(*iii*) large expansion of employment opportunities;

(*iv*) reduction of inequalities in income and wealth and a more even distribution of economic power.

The Plan aimed at increasing the rate of investment from about 7 per cent of the national income to 11 per cent by 1960-61. It laid emphasis on increasing the production of iron and steel, heavy chemicals including nitrogenous fertilizers and development of heavy engineering and machine building industry.

Third Five Year Plan (1960-61 to 1965-66). The first two Five Year Plans helped in generating the required infrastructure and Indian economy entered the "*take off stage*" at the beginning of Third Five Year Plan. Therefore this Plan aimed at securing self-reliance, self-generating economy and self-sustained growth. Its immediate objectives were to :

(*i*) secure over five per cent per annum increase in national income and at a same time ensure a pattern of investment that could sustain this rate of growth in the subsequent plan periods;

(*ii*) achieve sell sufficiency in food grains and also increase production of other crops to meet requirements of industry and export;

(*iii*) expand basic industries like steel, chemicals, fuel and power and establish machine building capacity so that requirements of further industrialization could be met within a period of about 10 years mainly from the country's own resources;

(*iv*) fully utilize the manpower resources and increase substantially the employment opportunities;

(*v*) establish progressively greater quality of opportunity and bring about reduction in disparities of income and wealth and more even distribution of economic power.

The Third Five Year Plan was *shifted from development to defence at a later stage due to invasion of India by China in 1962 and India's war with Pakistan in 1965.*

Annual Plans (1966-67 to 67 to 1968-69). Many problems cropped up by the end of the Third Five Year Plan which delayed the finalization of the Fourth Five Year Plan. These problems were : (*i*)

Indo-Pakistan conflict in 1965; (*ii*) two successive years of severe drought (1965-66 and 1966-67); (*iii*) devaluation of the currency; (*iv*) general rise in prices; and (*v*) erosion of resources available for plan purposes. Consequently, three annual plans from 1966-67 to 1968-69 were prepared. Although annual plans were prepared, there was no overall five-year framework and the period of 1966-67 to 1968-69 between the Third and the Fourth Five Year Plans is termed as ***"Plan Holiday."***

Fourth Five Year Plan (1969-74). The primary aim of this plan was to accelerate the tempo of development and reduce the fluctuations in agricultural production as well as the impact of uncertainties of foreign aid. It sought to raise the standards of living through programmes designed to promote equality and social justice. The Plan laid particular emphasis on improving the conditions of the less privileged and weaker sections by providing facilities of employment and education. Provision was also made for reducing concentration of wealth, income and economic power to promote equity. The average annual growth rate was 3.4 per cent against the target of 5.7 per cent.

Fifth Five Year Plan (1974-79). This plan was prepared against the backdrop of severe inflationary pressure. Its two primary aims were (*i*) removal of poverty and (*ii*) attainment of self-reliance through promotion of higher rate of growth, better distribution of income and very significant set up in domestic rate of saving. Efforts were mode to develop backward areas through the cooperation of the centre and state governments. The backward areas were divided into two classes *viz*. (*a*) areas where conditions of physical geography such as relief, climate etc. were not much suited for human habitation and where people of typical culture were living and (*b*) economically backward areas where land man ratio was low, infrastructure was poor or resources for development ever scarce. Separate plans were prepared for both types of areas. This led to the development of concept of area specific planning and special programmes were chalked out for drought affected hilly areas and for areas inhabited by the tribal people. Medium and minor irrigation projects were launched to meet the requirements of drought affect areas. Special plan was also prepared for afforestation, soil conservation, orchards, livestock diary farming, road construction and drinking water. The plan targeted an annual growth rate of 5.5 per cent but actual growth rate was 5.0 per cent.

Four Annual Plans pertaining to this plan were completed. Then there was change of guards and Government headed by Janata Party replaced the Congress led Government at the centre. The new Government at the centre decided to end the Fifth Plan period with the close the Annual Plan 1978-79.

Sixth Five Year Plan. There are two different types of Sixth Plan in the planning history of India. One of the Sixth Five Year (1978-83) Plans was prepared by the Government led by Janata Party which sought to reconcile the objectives of higher production with greater opportunity for employment. Provision was made for increasing employment opportunities in agriculture and allied activities, incentives for small scale and cottage industries and increasing income of low income groups.

As a result of 1980 general election, Janata Party was defeated and Congress (I) came back to power. The new government led by Congress (I) presented its own Sixth Five Year Plan (1980-85). The thrust of this plan was to expand the economic base and to reduce poverty. This was to be achieved by strengthening the agricultural and industrial base. Stress was laid on tackling inter-related problems through a systematic approach with greater management, efficiency and intensive monitoring in all sectors and active involvement of people in formulating specific schemes of development at local level and securing their speedy and effective implementation.

The actual expenditure in this plan stood at ₹ 1,09,291.7 crore (current price) at against the envisaged total public sector outlay of ₹ 97,500 crore (1979-80 prices) accounting for a 12 per cent increase in nominal terms. The achieved annual growth rate of 5.4 per cent was higher than the targeted annual growth rate of 5.2 per cent.

Seventh Five Year Plan (1985-90). This plan emphasized on policies and programmes, which aimed at rapid growth in food grains production, increase in employment opportunities and productivity within the framework of basic tenents of planning, namely growth, modernization, self-reliance and social justice. Production of food grains increased

by 3.23 per cent compared to a long-term growth rate of 2.68 per cent between 1967-68 and 1988-89. To reduce unemployment and poverty, special programmes like ***Jawahar Rozgar Yojna*** were launched in addition to the existing programmes. Special attention was paid to small scale and food processing industries. The Gross Domestic Product (GDP) grew at an average rate of 5.8 per cent exceeding the targetted growth rate of by 0.8 per cent.

Annual Plans. The Eighth Five Year Plan could not take-off due to fast changing political situation at the centre. The new Government at the centre decided that the Eighth Five Year Plan would commence on 1st April, 1992 and that 1990-91 and 1991-92 would be treated and separate Annual Plans. The basic of the Annual Plans was on maximization of employment and social transformation.

Eighth Five Year Plan (1992-97). This plan was prepared in the backdrop of worsening inflation and Balance of Payments position. The Plan aimed at an average annual growth rate of 5.6 per cent and an average industrial growth rate of about 7.5 per cent. The salient features of this plan were (*a*) a faster economic growth, (*b*) a faster growth of manufacturing, agriculture and allied sectors, and (*c*) significant growth in exports and imports. Following programmes were initiated to achieve these goals :

(*i*) increase employment opportunities and achieve full employment by the end of 20th century;

(*ii*) control population growth with the cooperation of the people;

(*iii*) universalization of primary education and spread literacy among the people in age group 15-35 years;

(*iv*) providing drinking water and primary health services;

(*v*) development and diversification of agriculture for self-reliance in food grains and for export of agricultural commodities;

(*vi*) strengthen the infrastructure (power, transport, communication, irrigation), to sustain the tempo of growth.

The actual average annual growth rate was 6.8 per cent against the envisaged growth rate of 5.6 per cent.

Ninth Five Year Plan (1997-2002). The aim of this plan was to achieve the targeted GDP growth rate of seven per cent per annum and there was emphasis on seven identified **Basic Minimum Services (BMS).** These include (*i*) provision of safe drinking water; (*ii*) primary health services, (*iii*) universalization of primary education, (*iv*) public housing assistance to shelterless poor families, (*v*) nutritional support to children, (*vi*) connectivity of all villages and habitations, and (*vii*) streamlining the public distribution system with a focus on the poor. The plan also aimed at reduction in revenue deficit through a combination of improved revenue collections and control of inessential expenditures. Following steps were proposed to achieve the targets set in this plan :

(*i*) priority to agriculture and rural development for eradication of poverty and generating adequate employment;

(*ii*) accelerating the growth rate of economy with stable price;

(*iii*) ensuring food and nutrition security for all; particularly the vulnerable sections of society;

(*iv*) providing basic minimum services of safe drinking water, primary health care, universal primary education, shelter and road conductivity to all in a time bound manner;

(*v*) containing growth rate of population;

(*vi*) ensuring environmental stability;

(*vii*) empowering women, backward classes (scheduled castes, scheduled tribes, etc.) people belonging to minority communities as agents of economic and social change;

(*viii*) promoting and developing people's institutions like Panchayati Raj Institution, Cooperatives and self-help groups;

(*ix*) strengthening efforts to build self-reliance;

(*x*) strengthening foreign exchange.

Tenth Five Year Plan (2002-2007). This plan was approved by the National Development Council (NDC) which envisaged to double the per capita income in ten years and achieve a growth rate of eight per cent of GDP per annum. The plan also aimed at harnessing the benefits of growth to improve the quality of life by setting the following targets :

(i) Reduction in poverty rates from 26 per cent to 21 per cent by 2007.

(ii) Reduction in decadal population growth from 21.3 per cent in 1991-2001 to 16.2 per cent in 2001-11.

(iii) Growth in gainful employment, at least, to keep pace with addition to the labour force.

(iv) All children to be in school by 2003 and all children to complete five years of schooling by 2007.

(v) Reduce gender gaps in literacy and wage rates by 50 per cent.

(vi) Increase literacy rate from 65 per cent in 1999-2000, to 75 per cent in 2007.

(vii) Provide potable drinking water to all villages.

(viii) Reduction in infant mortality rate from 72 in 1999 to 45 in 2007.

(ix) Reduction in mortality ratio from 4 in 1979-2000 to 2 in 2007.

(x) Increase in Forest/Tree cover from 19 per cent in 1999-2000 to 25 per cent in 2007.

(xi) Cleaning the major polluted rivers.

The growth rate during this plan was 7.7 per cent against the target of 8 per cent.

Eleventh Five Year Plan (2007-2012). This plan provided a comprehensive strategy for inclusive development, building on growing strength of economy, while also addressing the weaknesses that have surfaced. It set a target for 9 per cent growth in five year period with acceleration during the period to reach 10 per cent by the end of the plan. It also covered 26 major indices of performance relating to poverty, health, education, women and children, infrastructure and environment.

The new priorities outlined in the plan relate to reviving dynamism in agriculture and building the necessary supportive infrastructure in rural areas, expanding access to health and education, especially in rural areas, undertaking programs for improving living conditions for the weaker sections and for improving their access to economic opportunity. Major thrust for infrastructure development was also included.

The plan provided a major expansion in irrigation and water management for increasing agricultural production. The National Food Security Mission aimed at increasing cereal and pulses production by 20 million tons over a period of five years.

In education, it was proposed to spend more than double the amount what was spent in the tenth plan. The plan aimed at providing improved broad based health care in rural areas through the National Rural Health Mission. The *Rashtriya Swasthya Bima Yojna* provided insurance cover against illness to the population below poverty line.

The Plan improved the need for energy conservation, increasing energy efficiency, and development of renewable sources of energy.

Achievements of Five Year Plans. Although Five Year Plans have failed to achieve the fixed targets, yet the constructive role played by these plans in the socio-economic development of the country cannot be under estimated. Some of the major achievement of these plans are listed below :

1. During the period from 1950-51 to 2002-03, the national income—Net National Product (NNP) has increased 8.7 times from ₹ 1,32,367 crore to ₹ 11,56,714 crore (at 1993-94 prices) implying a compound growth rate of 4.2 per cent per annum.
2. The per capital income had increased three times from ₹ 3,687 to 10,964 (at 1993-94 prices) registering a compound growth rate of ₹ 2.1 per cent.

Table 14.1 gives the targets and actual achievements right from the First Five Year Plan to the Eleventh Five Year Plan. This table shows that the economy has performed better than the target in five of the first nine plans and even in the Second Five Year the gap was not very large. In the Third and the Fourth Five Years Plans shortfalls were due to severe drought conditions in 1965 and 1966 and the Indo-Pakistan war of 1965. The Fourth Five Year Plan experienced three consecutive years of drought (1971-73) and increase in oil prices in the international market in 1970. After the Fourth Plan, there had been a steady improvement in the growth rate of economy until the Ninth Five Year Plan when it received setback.

TABLE 14.1. Growth Performance in the Five Year Plans

(Per cent per annum)

Sl. No.	Plan	Target	Actual
1.	First Plan (1951-56)	2.1	3.60
2.	Second Plan (1956-61)	4.5	4.21
3.	Third Plan (1961-66)	5.6	2.72
4.	Fourth Plan (1969-74)	5.7	2.05
5.	Fifth Plan (1974-79)	4.4	4.83
6.	Sixth Plan (1980-85)	5.2	5.54
7.	Seventh Plan (1985-90)	5.0	6.02
8.	Eighth Plan (1992-97)	5.6	6.68
9.	Ninth Plan (1997-2002)	6.5	5.5
10.	Tenth Plan (2002-2007)	8.0	7.7
11.	Eleventh Plan (2007-2012)	9.0	—

Note : The growth targets for the first three plans were set with respect to National Income. In the Fourth Plan, it was the Net Domestic Products. In all plans thereafter, it has been the Gross Domestic Product at factor cost.

Source **:** India 2014 : A Reference Annual, p. 671.

3. Impressive industrialisation in capital goods sector through public sector.
4. Development of economic infrastructure including improvement in energy, irrigation, transport and communication.
5. Large scale diversification in international trade (both exports and imports).
6. Rise in the life expectancy from 37 years in 1951 to over 66 years in 2010.
7. Literacy rate increased from 18.33 per cent in 1951 to 74.04 per cent in 2011.
8. Development of science and technology and nuclear power for peaceful purposes.
9. Achievement of self-sufficiency in foodgrains and full food security. Per capita cereal consumption increased from 417.6 grams per day in 1971 to 468.9 grams per day in 2013. (Economic Survey 2013-14, Statistical Appendix, p. 21).

Failures of Five Year Plans. Although Five Year Plans have succeeded on many fronts and have contributed a lot to improve the living a conditions of the masses, yet these plans have failed miserably to achieve some important objectives as described briefly below :

1. Plans failed to evolve a society free from exploitation.
2. India has still not been able to evolve a society based on equity and social justice.
3. India has failed miserably to eradicate poverty. Even as late as 2011-12 as much as 21.9 per cent of the total population of India was living below poverty line. In rural areas, it was still higher at 25.7 per cent (Economic Survey 2013-14, p. 233).
4. Plans could not succeed in reducing hunger, malnutrition, unemployment, child labour and social injustice as targetted in the plans.
5. Gender discrimination still prevails and women are deprived of their fundamental rights. Sex ratio has fallen from 946 in 1951 to 940 in 2011.
6. A lot of black money has been generated and this black money is running a parallel economy in the country.
7. Not much success has been achieved to control the population growth through Five Year Plans. The benefit of economic growth is not available to the common man and big industrialists, traders and politicians are the main beneficiaries.
8. The pace of land redistribution and land reforms has been tardy which has adversely affected agricultural growth.
9. Planing has not been able to remove or even reduce—economic, social and regional inequalities.
10. Plans have failed to achieve the target of balanced regional development.

Regional Planning

As national planning is concerned with the development of the entire country, regional planning is concerned with the development of a particular region. It is neither economic planning alone, nor physical planing alone. Instead, it is such a planning whose core area of interest lies in the synthesis of physical, social, economic, political *et al.* interests of the concerned region. Thus regional planning is a specific type of planing, based on a specific planning structure (regional system), for inducting pubic action aimed at social well being. It implies that regional planing is concerned fundamentally with the society in the context of space (Chandna, 2008 : 33). Regional planning is concerned both with space and society as both are intimately interwoven with each other and form the basis of regional planning. Regional planning is, thus, a specific type of planning, based on a specific planning structure, the primary aim of which is the well being of the society and improvement in living standard. A regional planner is supposed to reorganise or reshape the regional system in such a way that the regional plan is able to serve the society to the best. Regional planning while confining to the planning of regional space can hardly afford to overlook the economic, socio-cultural and political dimensions of the ever evolving regional organism. Right location of each of the economic activities is the main concern of a regional planner.

Principles of Regional Planning

Regional planning is guided by the following seven principles :

1. The principle of vertical unity of phenomena
2. The principle of horizontal spatial unity
3. The principle of space-time continuum
4. The principle of comprehensive development
5. The principle of community development
6. The principle of equilibrium between social desirability and economic viability
7. The principle of ecological equilibrium.

1. The Principle of Vertical Unity of Phenomena. The principle of vertical unity of phenomena means that are phenomena in a region are inter-related and no single phenomena can change independently without influencing the other phenomena. **Figure 14.2** shows that vertical phenomena consists of four different spaces. On the base is the *real physical* space relating to lithosphere, hydrosphere and atmosphere (both known and unknown). On the real physical space, lies perceived physical space, as perceived by the regional planner. It may consist of all known physical phenomena concerning lithosphere, hydrosphere and atmosphere. Above the perceived physical space lies the human space consisting of all sorts of human phenomena enamating from the demographic structure. The interaction between the physical space and the human space gives rise to economic space. **Figure 14.2** shows the economic space, the human space and the physical space get integrated with each other. It implies that we have to realize the vertical unity of all phenomena and planning for any single phenomenon independent of other phenomena will not be in the real spirit of regional planning.

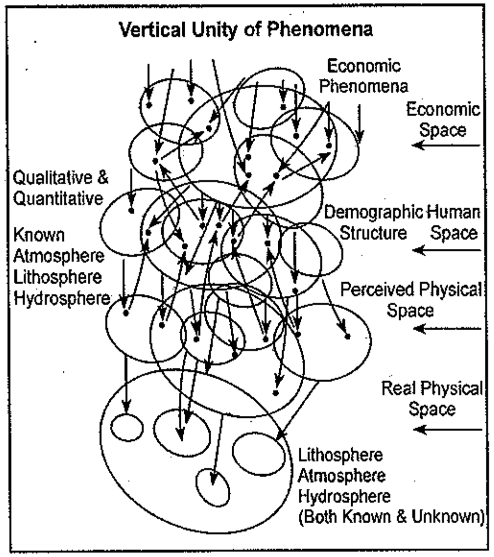

FIG. 14.2. Vertical unity of Phenomena

2. The Principle of Horizontal Spatial Unity. According to this principle, each region is a sub-system of the regional system whole. This means that different regions constituting the regional space do not exist in isolation, rather they co-exist in integration with each other as a part of the regional system whole.

The human body provides the best illustration of such an integration between sub-systems and the system. The entire human body as a whole functions

as a system, which consists of a number of sub-systems like digestive system, renal system, respiratory system, nervous system etc. Each one of them constitutes a complete system in itself and yet is a sub-system of the body whole. If something goes wrong with any of these sub-systems say the digestive system, it will affect the functioning of the entire human body, as the person may fall sick and may not be able to perform even day to day functions. (Chandna, 2008 : 50)

Similarly a region may be a complete system in itself and yet may constitute a sub-system in the regional system whole. One thing happening in a region affects the regional system whole because all the regions are integrated with the whole just as different parts of the human body are integrated with the whole body. **Figure 14.3** shows how a single regional unit gets integrated with other regional units of a nation—state and the nation-states getting integrated with the international space.

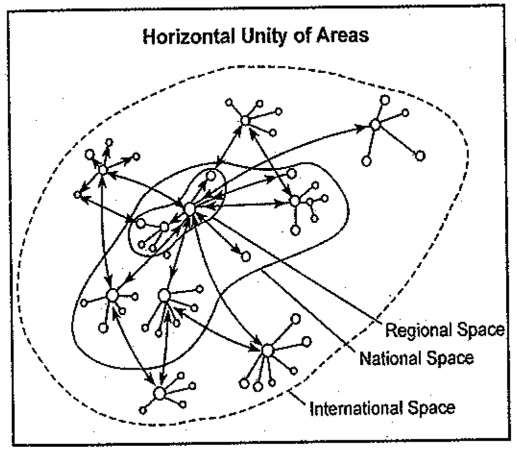

FIG. 14.3. Horizontal Unity of Areas

Thus the principle of horizontal spatial unity implies that planning for any region cannot be done in isolation from the adjoining regions within the same nation. Similarly, the planning within the national space cannot be done in isolation from planning in international space. Therefore regional planning amounts to planning in universalism.

3. The Principle of Space-time Continuum. According to this principle, spatial reality has four dimensions of which three dimensions (length, breadth and thickness) are of space and the fourth dimension is that of time. Also space and time cannot be separated from each other and time is considered as an integral part of space. A region is a living dynamic identity which operates simultaneously in the past, present and future like the human body's DNA. It uses the past experience for the present and preserves energy for the future. Therefore, the regional planner has to realise the fact that regional space is a continuously growing organic whole and the region changes through time not only in terms of space-content but also in terms of space relationships. Thus, the regional planner should be conscious of the fact that while he is planning in space, be is planning in time also.

4. The Principle of Comprehensive Development. This principle means that regional planning seeks to achieve the comprehensive development of the entire region, the regional system in its entirely. In other words, the regional planner seeks comprehensive development of all sectors of economy along with all segments of society.

5. The Principle of Community Development. This is the principle of equal opportunities to all for self development. The entire community is considered as an organic whole in which each individual is a sub-system of this whole. It is only through equal opportunities (like education, health, employment, etc.) to each individual that the whole society can be developed into community with the sense of belonging to each other.

6. The Principle of Equilibrium between Social Desirability and Economic Viability. According to this principle, the regional planner is supposed to maintain a balance between what is socially desirable and economically viable while planning for comprehensive development of all regions. This means that the regional planner has to consider the potentialities of the regional economy and society while creating hospitality in the regions of human occupance.

7. The Principle of Ecological Equilibrium. This principle seeks adherence to the maintenance of ecological balance. The regional planner has to assure the sustainability of ecology and environment. It means that he has to develop the regional space at his disposal only within the framework of ecological equilibrium. In simple words all the development plans in the region should be carried out in harmony with nature and without disturbing the ecological balance.

REGIONAL PLANNING IN INDIA

As mentioned earlier, the basic postulates of planning in India were conceived and formulated during the heat of India's freedom struggle and the First Five Year Plan was launched in 1951 *i.e.* within four years of India's Independence. The primary objectives of the plan were accelerating the pace of economic and social development, elevating poverty and unemployment and improving the standard of living. However, planning process in India remained highly centralised for most of the plan period barring a few exceptions here and there. The chief components of planning machinery in India include :

(*a*) Planning Commission of India handed by the Prime Minister of India as its Chairman and having a full time Deputy Chairman. It was constituted in 1950 as an advisory as well as executive body. The main functions of the Planning Commission are :

(*i*) to formulate five year annual plans;

(*ii*) to supervise the work of national planning;

(*iii*) to consider the national plans formulated by the Planning Commission;

(*iv*) to recommend measures for achieving the targets set out by the plans;

(*v*) to review the working and to monitor the plans from time to time.

(*vi*) to encourage people's participation in the planning process.

(*b*) The National Development Council, and

(*c*) State Level Planning Boards for each state.

Unfortunately no recognition worth the name was given to regional planning in the first two Five Year Plans (from 1950-51 to 1960-61). Following could be the probable reasons for this complete negligence of Regional Planning in the early phase of planning period :

(*i*) There was no serious attempt to identify a regional scheme or a set of regions, which could form the basis of the planning activity in the country.

(*ii*) The leaders who took the reigns of the country immediately after Independence were perhaps too enthusiastic and too keen to initiate the process of planned development that could not wait for discovering the existing regional system/real region nature.

(*iii*) Perhaps the leaders of that time could not appreciate the utility of planning process based on regional system.

(*iv*) The leadership of the early plan period probably believed that as the developmental process starts, the new regional system may emerge in the country which could form the basis of future regional planning process.

The regional or spatial planning process in the country was most probably incorporated in the Third Five Year Plan when the philosophy of balanced regional development got appended to the era of Five Year Plans. Even during and after the Third Five Year Plan, the concept of Regional Planning could not much influences our planners because our plans are still conceived and termed as Five Year or Annual Plans rather than Regional Plans devised for different regions. Our planners have probably failed to realise the fact that identification of a regional scheme is fundamental to any regional planning. After the identification of a regional scheme, preparation of plans for each region has to be made. Care has to be taken that plan for any region is not to be prepared in isolation, rather in integration with other regions so as to achieve a comprehensive plan for the entire country.

The Planning Commission should supervise the process of regional planning at the regional level. Establishment of State Planing Boards at the state level is a step towards decentralisation of the country's planning and also to incorporate the spatial dimension to the planning process. In some of the states like Punjab, the State Planing Boards have taken a step forward to formulate the district level plans and even the block level plans.

Most of the Regional Plans are prepared according to the political boundaries of the states because official data are available according to the political divisions only. But political boundaries do not always coincide with the geographical boundaries and a planning process based on such political boundaries rarely succeeds. The Damodar Valley Corporation (DVC) and the National Capital Region (NCR) are two such examples which do not follow political boundaries. The Damodar Valley spreads over Jharkhand and West Bengal whereas the National Capital Region coves large areas of Union Territory of Delhi, Haryana, Uttar Pradesh and Rajasthan. Development plan for DVC has met with partial success while NCR plan has almost completely failed to achieve the target and serve the planned purpose.

The 73rd and 74th amendments in the Indian Constitution have given a new direction to the planning process in India. The primary aim of these amendments is to introduce the planning process at the grass-root level by involving Panchayats for identifying the problems at the grass-root level and initiate decentralisation of the entire planning process. Till now, not much success has been achieved as many states have shown likewarm interest in involving the village Panchayats in the planning process.

The 73rd and 74th constitutional amendments have provided for fund collection by the Panchayats at the local level for local development for which state governments are supposed to provide matching giant. Till now, not even a single state government has taken any initiate to generate resources at the Panchayat level. At the maximum the Panchayats can identify the problems at the local level which can provide guidelines to our planning process.

Unfortunately, no one at the administrative level is willing to share any power which creates great practical hindrances in decentralisation of the planning process and give much needed thrust to regional planning. The success of regional planning primarily depends upon :

(*i*) quality of planing education

(*ii*) degree of public awareness about the rationale for a planned effort

(*iii*) efficiency of planning institutions, and

(*iv*) proper comprehension and appreciation of the basic issues involved in regional planning by society itself.

In India, regional planning is still at its nascent stage and is not very popular with our planners. It has a long way to go in terms of its content and implementation before it is able to show its utility and be of some use to people at the regional level.

Integrated Rural Development Programmes

The integrated rural development programme was launch in 1977 when Janta Party formed the government at the centre after defeat of the Congress Party. This programme was initially implemented in 2000 blocks out of a total of 5004 blocks at that time. Its broader version was presented in 1978-79 through which 2300 blocks were benefitted. Another 300 blocks were brought under this programme in 1979-80.

The main objective of this programme was to provide employment opportunities to the poor rural people and to increase their assets for which provision for financial assistance was made. This programme covered poor people living below poverty line, which included small and marginal farmers, agricultural labourers, scheduled castes and scheduled tribes and economically backward people having an annual income of less than ₹ 11,000 at the time of the Eighth Five Year Plan. With a view to give maximum benefit to the most vulnerable families, it was decided that at least 50 per cent of the families should be from the scheduled castes and scheduled tribes. Besides, reserved benefit was 40 per cent for women and 3 per cent for handicapped people. Families rather than persons were selected and among families too, women were given priority.

The Integrated Rural Development Programme was implemented at the grassroot level through District Rural Development Agencies (DRDA) and Block Level Agencies (BLA). DRDA was established in April 1, 1999 with the objective of strengthening the programme. The funding pattern of the DRDA administration is in the ratio of 75 : 25 between the Centre and the States for non-NE States and 90 : 10 for NE-States. In the case Union Territories, it is hundred per cent under the scheme. The governing body DRDAs include local MPs, MLAs, Chairman of Zila Parishad, Heads of District Development Departments, representatives of Scheduled Castes and Schedule Tribes, and women. Staff of blocks is responsible for implementing the programme on the grassroot level. At the state level, this programme is implemented by the State Level Coordination

Committee. Ministry of Rural Areas and Employment is responsible for providing financial assistance, framing policies, guiding the implementation of policies, and evaluating the programme at the central level. Some of the important programmes are National Rural Employment Programme (NREP), Training of Rural Youth for Self-Employment (TRYSEM), Development of Women and Children in Rural Areas (DWCRA), *Indira Awas Yojna* (IAY), Council for Advancement of People Action and Rural Technology (CAPART), *Jawahar Rojgar Yojna*, the *Ganga Kalyan Yojna*, etc.

Some of the important projects initiated under Integrated Rural Development Programmes are briefly describe as under :

1. Training of Rural Youth for Self-Employment (TRYSEM). Initiated on 15th August, 1979, this is an integral part of IRDP. Young people in the age group of 18-35 years are selected to become skilled workers and they are imparted technical training also. They are trained in such a way that they become capable of starting their own work for self employment. Young people are selected form families having income less than ₹ 3,500 per annum and poorest of the poor are given priority. Only one member is selected from each family. Preferential treatment is given to people belonging to Scheduled Castes, Scheduled Tribes, Ex-Army men and also those people who have participated in the National Adult Education for nine months.

2. Supply of Tools Kits in Rural Areas (SITRA). This scheme aims at providing quality implements to rural artisans so that they are able to improve quality and increase quantity of their products. As many as 7.46 lakh kits of implements costing ₹ 14.8 million were distributed among the rural artisans during 1992-93 to 1997-98.

3. Development of Women and Children in Rural Areas (DWCRA). This programme aimed at improving the income levels of women belonging to poor families. Groups of 5 to 10 women are constituted so that they can help each other in work and increase their income. The programme is based on equal contribution by the central and state governments as well as by UNICEF. Basic facilities like womens' health, education, children care and nutritional food are also provided.

4. Council for Advancement/Peoples Action and Rural Technology (CAPART). Set-up on 1st September, 1986, it is an autonomous organisation under the Ministry of Rural Development and acts as a funding agency for voluntary organisations. Its primary objective is to promote voluntary action through community participation and to propagate rural technologies for the benefit of downtrodden people (SC/ST/OBC and others) living in rural areas.

5. Jawahar Rojgar Yojna. This scheme came into being by the merger of National Rural Employment Programme (NREP) and Rural Landless Employment Guarantee Programme (RLEG) in April, 1989. The primary object of this scheme is to provide additional employment opportunities to unemployed and under-employed men and women and to increase their assets. Besides, this scheme aims at improving the living conditions of the villagers and to provide sustainable employment. The funding by the centre and the state governments for this scheme are in the ratio of 80 : 20. For schedule caste and schedule tribes, 22.5 per cent of the allocation is reserved. The other components of this scheme are assistance to wards of child labourers living below poverty line, disabled and food for work. This scheme was further strengthened in the Ninth Five Year Plan so that it could work more effectively.

6. Indira Aawas Yojna (IAY). This scheme was started as a sub-scheme of Jawahar Rojgar Yojna in May, 1985. It aims at providing financial assistance to extremely poor people belonging to SCs/STs, for constructing their houses and for repairing the dilapidated *kutcha* houses. Since 1995-96, this benefit has been extended to war windows and retired workers of military and para-military forces, subject to their qualifying the laid conditions. About 3 per cent of the allocated funds has been reserved for disabled people living below poverty line. People living below poverty line and belonging to minority communities have also been included among the beneficiaries from this scheme.

IAY is being implemented across the country (except Delhi and Chandigarh) and funding for this scheme is shared between the centre and the states in the ratio of 75 : 25. In case of union territories, the entire fund is provided by the centre. In case of north-eastern states the funding ratio between the centre and states is 90 : 10. With effect from April 1, 2010, the

ceiling on construction assistance under IAY scheme is ₹ 45,000 per unit in the plain areas and ₹ 48,500 in the hilly/difficult areas. For upgrading *kutcha* house, the financial assistance to ₹ 15,000 per unit.

During 2010-11, as against the target of constructing 29.69 lakh houses, only 14.57 lakh houses were constructed. Since its inception, about 286.88 lakh houses have been constructed with an expenditure of ₹ 85141.13 crore.

7. Swarnajayanti Gram Swarojgar Yojna/ National Rural Livelihood Mission (NRLM). This scheme was launched on 1st April, 1999 and is designed as a holistic self employment scheme aimed at providing sustainable income to rural BPL (below poverty line) families through income generating assets/economic activities so as to bring them above the poverty line. Thrust is on empowerment of the vulnerable sections of the society, is 50% for SC/STs, 40% for women, 15% for minorities and 3% for disabled persons.

Assistance under Swarnajayanti Gram Swarojgar Yojna to individuals or Self Help Groups (SHGs) is given in the form of Revolving Funds Assistance and Capital Subsidy by the government linked credit by the banks. Since its inception upto March, 2012, 43.34 lakh SHGs have been formed and 14.46 lakh SHGs have taken up economic activities.

8. Employment/Assurance Scheme. Poor labourers do not get any employment during the lean season in agricultural operations. The Government of India launched scheme for employment assurance on 2nd October, 1993 in some selected blocks. National Rural Employment Guarantee Act was passed which was implemented for 200 most backward districts of the country in its first phase. In the second phase, it was implemented for 130 districts in 2007-08 and for 274 districts in the third phase after 1st April, 2008.

This is the first law which guarantees employment opportunities to the poor people on such a large scale. Its other aims are to provide safety against droughts, deforestation, soil erosion etc. for sustainable growth. These are some of the factors responsible for poverty.

9. Million Wells Scheme. This programme was started in 1988-89 as a sub-programme of National Rural Employment Programme (NREP) and Rural Landless Employment Guarantee (RLGP). It continued to work as a sub-programme of Jawahar Rojgar Yoja from 1st April 1989 to 31st December 1995 and became a full-fledged independent programme on 1st January, 1996. The main purpose of this scheme is to provide irrigation facilities to small and marginal farmers living below poverty line and to bonded labourers who have been freed from the clutches of their masters. This scheme was basically meant for people belonging to SCs and BCs but poor people belonging to other castes were also included in 1993-94. There is provision for 3% reservation for physically handicapped persons. Panchayati Raj organisations are doing a wonderful job preparing the list of beneficiaries from this scheme.

10. Ganga Kalyan Yojna (GKY). This programme was initiated by the Central Government on 1st February 1997 to provide irrigation facilities to small and marginal farmers or groups of such farmers living below poverty line by utilising ground water through wells and tube-wells. The finances for this programme are provided by government subsidy or financial organisations. The funding ratio between the Centre and the States is 80 : 20. Priority is given to SCs and BCs.

11. National Social Assistance Programme (NSAP). Started on 15th August, 1995, this programme has the following three components :

(*i*) old age pension of ₹ 75 per month to people of age 65 years and above.

(*ii*) one time financial assistance to those families which have lost their only earning member; ₹ 5,000 in case of natural death and ₹ 10,000 in case of accidental death.

(*iii*) financial assistance to pregnant women living below poverty line for the birth of first two children under National Maternity Benefit Scheme (NMBS), provided the women is above 19 years of age.

12. Total Sanitation Campaign (TSC). Rural sanitation came into focus of the Government of India during the World Water Decade of 1980s. The Central Rural Sanitation Programme (CRSP) was started in 1986 for providing sanitation facilities in rural areas. Following are the main objectives of this campaign :

(i) Bring about an improvement in the general quality of life in the rural areas.

(ii) Accelerate sanitation coverage in rural areas.

(iii) Generate felt demand for sanitation facilities through awareness creation and health education.

(iv) Cover schools/anganwadis in rural areas with sanitation facilities and promote hygiene education and sanitary habits among students.

(v) Encourage cost effective and appropriate technologies in sanitation.

(vi) Eliminate open defection to minimise risk of contamination of drinking water sources and food.

(vii) Convert dry latrines to pour flush latrines, and eliminate manual scavenging practice, wherever it is in existence in rural areas.

Panchayati Raj and Decentralised Planning

It is a strongly believed that Panchayati Raj is a very powerful weapon for rural economic, social and cultural development and also for decentralisation of rights and taking the process of democracy to the common and most humble mean of the rural community. This enables people to become a part of the development process and increases the possibility of decentralised planning. Panchayati Raj is an important medium of politics, administration and planning.

India has a very old tradition of forming panchayats. Panchayats were recognised as the local unit of administration right from the beginning of the British rule in India. Later on, the Britishers tried to strengthen the institution of Panchayati Raj to divert the attention of our national leaders from the demand of complete Independences.

Mahatma Gandhi often used to say that real India lives in villages and the country cannot grow as a nation until the life style of the villagers is not improved. About one-third of our villages had Panchayats when India got freedom in 1947. The Congress Government at the centre took immediate steps to strengthen village Panchayats after Independence. The 40th amendment in the constitution in 1950 stated that "The state shall take steps to organise village panchayats and to endow them with such powers and authority as may be necessary to enable them to function as units of self-government."

Programme of Community Development was started in the year 1952 which aimed at infusing awakening among the rural folks about economic planning and social reconstruction. But this programmer could not yield the desired results. Consequently Block Advisory Committees were constituted which were renamed as Block Development Committees. This step also did not get much success. Then it was realised that the rural masses will not take interest in any scheme unless they are directly involved in framing and implementing any development programmes. Balwant Rai Mehta Committee was constituted to remove the shortcomings in the Panchayati Raj (See box).

> A Committee to study the Panchayati Raj was constituted in 1957 under the chairmanship of Sh. Balwant Rai Mehta and it is known as Balwant Rai Mehta Committee. This committee submitted the report by the end of 1957. The report said that such programmes can succeed only if the local people at the village level are involved in it. It was recommended the Panchayati Raj institutions should be constituted immediately for decentralisation of democracy and development of the community.
>
> Following were the main recommendations of this committee :
>
> 1. There should be three tier Panchayati Raj from village to district level. Gram Panchayat at the village level, Block Samiti at the Block level and Zila Parishad at the district level, they should be inter-related to each other.
> 2. Their rights and duties should be well defined.
> 3. They should have sufficient resources to discharge their duties in the desired manner.
> 4. Programmes regarding social and economic planning should be executed through these institutions.
> 5. In future all the facilities, rights, responsibilities and resources should be transferred under the Panchayati Raj system.

The National Development Council accepted the recommendations of the Mehta Committee report in 1958 and different states started implementing the Panchayati Raj scheme.

Various Patterns of Panchayati Raj Institutes

Different states have different patterns of Panchayati Raj institutions. Some states have three tier panchayats at the village, block and district level while some states have two tier panchayat at the village and block levels and still some other states have only one tier Panchayati Raj.

Panchayati Raj was formally inaugurated by Pandit Jawaharlal Nehru on 2nd October, 1959 in Nagaur district of Rajasthan. It had three constitutional parts *viz.* Gram Panchayat, (*ii*) Panchayati Samiti and (*iii*) Zila Parishad. This system worked for about three decades after which Maharashtra and Gujarat also constituted three tier Panchayati Raj.

Karnataka introduced a system of Panchayati Raj under 1985 Ordinance which was different from the recommendations of Mehta Committee. The three tier system accepted by this state consisted of Zila Parishad at the district level, Taluka Panchayat Samiti at block/taluka level and Mandal Panchayat at mandal level.

Achievements of Panchayati Raj Institutions. Spatial and temporal changes keep on occurring in the structure of Panchayati Raj. For example, there are changes from time to time in tiers and duties of Panchayati Raj institutions. In Andhra Pradesh, Panchayati Raj institutions have done a wonderful job in the basic fields like education and health. In Rajasthan, these institutions play a major role with respect to development at the initial stage. Panchayati Raj institutions in Tamil Nadu did a commendable job in the fields of education, water supply, roads and nourishment. In Maharashtra and Gujarat, these organisations worked very hard for decentralisation of planning.

The greatest achievement of Panchayati Raj institutions is that villages have got rid of fear psyche and are no longer affairs of government officers. They can easily and directly talk to the concerned Block Development Officer (BDO) and get solution to their problems. The main purpose of constituting panchayat was to develop self confidence among the villagers, provide them with basic facilities of life and persuade them to come forward for planning and development. Panchayati Raj has infused awareness about development, planning and democracy and now they can take their own decisions and prepare programmes which are beneficial for them.

The Features of Panchayati Raj

Many weaknesses have been observed in Panchayati Raj during the last few decades as a result of which many failures of this system have come to light. Some of the major failures are listed below.

1. Lack of Conceptual Charity. The greatest drawback of Panchayati Raj system is the lack of conceptual clarity. Some scholars recognise it just an administrative agency while others treat it as spread of democracy at the grass root level. Still some others see it as government at the rural level. All these concepts work simultaneously which creates hinderance in the developing of a clear and universally accepted concept.

2. Lack of Political Will. Critical analysis of the working of Panchayati Raj has revealed that these organisations do not have sufficient resources, their activities are insufficient and not upto the mark and proper attention is not paid to them. Because of these factors the achievements of Panchayati Raj institutions are not upto the desired level. Such a situation is largely attributed to lack of will power. In certain states, the Panchayat elections are not held at the scheduled time and often the elected panches are ignored. Normally, MPs and MLAs work against the elected members of the gram panchayats and the grassroot problems are often ignored. Generally the political leaders cultivate a feeling that the panchayat members are working against their interests. In such a scenario, the panchayat members are not able to receive political support and proper action is not taken on their plans.

3. Role of Bureaucracy. Bureaucracy in India enjoys immense powers and bureaucrats often deprive panchayat members of their role in the development process. Most of the government officers do not like to work under panchayat members and consider themselves as representatives of the government, rather than as part of the development mechanism.

4. Disillusionment about structural functioning. In most panchayats, only the wealthy and influential people get elected and those people do not bother much about the interests of the poor and downtrodden. Due to panchayat elections, the villagers are often divided into political and social groups which leads to frequent and sometimes serious disputes. Such a situation creates great obstacle in the path to progress and the primary aim of Panchayati Raj is ignored.

In addition to the above mentioned factors it is felt that planning is priority the job the planner and interference by panchayats causes shortcomings in planning and retards the pace of progress.

Ashok Mehta Committee

As a result of 1977 general elections, Congress Party was defeated and Janata Party come to power at the centre. In December 1977, the Janata Party Government at the centre constituted a 14 member Committee with Ashok Mehta its chairman. The report submitted by this Committee in August, 1978 said that it was wrong to think that Panchayati Raj does not cooperate in the process of development. Panchayati Raj has achieved many successes but they are not given much opportunities to be a great instrument of development. Panchayati Raj institution should be constituted in such a way that it becomes a strong medium of economic, social and political development through peoples' participation.

RECOMMENDATIONS OF ASHOK MEHTA COMMITTEE

Report submitted by Ashok Mehta Committee made about 132 recommendations. The main recommendations pertained to (*a*) functional necessity for decentralization of administration through under democratic supervision; (*b*) two-tier system of Panchayati Raj *viz.* the revenue District assuring the technical expertise of high order required for rural development and the Mandal Panchayat to be constituted by grouping a number of villages; (*c*) the Panchayati Raj Institutions to have compulsory powers of taxation and mobilize their own resources, thus reducing their dependence on diversion of funds from the state government. Certain taxes collected from the area such as provision tax, entertainment tax and special tax on land and building be transferred to Panchayati Raj Institutions; (*d*) open participation of political parties in Panchayati Raj affairs; (*e*) the creation of certain economic groups in the villages; (*f*) a regular social audit by a district level agency as well as a committee of legislators to check whether funds earmarked for these social and economic groups are actually spent on them; (*g*) the State legislators will have a committee on Panchayati Raj with adequate representation for schedule castes and tribes to cater to their needs and mitigate grievances of the weaker sections; (*h*) the State Government must not supersede the Panchayati Raj Institutions on partisan grounds. In case of an imperative suppression, election must take place within six months; (*i*) provision of urban amenities such as roads, potable water, medical care, employment and education in rural areas to neutralise pull for immigration to urban centres.

50 PER CENT RESERVATION FOR WOMEN

The central cabinet passed a resolution on 27th August, 2009 according to which 50 per cent seats in panchayats are reserved for women. According to data released in 2009, there were 28.18 lakh elected representative in Indian panchayats out of which 36.87 per cent were women. After this resolution, more than 14 lakh women are supposed to the members of panchayats.

Command Area Development

An area reserved by canals, wells, tube wells, tanks etc. for irrigation is known as command area. The irrigation potential created is not used to its optimum due to the following reasons :

1. Proper basic structure for carrying water from its source so the agricultural fields—like channel, drainage etc. is lacking.
4. There is lack of proper agricultural system according to the ecological conditions.
3. There is lack of awareness on the part of farmers.
4. Lack of proper maintenance of canals results in loss of water.
5. There is over irrigation in areas near the source of canals which leads to water logging, salinity and alkalinity of vast area on one hand and shortage of water at the tail of the canals and agricultural fields do not get sufficient water.

Keeping in view the above problems, the Central Government started Command Area Development (CAD) programme in 1974-75 with the objective to bridge the gap between irrigation potential created and utilized through micro level infrastructure development for efficient water management and enhancement of agricultural production and productivity so as to improve socio-economic conditions of the farmers. This programme is implemented by Area Development Authority. Specialists from different departments work under this authority which makes it easy to achieve the fixed targets.

This programme was initially applied to Indira Gandhi Canal Command Area in 1974. In the Fifth Five Year Plan, 38 Area Development Authorities were constituted for 50 irrigation projects. These authorities provided irrigation facilities to 12.4 million hectares spread over 108 districts in 13 states. So far it has covered 332 irrigation projects with a Cultivable Command Area of nearly 29 million hectares.

Following are the main objectives of this programme :

1. Influential farmers with large expanses of land at their disposal get the maximum benefit of irrigation facilities and a small and marginal farmers are often deprived of irrigation facilities which they rightly deserve. ***Warabandi*** was introduced to solve this problem. It is a rotational system which assures equitable and timely supply of water to all farmers irrespective of the size of their holdings. This programme is implemented with the help of Panchayat Samities.
2. Construction of field channels and field-drains to reduce the pilferages and mis-use of water and making sure of effective use of water for irrigation. Central assistance up to 50 per cent (limited to the prescribed cost norms) is provided for irrigation and field-development activities.
3. Land has to be levelled so that water is spread uniformly in the agricultural fields.
4. Giving proper shape to fields and their boundaries through consolidation of holdings so that the objective of optimum utilisation of water is achieved. Simultaneously provision of **chak roads** is also essential.
5. Educating farmers through demonstrations and imparting technical training for adopting new agricultural innovations and adopting cropping patterns according to natural environment as well as improving farming practices and maintaining fertility of soil.
6. Preparing plan for supply of inputs, credit, seeds, fertilisers, insecticides and pesticides to the farmers.
7. Promoting ancillary activities such as animal husbandry, forestry, poultry, marketing and processing facilities.
8. Updating land records.
9. Diversifying agriculture to make it more profitable.
10. To lay more emphasis on the cultivation of more remunerative crops like oil-seeds, pulses, green-manure crops.
11. To use ground water for compensating the shortage of surface water.
12. Reclamation of the water-logged, saline and alkaline areas rendered uncultivable due to over irrigation by canals.
13. To introduce participatory management of irrigation.

The Command Area Development programme was restructured and renewed as Command Area Development and Water Management (CAD&WM) with effect from 1st April, 2004. During the mid-term appraisal, the Planing Commission has emphasised the need for implementing CAD and WM programme *paripassu* with creation of infrastructure. Under this programme, financial assistance is being provided to the State governments on 50 : 50 basis for construction activities and on 75 : 25 basis to carry out training programmes for field functionaries/ farmers, monitoring, evaluating, adaptive trials and demonstration.

At the initial stage, 60 major and medium irrigation projects were taken up under the CAD programme, covering a Culturable Command Area (CCA) of about 15.0 million hectares. At present there are 145 projects covering a CCA of 16.02 million hectares. The scheme had been implemented as a State Sector Scheme during the Eleventh Five Year Plan (2008-09 to 2011-12).

An area of about 18.06 million hectares was covered under the programme, upto the end of March, 2007 and another 1.62 million hectares have been covered between March 2007 and March 2011.

The National Water Policy, 2002, stresses on participatory approach in water resources management. There is a great realisation of the fact that participation of beneficiaries greatly enhances the optimal use of the irrigation facilities and proper use of irrigation water. The participation of farmers in the management of irrigation would give responsibility for operation and maintenance, collection of water charges from the areas under the jurisdiction of Water Users Associations (WUAs) and redressal of petty grievances.

Reports from various states reveal that the CAD programme has made positive impact on some important indicators, like increase in irrigated area, productivity and production, irrigation efficiency etc. In spite of all these efforts, the problem of water logging has been reported in many irrigated commands. For reclaiming the water logged areas, 579 schemes in 9 states *viz*. Bihar, Gujarat, Madhya Pradesh, Jammu and Kashmir, Karnataka, Kerala, Odisha, Maharashtra and Uttar Pradesh have been approved for reclaiming 78.81 thousand hectares of water logged area; of which about 52.11 thousand hectares of water logged area has already been reclaimed.

Indira Gandhi Canal Command Area Development Programme

Indira Gandhi Canal Project is a living example of man's effort to transform a desert land into a green

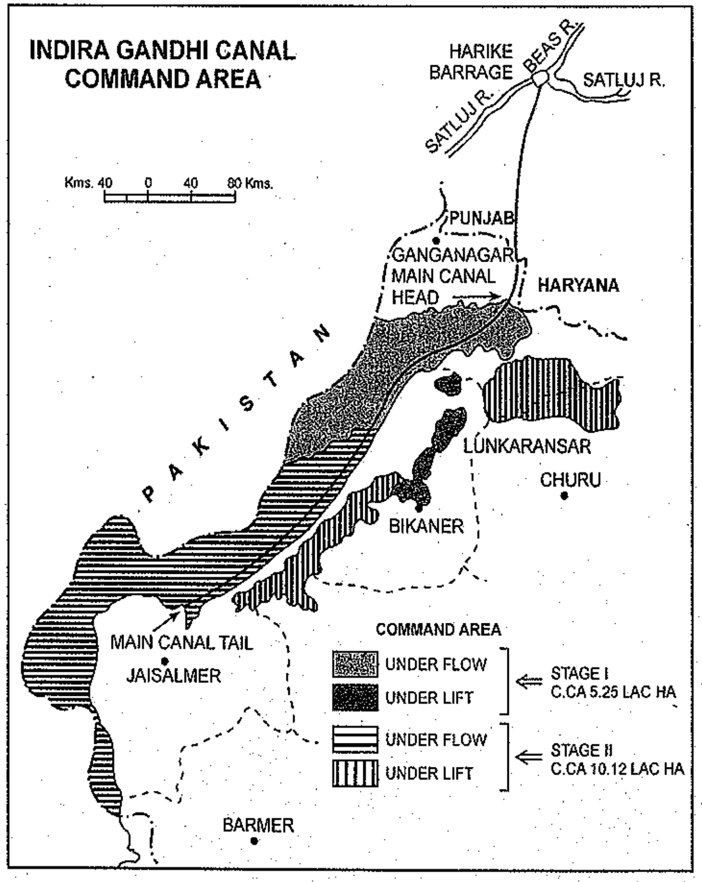

FIG. 14.4. Indira Gandhi Canal Command Area

land of prosperity and plenty. It is one of the largest canal systems of the world. The command area of this canal is located in dry desert lands of Ganganagar, Bikaner, Jaisalmer, Barmer, Jodhpur and Churu districts in Rajasthan. It stretches over 23,725 sq km having 525 kms length and 45 kms breadth along the international boundary between India and Pakistan. The Indira Gandhi Main Canal runs parallel to the Pakistan border for an approximate distance of 38 kms from north-east to south-west.

The Canal originates from Harike Barrage near the confluence of Satluj and Beas rivers in Ferozepur district of Punjab. The plan for this canal was prepared in 1957-58 and the work on this project started on 31st March 1958. The canal does not do any irrigation in Punjab and is known as Rajasthan Feeder. The total length of Rajasthan Feeder is 204 kms. The main canal is 40 metres wide at bottom and 6.4 metres deep. The carrying capacity of canal is 18,500 cusecs of water at its head. According to a proposal in 1981, Rajasthan was allocated 8.6 million acre feet of Ravi-Beas surplus water. The Indira Gandhi Canal envisages the utilisation of 7.6 million acre feet of water allocated to Rajasthan.

The head of the main canal is located near Masitanwali in Hanumangarh district. The tail of the 445 km long main canal is located near Mohangarh in Jaisalmer district. The command area of the canal is further extended till Gadra Road in Barmer district, through Sagarmal Gopa branch.

Construction work of the project has been carried out in two stages. Water was released in the main canal on 11 October 1967 and reached its tail on 1 January 1987. The main canal has two kinds of branches and distributaries. The right bank branches of the canal are flow channels as the land west of the main channels slopes down gently towards Pakistan border. The left bank branches except Rawatsar Branch which takes off from the head of the main canal, are lift channels. This is because of the fact that area towards the south-east of the main canal slopes towards the canal and water is to be lifted against the slope of the land.

Stage I. Construction work of Stage I has been completed at a cost of ₹ 246 crore. It included the construction of 204 kms long feeder, 189 kms of the main canal and 2,960 kms long distribution system. Stage I has five flow branches and one lift canal covering south and south-western part of Ganganagar district and north and northwestern parts of Bikaner district. Nearly 4.79 lakh hectares of land is provided with flow irrigation and 0.46 lakh hectares get lift irrigation. The irrigation potential on full development has been estimated to be 5.78 lakh hectares. The project plan of Stage I envisages intensive irrigation with an irrigation intensity of 110%. *Irrigation intensity is expressed as percentage ratio between gross irrigated area and culturable command area of the project.*

The above facilities results in annual food production of 14.50 lakh tonnes [*See* **Table 14.2**].

Stage II. Stage II of the project includes the construction of 256 kms long main canal and 4,800 kms long distributaries. According to the revised plan, this stage provides extensive irrigation. Extensive irrigation means reducing per acre allowance of water and providing irrigation to maximum cultivated area. Irrigation intensity of this region is *80%* that amounts to provide irrigation to 80% of culturable command area. This will prevent water-logging and soil-salinity and help in growing light irrigated crops. Stage II proposes to develop irrigated pastures on an area of about 3.66 lakh hectares. This would help in providing benefits of irrigation to aboriginal nomadic communities, develop animal husbandry and arrest desertification. This stage of the project envisages to provide flow irrigation to 7 lakh hectares and lift irrigation to 3.12 lakh hectares of land. This will lead to annual food production of 22.50 lakh tonnes (*See* **Table 14.2**).

Command Area Development Programme. The Command Area Development Programme is an integrated area development approach towards the command area of major and medium irrigation projects in the country. This programme is aimed at bridging the gap between created irrigation potential and its utilisation in the command areas of major and medium irrigation projects. The Fifth Five-Year Plan document emphasized the need of implementing this programme in all the command areas of major and medium projects in the country. The importance of Command Area Development (CAD) is all the more important in a desert areas because it requires proper use of water and ecological development for the following reasons :

TABLE 14.2. Salient Features of Indira Gandhi Canal Project

Particulars	Unit	Stage I	Stage II	Total
1. Length of the Main Canal :				
(i) Indira Gandhi Feeder	kilometres	204	—	204
(ii) Indira Gandhi Main Canal	kilometres	189	256	445
Total		**393**	**256**	**649**
2. Length of Distribution System	kilometres	2,960	4,800	7,760
3. Culturable Command Area :				
(i) Under flow irrigation	Lakh hectares	4.79	7.00	11.79
(ii) Under lift irrigation	Lakh hectares	0.46	3.12	3.58
Total		**5.25**	**10.12**	**15.37**
4. Irrigation Potential on Full Development	Lakh hectares	5.78	8.10	13.88
5. Irrigation Intensity	Per cent	110	80	90
6. Water Requirement	Million acre feet	3.59	4	7.59
7. Drinking and Industrial Use of Water	Cusecs	300	900	1200
8. Cost	Crore ₹	246	1,420	1,666
9. Annual Food Production	Lakh tonnes	14.50	22.50	37.00

(i) Conveyance loss of water is 30 to 50% below outlet level in sandy soils. This results in under-utilisation of water and leads to water-logging and soil-salinity. Consequently, it adversely affects agricultural production.

(ii) This is a newly settled area and requires civic amenities as well as modern agricultural inputs.

(iii) There is large-scale siltation in the main canal and its distributaries by wind. In addition, cultivable land is also eroded.

The Command Area Development Programme was introduced in the Indira Gandhi Canal Command Area in 1974 and it was entrusted with following tasks :

(a) On-farm development which includes surveying and planning water course lining, land levelling, shaping and reclamation of degraded lands.

(b) Afforestation and pasture development which includes canal side and roadside plantation, block plantation near new settlements, sand dune stabilisation and pasture development on culturable waste land.

(c) Providing communication and civic amenities which includes construction of roads, connecting the settlements with markets, construction of new markets and supplying drinking water.

(d) Availability of modern agricultural inputs including ensuring supply of HYV seeds, chemical fertilizers, insecticides and pesticides and providing agricultural extension and training facilities to the farmers.

Agricultural Development. Crops could be grown only in the *kharif* season in this dry area and a large tract of cultivable land was left as culturable waste and fallow land. Introduction of irrigation has dramatically increased the net sown area (NSA) and area sown more than once, *i.e.*, double cropped area. Drought-resistant crops like *bajra, guar, moong, moth* and *gram* used to occupy about 95% of the gross cropped area of this region before the introduction of irrigation. Cropping pattern has undergone drastic changes as a result of irrigation. Commercial crops, such as cotton, groundnut, wheat and mustard have become very important occupying nearly two-thirds of the gross cropped area in Stage I. Wheat alone occupies about one-fourth of the gross cropped area. The yield of cotton, groundnut, paddy and wheat is

increasing consistently, while yield of *guar*, gram and mustard is fluctuating. The main reason for the fluctuations of yield level of these crops is that they are not fully irrigated.

The production of cotton, groundnut, wheat and mustard has increased considerably. This is due to increase in area under these crops as well as their increase in yield per hectare as a result of irrigation and use of better seeds.

Impact of Irrigation on Environment. Whereas irrigation has increased the agricultural production tremendously, it has resulted in environment degradation in the form of water logging and soil-salinity. The ground-water table is rising at an alarming rate of 0.8 metre per year in most parts of Stage I. About 25% of land under the command area near Ghaggar basin is critical area as the ground water level in this area is less than 6 metres below surface level. In a large part of the command area in Stage I, soil-salinity has arisen because of water-logging and the presence of salt in the soils. This has adversely affected the soil-fertility and agricultural productivity. This problem is more serious in the command area of Stage II where irrigation was introduced in mid-eighties. This part of the command area is underlain by hard pan of calcium carbonate and clay at a depth of few metres which causes parched water table : water-logging.

Watershed Management

Water is one of the most important natural resources and no life is possible without water. For sustainance of life and for better standards of living, optimum development and efficient utilisation of water resources is of paramount importance. According to the Ministry of Water Resources, the average annual water availability of the country is assessed as 1862 billion cubic metres (BCM). Of this, total utilizable water resource is assessed as 1123 BCM out of which 690 BCM is surface water and 433 BCM replenishable ground water resources. Since the total availability of water is fixed and our population is increasing at an accelerated rate, the per capita availability of water has reduced drastically from 6008 cubic metres a year in 1947 to less than 1800 cubic metres a year in 2014. Keeping in view this critical trend in falling per capita availability of water, the Ministry of Water Resources has come out with certain policies and programmes for development and regulation of the water resources of the country. It covers sectoral planning, coordination, policy guidelines, technical examination and techno-economic appraisal of projects.

Watershed management is a very important component of water policy and planning. *Watershed is the line separating headstreams which flow in different river systems. It may be sharply defined such as crest of a ridge or it may be indetermined as is the case in a low undulating area.* The water divide determines the boundary of the watershed. Watershed becomes a practical agricultural unit in two different situations (*i*) when it is used as drainage line or flood control and (*ii*) when it is accepted as a unit planning for hydro-electric production, irrigation, drinking water, etc.

The All India Soil and Land use Survey Organisation of the Department of Agriculture, Government of India, has finalised a nationwide system of delineation and codification of watersheds. According to this system, watersheds have been divided into the following four categories depending upon their size :

(*i*) basins, (*ii*) catchments, (*iii*) subcatchments, and (*iv*) watersheds.

As per computation made by this organisation, India has 35 river basins, 12 catchments, 500 sub-catchments, and 320 watersheds. Depending upon their area, watersheds are divided into following four categories :

(i) Sub-watersheds (10,000 to 20,000 hectares)
(ii) Milli-watersheds (1,000 to 10,000 hectares)
(iii) Micro-watersheds (100 to 1,000 hectares)
(iv) Mini-watersheds (1 to 100 hectares)

The watershed management is a multi-departmental and comprehensive programme which aims at the optimum utilisation of the available water and other resources to achieve the following goals :

(i) increasing agriculture productivity
(ii) promoting allied activities
(iii) generating additional income from social forestry
(iv) checking soil erosion
(v) developing cottage industries
(vi) maintaining ecological balance

Integrated Watershed Management Programmes (IWMP). It has been estimated that about 60 per cent of cultivated area in India is rainfed which suffers from cronic problem of water shortage, low agricultural productivity, land degeneration, poverty, malnutrition, etc. Watershed development programme is considered to be an effective tool to solve these problems.

Under the aegies of the Planning Commission, National Rainfed Area Authority (NRAA), farmed Common Guidelines for watershed programmes based on Parthasarathy Committee Report. Accordingly, a single modified programme called Integrated Watershed Management Programme (IWMP) was launched in 2009-10 which is being implemented as per Common Guidelines for Watershed Development Projects, 2008.

Impact Assessment Studies of Watershed Projects. A study entitled "Comprehensive Assessment of Watershed Programmes in India" has been assigned to International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad to assess the impact of various watershed development programmes in India, which among other things, gave the following report:

- Soil loss of 1.1 tonne/hectare/year was prevented
- Additional water storage capacity of about 38 hectare metre was created in 9500 hectare watershed.
- The area under irrigation increased by 52 per cent and the cropping intensity increased by 35.5 per cent.
- Low income regions were more benefited than high income regions.
- Benefits were more in areas receiving between 700 mm and 1000 mm of annual rainfall with the available technologies.
- Peoples' participation produced better results.
- The macro, watershed (area more than 1000 hectares) performs better than micro watersheds (area below 500 hectares).

PLANNING FOR BACKWARD AREA

It is difficult to define and identify backward areas because several parameters are used for this purpose. Generally areas with low per capita income are treated as backward areas. But this is not a very reliable measure. Various other measures have to be applied for proper identification of backward areas. Some such measures can be (*i*) the percentage of the scheduled caste and schedule tribe population to the total population of the area, (*ii*) the ratio of population to the cultivated land, (*iii*) the percentage of the working force engaged in agriculture, (*iv*) the ratio of urban to rural population, (*v*) availability of transport, communications, and other services, (*vi*) availability of water, electricity, and other facilities, (*vii*) level of literacy, etc. During the first decade of planning no attempt was made to specify the backward areas and pockets of underdevelopment taking into account these various indicators. Perhaps the Committee on the Dispersal of Industries, set up by the Small Scale Industries Board in 1960, was the first to identify the backward areas for purposes of rural industrialisation. The criteria for backwardness suggested by this Committed were as follows:

1. Poverty of the people as indicated by
   (*a*) Low per capita income; and
   (*b*) Low per capita consumption.
2. High density of population in relation to development of productive resources and employment opportunities as indicated by the following factors:
   (*a*) High ratio of population to cultivable land (50% above the national average should be considered as backward);
   (*b*) Low percentage of population engaged in output (50% or more below the national average should be considered as backward);
   (*c*) Absence or under-exploitation of other natural resources, *viz.*, minerals, forest and animals;
   (*d*) Low percentage of population engaged in secondary and tertiary activities (25% below the national average should be considered as backward);
   (*e*) Low ratio of urban to rural population (districts where the ratio was less than 50% of the national average might be considered as backward);

   (*f*) Low percentage of factory employment (50% below the national average might be considered as backward).
3. Poverty of communications as indicated by small lengths of railways and metalled roads per square mile (districts where the railway and road mileage fall below 50% of the national average might be considered as backward).
4. High incidence of unemployment or gross underemployment.
5. Consumption of electric power.

At the time of formulating the Fourth Plan (1966-1971) the Planning Commission appointed a Study Group to suggest the criteria for identifying the backward areas. The Group suggested the following indicators:

1. Total population and density of population;
2. Number of workers engaged in agriculture including agricultural labourers as percentage of total workers;
3. Total area per agricultural worker;
4. Cultivable area per agricultural worker;
5. Net area sown per agricultural worker;
6. Percentage of gross irrigated area to net sown area;
7. Percentage of area sown more than once to net sown area;
8. Per capita (rural population) gross value of agricultural output;
9. Establishments (manufacturing and repair) using electricity:
   (*a*) Total
   (*b*) Household
   (*c*) Non-household
10. Number of workers per lakh of population employed in registered factories;
11. Mileage of surfaced roads:
   (*a*) Per 100 sq miles
   (*b*) Per lakh of population
12. Number of commercial vehicles registered in a district;
13. Percentage of literate population:
   (*a*) Men
   (*b*) Women
14. Percentage of school going children:
   (*a*) Boys
   (*b*) Girls in age groups of
   (*i*) 6-11 years, and (*ii*) 11-14 years.
15. Number of seats per million population for technical training:
   (*a*) Craftsmen
   (*b*) Diploma level
16. Hospital beds per lakh of population.
17. Per capital income.

In the year 1968, the Planning Commission set up two Working Groups for studying the regional imbalances. One group was for recommending the criteria for the identification of backward area and the other for recommending the fiscal and financial incentives for starting industries in the backward areas. The committee for specifying the criteria for identification of backward areas was set up under the chairmanship of B.D. Pande (and is popularly known as the Pande Committee) and the committee for recommending the fiscal and financial incentives in the backward areas was set up under the chairmanship of N.N. Wanchoo (and is popularly known as the Wanchoo Committee).

The criteria for the identification of industrially backward States and Union territories adopted by the Pande Committee were as follows:

1. Total per capital income.
2. Per capita income from industry and mining.
3. Number of workers in registered factories.
4. Per capita annual consumption of electricity.
5. Length of surfaced roads in relation to:
   (*a*) the population, and
   (*b*) the area of the State.
6. Railway mileage in relation to:
   (*a*) the population, and
   (*b*) the area of the State.

Based on the above described criteria, the Pande Committee classified ten backward states. These states are Andhra Pradesh, Assam, Bihar, Himachal Pradesh, Jammu & Kashmir, Madhya Pradesh, Nagaland, Odisha, Rajasthan and Uttar Pradesh. All Union territories except Chandigarh, Delhi and Puducherry were also classified as industrially backward.

This committee identified 238 districts all over India comprising 60% of the country's area and an equal proportion of its population as industrially backward.

The Wanchoo Committee recommended following incentives to develop industries in backward areas :

(*a*) Grant of higher development rebate to industries located in backward areas.

(*b*) Grant of exemption from income-tax, including corporate tax, for 5 years after providing for the development rebate.

(*c*) Exemption from the payment of import duties on plant and machinery, components, etc., imported by units set up in backward areas.

(*d*) Exemption from excise duties for a period of 5 years.

(*e*) Exemption from sales tax, both on raw materials and finished products, to units set up in specified backward areas for a period of 5 years, from the date of their going into production.

(*f*) Transport subsidy for taking out the finished products for as a period of 5 years. Upto 400 miles (650 km) the distance should be considered as normal and beyond that the transportation cost for finished products should be subsidized for such backward areas as may be selected in the States of Assam, Nagaland, Manipur, Tripura, NEFA (present Arunachal Pradesh) and Andamans. The transport subsidy should be equivalent to 50% of the cost of transportation in case of the backward areas specified in J&K State.

The National Development Council (NDC), decided in September, 1969 that the recommendations of the Pande Committee should be applied not only to backward districts in backward states only, rather such concessions should be made available to selected backward area in all the States and Union Territories. The criteria for the selection of the industrially backward districts in the States sand Union territories were to be decided by the Planning Commission in consultation with the financial institutions and the State governments, in the light of the two sets of criteria recommended by the Pande Committee. The following set of criteria was evolved by the Planning Commission for the purpose of identification of the industrially backward districts to qualify for concessional finance :

1. Per capita foodgrains/commercial crops production depending on whether the district is predominantly a producer of foodgrains/cash crops. (For inter-district comparisons, conversion rates between foodgrains and commercial crops may be determined by the State government on a pre-determined basis where necessary.)
2. Ratio of agricultural workers to population.
3. Per capita industrial output (gross).
4. Number of factory employees per lakh of population or alternatively number of persons engaged in the secondary and tertiary activities per lakh of population.
5. Length of surfaced roads in relation to population or railway mileage in relation to population.

On the basis of these criteria, 241 districts (later raised to 247) all over the country were classified as industrially backward.

Location of Large Public Sector Projects. Several public sector projects were located in the backward areas for their economic development. Such projects included steel plants, fertilizer plants, heavy electrical plants in states like Odisha, Chhattisgarh, Jharkhand and Madhya Pradesh. Though economic and technical considerations cannot be ignored while deciding the location of these projects, the Third Plan felt that "the disadvantages which particular areas may have for the location of the larger projects are not always basic or irremediable, for at times they may reflect only the lack of basic facilities and services."

Industrial Estates Programme. This programme was initiated in 1955 when 12 estates were

sanctioned. The construction, organization, and management of ten estates was entrusted to the State governments while the development of two estates (one situated in Naini at Allahabad and the other in Okhla at Delhi) was the responsibility of the National Small Scale Industries Corporation. The ten estates entrusted to the respective State governments were situated at Rajkot in Gujarat, Guindy and Virudhunagar in Tamil Nadu, Kanpur and Agra in Uttar Pradesh and Palghat, Trivandrum (Thiruvananthapuram), Kottayam, Quilon and Trichur in Kerala. The State governments were sanctioned a loan of ₹ 57.89 lakhs and a grant of ₹ 0.495 lakhs each for the purpose.

The principal objectives of the programme, varying to some degree with time and place, have been :

(*i*) to encourage the growth of small scale industries;

(*ii*) to shift small scale industries from congested areas to estate premises with a view to increasing their productivity;

(*iii*) to achieve decentralised industrial development in small towns and large villages; and

(*iv*) to encourage the growth of ancillary industries in the townships, surrounding major industrial undertakings, both in public and private sectors.

Desert Development Programme

The Desert Development Programme (DDP) was launched 1977-78 to reduce the adverse effects of the natural conditions prevailing in the desert areas. It is applied to 235 blocks of 40 districts in seven states. As many as 15,746 plans had been sanctioned between 1995-96 and 2007-08, which benefited 78.73 lakh hectares of land. A sum of ₹ 2103.29 crore was spent on these plans. The seven states which are benefited from this programe are Rajasthan, Haryana, Gujarat, Himachal Pradesh, Jammu and Kashmir, Andhra Pradesh and Karnataka. These states have hot sandy or cold deserts. The funding programme between centre and states is in the ratio of 75 : 25 for hot sandy deserts but the Central Government bears the entire cost in case of cold deserts. The primary aim of this project is to encourage proper use of natural resources, increase employment opportunities, remove poverty and illiteracy and raise the living standard of the common man.

Problems of Desert Area

1. Most of the desert areas receive scanty rainfall and enough water is not available for crops. Vast areas of Rajasthan and the adjoining parts of Haryana and Gujarat receive less than 40 cm annual rainfall. The amount of annual rainfall is less than 20 cm in Barmer and Jaisalmer districts in the western part of Rajasthan. Leh-Ladakh region of Jammu and Kashmir also receive less than 20 cm annual rainfall. Most parts of Andhra Pradesh, Telangana and Karnataka are located in the rain shadow area of the Western Ghats where the amount of annual rainfall is less than 60 cm. Lesser amount of rainfall is not the only problem, rainfall variability is also very high. Rainfall variability is as high as 50 per cent in Rajasthan and its neighbouring areas and 40 per cent in the Leh-Ladakh. Under such conditions, it is not an easy task to depend on natural amount of rainfall and people have to face famine conditions whenever the actual rainfall is below average.
2. In most parts of Rajasthan and its neighbouring areas, the soils are sandy which are easily blown away by winds. This leads to soil erosion and low agricultural productivity.
3. Only those crops can be grown which need lesser amount of water for their proper growth. These include coarse grains such as *jowar, bajra,* barley and pulses. They have lesser market value and their yields are also very low. With the construction of the Indira Gandhi Canal in the western part of Rajasthan, the cropping pattern has changed and wheat and at certain places rice cultivation has become possible.
4. Most of the farmers in the desert areas are poor and cannot afford modern inputs like high yielding varieties of seeds, fertilizers, pesticides and new implements,

5. In the event of a drought condition, there is acute shortage of food and fodder and people are force to migrate to other places in search of food, fodder and livelihood.
6. The infrastructural facilities like market, storage, transport etc. are badly lacking.

Main Objectives

1. To check the spread of desert and increase productivity.
2. To promote dry farming and increase productivity.
3. To make optimum use of natural resources of the desert areas and raise the living standard of the common man.
4. To generate more employment and enhance per capita income so that people can lead a comfortable life.

Strategies for Development

1. The most important strategy is to check the spatial growth of desert through shelter belt and to stabilize sand dunes by intensive plantation.
2. The Desert Development Programme has been made an integral part of the 20-point Programme of the government so that maximum benefit reaches the maximum number of people.
3. Under the dry farming programme, crops needing lesser amount of water have been promoted. Course grains (*jowar*, *bajra*, barley), pulses, oil-seeds etc. are such crops.
4. New technologies are promoted to increase the production of fodder.
5. Proper use of resources has been encouraged to maintain ecological balance.
6. Much emphasis has been laid on the use of eco-friendly pesticides and wedicides.
7. Irrigated agriculture and animal husbandry has been given priority in the cold deserts of Ladakh and Spiti.
8. Various devices for water harvesting have been used to meet the water shortages.
9. In addition to growing crops, allied activities like milk production, poultry, horticulture, selviculture, sheep rearing, bee-keeping etc. have been suggested to help farmers, especially small and marginal farmers.
10. Emphasis has been laid on agro-forestry, social-forestry etc. to check soil erosion and to maintain ecological balance.
11. Plan has been prepared to reclaim water logged areas in the Indira Gandhi Canal Command Area.
12. Programme to involve Non-Government Organisations (NGOs) in desert development programmes.

Drought Prone Area Development Programme

On an average, about 12 per cent of population and 16 per cent of the total area of India is affected by droughts and a severe drought occurs after every 4-5 years. At the micro level, one part of the country or another is affected by a drought almost every year. Drought causes shortage of food and fodder and lakhs of people and animals become victims of hunger and malnutrition. Hence solid steps are required to be taken to solve the problem of droughts. Drought Prone Area Programme ((DPAP) was initiated in 1973-74. Currently 972 blocks in 193 districts of 16 states are being benefited by this programme. Between 1995-96 and 2007-08, as many as 27439 schemes covering a vast area of 130.2 lakh sq km were prepared at the cost of ₹ 2837.81 crores. The primary aim of this programme is to make provisions for optimum use of land, water and animals resources, maintain ecological balance and to raise the income level of the poor section of society. Following are the salient features of this programme :

1. Management and conservation of water resources.
2. Land reforms.
3. Conservation of soil and soil moisture.
4. Special emphasis on forestation and social forestry.
5. Development of pasture lands and sheep rearing.
6. Development of livestock and dairy.
7. Restructuring the cropping pattern and changes in the farming process.

8. Cleaning of ponds, canals, rivers and other water reservoirs.
9. Special assistance to small and marginal farmers as well as to agricultural labourers.
10. Availability of infrastructural fund and development of citizens' conveniences.
11. Development of allied activities, in addition to the main agricultural activity.

Since 1995-96, this programme is being carried on for watershed administration based on new guidelines in which local people are also involved. The primary object of this programme is to minimise the problems of areas prone to low rainfall and drought conditions for which coordinated programme involving local people and based on new techniques is adopted. The main emphasis is laid on irrigation, forestation, development of pasture lands, rural electrification, rural road connectivity, markets for agricultural products, loans to farmers and services. These factors help in strengthening infrastructure and reducing the impact of drought.

Different systems for implementing this programme prevail in different states. For example, this work is done by the District Planing Board in Maharashtra. In Karnataka this work is done at the district level under the chairmanship of the Divisional Commissioner while in Tamil Nadu, it is implemented by the District Development Corporation.

Shortcomings of the Drought Prone Area Development Programme

1. The process of fixing the targets is faulty. In many areas small and marginal farmers as well as agricultural labourers do not get benefit from the programme; and this section of society is in dire need of assistance in such a situation.
2. Programmes are often delayed due to shortage of working force with the requisite skill.
3. There is a general lack of experience to run such a programme.
4. The expected results are not obtained due to lack of information.
5. Dualism and dichotomy in efforts results in lower capabilities.

Hill Area Development Programme

According to 1951 Census data, about 18.6 per cent of India's total area is termed as hilly area (305-2135 metres) and as per 2001 census, these hilly areas are divided into following two broad categories :

(*i*) **The Hilly Areas that are along the boundaries of the States and Union Territories.** This category includes Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Darjeeling hills areas of West Bengal, and north-eastern states (Assam, Arunachal Pradesh, Nagaland, Mizoram, Manipur, Tripura, Meghalaya and Sikkim). These are termed as ***Special Category States*** and most part of the outlay for development of these areas is provided in the shape of Central Assistance.

(*ii*) **Hilly Areas which are parts of States.** These hilly areas form part of one or more than one states. The main examples of this category of hilly areas are the Aravalli, the Vindhyas, the Satpura, the Mahadev, the Maikala, the Ajanta, the Western Ghats and the Eastern Ghats. All these hilly areas are situated in the peninsular plateau area and they spread in different directions. The development plans for these areas are prepared and executed by the concerned state governments.

For the integrated development of the North-eastern region, the Central Government set up the North-Eastern Council by an Act of Parliament. This council prepares development plans for one or two states or for the whole of North-eastern region. The North-eastern council has played a significant role in the development of inter-regional programmes of power generation and its transmission, construction of roads, agriculture, animal husbandry, fisheries, forestry, etc. This council is also engaged in research, experiment and human development as well as in educating the people.

Some of the typical hilly areas from the development planning point of view are Karbi Anglong and Cachar in Assam (area 15,200 sq km) Darjeeling in West Bengal (area 2,400 sq km), Dehra Dun, Pauri Garhwal, Chamoli, Uttarkashi, Almora, Pithoragarh, Tehri Garhwal, and Nainital (area 51,100 sq km) in Uttarakhand. Although the concerned state governments are responsible for the development of these areas, yet need for central assistance was felt during the Fifth Five Year Plan, which was granted keeping in view the area and population of the concerned regions. The concept of sub-plans was also encouraged so that they are made complementary to each other. Another major hilly area is the Western Ghats which spreads over 132 talukas (area 1,37,000 sq km) in Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu. The Central Government provides financial assistance for the development of the Western Ghats.

The problems of hilly areas are quite different from those of the plain areas. The rugged topography and different climate of hilly areas gives rise to a different set of economic, social and cultural conditions. These conditions required special planning for the hilly areas for which detailed information regarding economic, social, cultural, and political conditions as well as that of natural and human resources is very essential. Special attention is paid to the optimum utilisation of land, mineral, water, and biotic resources.

Active participation of the people, particularly of the women, is essential for the successful implementation of the plan. Peoples' involvement can be ensured by encouraging the concept of ***social fencing***, which implies a voluntary and self imposed discipline in managing resources of society at a local level. Under the development plan subsistence agriculture, plantation, agriculture, food grains culture, animal husbandry, poultry, bee-keeping, pig farming, forestry, etc. can be developed by using the local resources. Cooperative societies and Farmers' Service Societies are strengthened. Plantation Agriculture (tea, coffee, spices, etc.), agricultural forestry and social forestry are given priority under the forestry programme. Linkages are established between fruit producing and fruit consuming areas.

In some of the areas of the north-east region, the tribal people are practicing shifting agriculture locally known as ***Jhuming***. This type of agriculture causes heavy damage to forest and soil resources and disturb the ecological balance of the concerned area. Under the Hill Area Development Programme, the practice of shifting agriculture is discouraged and in its place, plantation crops such as tea, coffee, rubber etc. are encouraged. This change from shifting to plantation agriculture saves soil and forest resources and help the tribal people in leading a settled life. These tribal people become owners of plantations in due course of time.

Planning is also done for animal husbandry depending upon the number of animals and extent of pasture lands. Provisions are made for improving the breeds, health and productivity of the animals and plans are also prepared for processing and marketing animal products.

Major thrust of the Hill Area Development Programme is to promote the following :

- Agriculture-sedentary, plantation (tea, coffee, species, rubber, coconut, etc.)
- Horticulture, especially banana, apple, grapes, and citrus fruits.
- Animal husbandry, poultry, bee-keeping and piggery.
- Conservation of soil and forest resources.
- Cottage and village industries.
- Employment to the rural youth.
- Strengthen co-operatives and farmers' service societies.
- Discourage Jhuming.

The hilly areas are more suitable for industries that require pollution free atmosphere, relatively cool and comfortable climate, are based on high skill and are capable of high value addition. Electronics, watch-making, optical glasses, medicines, fold furniture are some of such industries which flourish in these areas. Cottage industries like handloom and carpet-making are also carried on. Besides, tourist industry is a very important economic activity. The natural beauty of the hilly areas attracts tourists in large numbers from far and wide places and tourism has great potential in these areas. Solid planning is required to harness this potential.

Vast hilly areas, particularly in the Himalayan region, provide ideal conditions for the growth of pharmaceutical herbs, fruits, flowers and other useful plants. Thus, pharmaceutical industry has a huge potential in these areas. In fact many such industries have already been developed in the Shiwalik and the Lesser Himalayan region. The wild life of this area is an added attraction as it adds to the bio-diversity of the hilly areas. Therefore, integrated planning for conserving botanical and zoological wealth of these areas is very essential, under which there should be provision for national parks, wild life sanctuaries and biosphere reserves.

For any successful planning for the hilly areas, extensive field survey is of utmost importance because we get a wealth of information from such surveys. These surveys need to be updated periodically so that latest ground realities are made available to the planner. For such survey, modern techniques like remote sensing, air photographs, Global Positioning System (GPS) etc. are very useful. Planning can be at the regional, sub-regional, taluka, block or even at settlement level. Peoples participation is very essential for the success of such plans. The plan should be eco-friendly and peoples' awareness is also important. There should be provision for compensating the loss of natural resources. For example reforestation should be made mandatory for compensating the loss of forests if a paper mill is set up in any one of these areas. Wastage of water can be avoided by constructing small dams and storing water in tanks, lakes and other reservoirs. Hilly areas are basically more suitable for perennial commercial crops like tea, coffee and fruits and are deficient in the production of food grains. Thus, there should be sufficient arrangement for storing food grains so that common man, along with those who are willing to stop the practice of shifting agriculture may get the right quantity of food at the right time.

There are regional disparities of development between the hilly areas and plain areas which has led to separatist sentiments in the peripheral hilly areas and there is lot of insurgency particularly in the north-eastern region. Most of these areas are inhabited by the scheduled tribes and their development is necessary. The only way to bring them in the main stream of the century is to improve their economic social and cultural condition. Thus there is dire necessity to prepare and implement solid development plans to bring about positive change in their life style.

Tribal Area Development

Defining a tribe is a difficult task, and no definition in India has proved satisfactory and precise. In general, the tribes are expected to possess some, if not all, of the following characteristics :

(*i*) their roots in the soil date back to a very early period.

(*ii*) they live in relative isolation of hills and forests.

(*iii*) their sense of history is shallow in the sense that after some generations, the remembered history tends to shade off into mythology because they usually do not keep a written record of their history.

(*iv*) they have a low level techno-economic development.

(*v*) in terms of their cultural ethos (language, institutions belief and customs), they stand out from other sections of society.

(*vi*) even if they are not egalitarian, they are at least non-hierarchic and undifferentiated.

As noted by **S.C. Dube**, the above mentioned characteristics are only rough indicators and cannot withstand a critical scrutiny. Thus neither all tribals are 'original' inhabitants of the soil nor all of them live in isolation. In fact, three-biggest tribes in India *viz*. Gonds, Bhils and Santhals, live in close proximity of non-tribals. The third, fourth and fifth characteristics are not the legacy of the tribals alone. They are to be found among non-tribals as well. The sixth characteristic is also not universally applicable to all tribes. There are many tribes which are divided into a number of endogamous sub-divisions which behave like castes.

However, in the absence of any other convincing criteria, the above characteristics are usually accepted to identify the tribals. Thus on the basis of these characteristic features, the Government of India has included 427 communities in the Scheduled Tribes, given in he Eighth Schedule of the Constitution of India. Numerically, the Bhils and Santhals are the most important tribal groups of India, each with a population of more than 35 lakh. Next to them are Minas, the Mundas and the Oraons, each having a population of over ten lakh. The Hos, the Khonds and the Kols are next to them, each with a population of over five lakhs. After that, there are 42 tribes, each having a population varying from one to five lakhs.

Economy. Economy is the basic parameter for identifying and classifying the Tribal people. They are mainly involved in hunting, fishing, gathering, animal husbandry and agriculture (mainly shifting and sedentary cultivation). Tribes of Andaman and Nicobar Islands depend on gathering and hunting. On the mainland of India, almost all the tribal people living in forests also depend on gathering and hunting. Birhor, Kharia, Kadar, Chenchu etc. are some of the tribes living in the forests of Central India and mainly depend on gathering various roots and tubers, fruits, honey, etc. They collect these items for their personal use or for exchange with agricultural products. The Todas of the Nilgiri Hills are pastoral tribes. They rear buffaloes and live on buffalo products. However most of the tribal people are engaged in agriculture although their method of cultivation is primitive and their agricultural productivity is low. It may be mentioned that about 90 per cent Bhils, Gonds, Santhals, Mundas, Oraons, Nagas, Khasi, Mizo, etc. are engaged in agriculture.

Most of the economic activities of the tribal people are low grade primary activities which do not provide enough means for their survival. Thus majority of the tribal people are not able to enjoy the basic facilities of good health, education and are still at lower level of economic development.

Tribal Development through Planning. The policy of the Central Government immediately after Independence was to focus on improving the economic condition of the Schedule Tribes and provide security to their interests. For the first time in 1954, about 43 special multi-purpose development schemes ever implemented. In the year 1957 the tribal block development plan was initiated, which aimed at improving the economy, education and communication for the tribal people. One development block consisted of 150-250 sq miles of area and 25,000 population. The Shibu Ao Committee constituted in 1969 recommended improvements in land tenure, loans, and economic conditions with respect to Scheduled Tribes.

Programmed initiated by the Central and State Governments

The Central Government and the State Governments have initiated a large number of programmes for improving the lot of the tribal people and for bringing them in the mainstream of the country. Some of the important programmes are named as under :

Centrally Sponsored Programmes

1. Scholarship to all the students (both males and females) after matric.
2. Special provision of hostels for girl students.
3. Pre-examination training.
4. Establishment of Tribal Development Blocks (TDBs).
5. Encouragement to cooperation.
6. Research, Training and Special Projects.
7. Improvement of working and living condition of those tribals who are working in unhygeinic occupations.
8. Setting up centres of Coaching-cum-Guidance.
9. Grants for All-India non-official organisations doing welfare work among the Scheduled Tribes and Schedules Castes.

Programmes Sponsored by the State Governments

1. Grant of pre-matric scholarship and stipends
2. Exemption from tuition and examination fee
3. Mid-day-meal
4. Provision for educational equipments
5. Setting up of Ashram Schools
6. Grants for the construction and maintenance of hostel and school buildings
7. Providing land and irrigation facilities
8. Provision for better seeds, fertilizers and agricultural implements
9. Bullock carts for transportation
10. Development of cottage industries in addition to agriculture for supplementing the income
11. Encouragement to cooperation
12. Development and improvement of communication system
13. Control on spread of shifting agriculture
14. Encouragement to animal husbandry and supply of poultry, sheep, pigs, goats, etc.
15. Health services at the village level.
16. Programme for providing drinking water.
17. Provision for house sites and houses.
18. Legal aid to resolve disputes.

19. Grants-in-aid to non-official organisations working at the State level.

Areas of Development

1. Agriculture. About 90 per cent of the tribal people are cultivators but majority of them are engaged shifting and/or sedentary or rudimentary cultivation. Their fields are of small size and their implements are old traditional and inefficient. The irrigation facilities are badly lacking. Consequently, their agricultural productivity is very low and many of them are not able to produce which may be considered sufficient even for their own family members. Economic gains from agriculture are simply out of question in such circumstances. Keeping these facts in view, the Central and the State Governments have prepared many plans for providing better seeds, fertilizers, implements, credit and irrigation facilities and making arrangements for land reforms, soil conservation, land reclamation, etc.

2. Land Distribution and Land Alienation. Land distribution is very uneven and irrational among the Scheduled Tribes and whatever little land they own, that is grabbed by the moneylenders, *Sahukars* and other non-tribal people. They lend money to the tribal people at very high rate of interest and when they are not able to pay back the loan, their land is transferred to the moneylenders. This transfer of land from the tribal to non-tribal people on the basis of non-payment of loan is known as ***land alienation***. This process has been operating in the tribal belts of India for a pretty long time and many tribals have little assets they had inherited from their fore-fathers. To safeguard against this trend many State governments have adopted several measures. Some of the remedial measures are as follows :

(*i*) In Gujarat, Odisha and Rajasthan, there is restriction on transfer of land from tribals to non-tribals by sale.

(*ii*) In West Bengal, there is restriction on transfer of tribal land to any person (whether tribal or non-tribal).

(*iii*) Tribal land cannot be transferred to any one by any means.

In spite of all the above mentioned legal safeguards, the government agencies have failed to check land alienation which is going on rampantly.

3. Industrialisation. Tribal people are generally engaged in cottage industries and subsidiary occupation. The activities of their cottage industry include making conventional and crude implements, weaving, bee-keeping, oil extracting, sericulture, *palm-gurs*, etc.

After Independence, some integrated iron and steel plants were set up in tribal areas. These include iron and steel plants at Durgapur, Rourkela, Bhilai, Bokaro, etc. Many illiterate, unskilled and semi-skilled workers find jobs in these iron and steel plants. Technical training is also being provided to tribals to enable them to work as skilled labour in these and other projects.

4. Education. The Central and State Governments are spending huge amounts of money to educate the tribal people and to bridge the gap between the tribals and the non-tribals. There is provision for scholarships, stipends, hostels, free stationary and books, free boarding, mid-day meal etc. Coaching and guidance facilities are available even to those candidates who are preparing for competitive examinations. Scholarships are also granted for higher studies abroad.

5. Employment. There is 7.5 per cent reservation for candidates belonging to Scheduled Tribes in all the vacancies created by the Central and the State Governments. The reservation in direct recruitment to Class III and Class IV categories of posts which normally attract candidates to belonging to a locality or a fixed region are fixed in proportion to the population of the Scheduled Tribes in the respective State and Union Territory.

6. Cooperation. The tribal people are almost invariably exploited by the money lenders, forest contractors and other non-tribals and there is urgent need to save the tribals from the clutches of these exploiters.

7. Transport and Communication. Most of the tribal people are living in hilly, mountainous of forested areas which are inaccessible and isolated. Such a situation creates great hindrance in the development of their life style. Therefore, it is necessary that areas inhabited by the tribes should be provided with transport (roads and railways) and proper means of communication so that they are absorbed and assimilated in the national stream.

8. Marketing. The tribal people are known for their handicrafts and produce a large variety of goods which do not need modern sophisticated technology. They are also well trained in collecting a variety of goods from the forests, some of which are very rare. They are exploited by the purchasers because the purchasers do not offer them the remunerative price for their goods. In order to overcome this difficulty, proper marketing facilities should be provided to them.

9. Tribal Development Agency Projects. The Tribal Development Agency Projects were started in 1971-72 in some areas on an experimental basis. The work of these agencies is implemented in some selected districts under the chairmanship of district collector. Such agencies have full-time project officers and other district officers as their members.

10. Other Schemes. In addition to the above mentioned schemes, several other schemes were also undertaken to improve the living standard of the tribals by providing them proper facilities of education, health, sanitation, etc.

Critical Appraisal of the Tribal Area Development Plan

The Tribal Area Development Plan has achieved great success in serving the tribals, improving their lot and bringing them in the main stream of the Indian society, yet some of the glaring shortcomings have been noticed, as is clear from the following points :

- **Achievements of the plans**
  1. Several policies adopted by the Central and the State Governments have helped in uplifting the tribal people and changing the mode of thinking and attitude of many tribals.
  2. The educational policies, reservation for tribals in government jobs, help in the field of agriculture, co-opertion, communications, industrialisation, social service, etc. have brought tribals closer to the main stream of national life.
  3. Tribal markets have been linked with the main stream markets which has given greater opportunities for economic progress to tribals and creating commercial aptitude among them.

- **Failures of the Plan**
  1. Benefits of the government policies could not percolate to the lower strata of the tribal community and remained concentrated in the upper crust of the tribals.
  2. The Tribal Development Blocks (TDBs) are usually criticised because they have not bothered about the participation of the tribal people in the preparation and implementation of the plan.
  3. The rigid, self-centred and unchanging bureaucracy has failed to appreciate the problems of the tribals and to fulfill the role of development agency.
  4. Local politicians also do not work much to safeguard the interests of the tribals and always work in their own interest.
  5. Large industrial projects in the tribal areas have resulted in large scale displacement of the tribals.

Area Development Programme

This is an integrated programme which has been prepared for areas with more 50 per cent or above of its population consisting of tribes. Emphasis has been laid in the sub-plan with the following aims in mind :

1. Narrowing the gap in the level of development between the tribals and non-tribals.
2. Improving the standard of living of the tribals.

Tribal Sub-plan

Different tribal areas have different environment and bio-diversity and their problems are also different from one another. Therefore different methods have to used for solving the tribal problems in different parts of the country. Taking these facts into consideration, Tribal Sub-plan was proposed during the Fifth Five Year Plan. Tribal areas of 19 States and 2 Union Territories were identified under this sub-plan. Financial assistance for this programme was provided by the Central Government and the State Governments.

- **Aims of the Tribal Sub-Plan**
  1. To relieve the tribal people from their exploitation by the money lenders and contractors.

  2. To improve the economic, social and cultural position of the tribal people.
  3. To bridge the gap between the development of tribals and non-tribals.
  4. To evaluate the resources from different sources.
  5. To prepare programmes for the Tribal Sub-plan.
  6. To develop proper structure of administration.

- **Strategies of Achieve the Goals**
  1. Checking the exploitation of the tribals as all levels.
  2. Developing the tribal economy by reforms in agriculture, land reforms; soil conservation, forest conservation and afforestation, irrigation, etc.
  3. Improving the infrastructure by providing facilities of education, health, training, electricity, etc.
  4. Understanding the problems of displaced, migrated, liberated bonded labourers, forest dwellers, Jhum cultivators and other backward groups and solving these problems.
  5. Arranging for numerative prices of tribal products.
  6. Improving the environmental conditions.

Three Tier Structure of the Tribal Sub-plan

The Tribal Sub-plan has three tier structure involving micro, meso and macro levels of planning. The ***micro-region*** is coterminous with development block, ***meso region*** is contiguous to the development block having a population of 3 to 5 lakhs and its boundaries are generally determined by the boundaries of talukas or tehsils. The ***macro region*** is a bigger tribal belt which may contain the entire tribal area of a state. The functions at the micro, meso and macro levels have been visualised as follows :

1. Micro Level. Functions at the micro level include :

(*i*) education upto higher secondary level
(*ii*) elementary and complementary health services
(*iii*) agricultural research extension
(*iv*) supply of agricultural inputs
(*v*) minor irrigation schemes
(*vi*) elementary veterinary services
(*vii*) multipurpose co-operatives
(*viii*) local panchayats
(*ix*) household industry
(*x*) village approach roads.

2. Meso Level. Functions included at the meso level are :

(*i*) higher general education
(*ii*) technical and vocational training
(*iii*) manpower planning and employment services
(*iv*) advanced health services with referral facilities
(*v*) agricultural research extension
(*vi*) seed multiplication forms
(*vii*) soil conservation and land management
(*viii*) apex interpreted credit marketing structure with adequate storage and buffer stock facilities.
(*ix*) development of road and communication infrastructure connecting markets with state/district highways
(*x*) distribution of network of power, rural electrification etc.
(*xi*) local resource based industries with adequate market linkages
(*xii*) forest management
(*xiii*) horticulture development
(*xiv*) complementary development programme in hinterland and the bigger industries
(*xv*) medium irrigation projects
(*xvi*) research strategies and evaluation.

3. Macro Level. The macro level function include :

(*i*) coordination of activities in tribal development projects
(*ii*) agricultural research on regional basis.
(*iii*) direction of various sectoral programmes in the project

(iv) major irrigation projects
(v) river valley development
(vi) industrial and mineral development
(vii) marketing support projects
(viii) evaluation

Some of the problems are still, un-attended and need immediate attention. These problems are : (i) land alienation, (ii) indebtedness and exploitation, (iii) bonded labour, (iv) low standard of education, (v) low agricultural production and productivity, (vi) inadequate supply of essential consumer goods, (vii) land reclamation, (viii) inadequate irrigation facilities, (ix) shortage of drinking water, (x) inadequate facilities of communication, (xi) shortage of houses, (xii) inadequate marketing facilities, (xiii) lack of employment opportunities, (xiv) under-developed state of health services.

Critical Evaluation of Tribal Sub-Plan

Although this plan has many merits and has served the intended purpose to a great extent, yet it has some of the glaring drawbacks, as is clear from the following points :

1. This sub-plan is just a part of the departmental plan of the state plan and does not enjoy the privilege of independent functioning.
2. Since it has been integrated with the state planning, it has failed to address the local problems.
3. The basic structure of the ground level information regarding development is overlooked.
4. The pattern of administrative unity within the sub-plan is lacking.

Suggestions for Improvement

1. The Tribal Sub-plan should be separated from the main State Plan and a separate plan for the tribal people should be prepared.
2. The Planning Commission should make separate financial provision for this plan so that it is not financially dependent on the State plan.
3. The department for Tribal Development should act as a coordinating unit in each state.
4. There should be separate financial provision for each department so that local problems are solved.
5. Participation of the tribal people is very essential for the proper preparation and implementation of the Sub-Plan. This will help in understanding the real problems of the tribal people and finding solution to such problems.

Strategies for Development

1. Problems of Agricultural Development. Developmental programme for increasing agricultural production and productivity should include : (i) increase in irrigation facilities; (ii) soil conservation; (iii) provisions of modern agricultural inputs at affordable prices; (iv) arranging for economic size of the holdings; (v) improving agricultural marketing facilities and (vi) making tribal farmers aware of the latest techniques used in agriculture.

2. Problem of Land Alienation. A large part of land belonging to the tribal people has been grabbed by the money lenders and forest contractors. Some strong steps are to be taken to check this trend which include : (i) legal protection to the tribals; (ii) making tribals conscious of their rights; (iii) improving and up dating the land records. Unfortunately there are no land records in some of the tribal areas.

3. Development of Transport and Communication. Roads and different modes of communication need to improved to provide better accessibility, social inter action and opportunities of economic well being to the tribals.

4. Forest Policy. The last Indian Forest Policy was framed in 1988 which needs to be revised keeping in view the interests of the tribal people so that they are not deprived of the benefits of the forests. It is worth mentioning that most of the economic activities of the tribes are based on forests.

5. Development of Allied Agricultural Activities. Allied agricultural activities such as dairing, poultry, bee-keeping, animal husbandry, piggery, etc. should be developed to supplement the income of the tribals.

6. Development of Public Distribution System. Development of public distribution system is needed for proper supply of essential consumer goods to the tribals.

7. Development of Cottage and Small Scale Industries. Cottage and small scale industries can provide additional employment and these industries should be developed at least in some selected growth centres. These industries can be useful especially to those who are displaced from their original habitats by development projects like dams, large scale industries; transport routes etc.

8. Provisions of Social Services. Social amenities like medical and health facilities, nutrition, drinking water, housing etc. are to be provided to the tribals so that they are able to lead a reasonably good life.

9. Co-operation. Co-operative movement and Panchayati Raj institutions can go a long way in improving the lot of the tribals because they have a strong community feeling and long tradition of democratic institutions.

10. Educational Facilities. Provision of education facilities is of utmost importance to have a sustainable economic development among the tribal people.

11. Prevention of Exploitation. Poor, ignorant, illiterate and helpless tribals have been exploited since a long-time by the money lenders, landlords, forest contractors, government officials, panchayat members etc. It is practically difficult to put a check on such a large variety of powerful people but this is necessary if we want to see our tribals leading a peaceful and respectful life.

12. Change in Administrative Set-up. Administrative set-up should be changed in such a way that it becomes more responsive to the needs of the tribal people.

13. Periodic Evaluation. All the plans and programmes meant for the tribals need periodic evaluation so that old programmes may give way to new programmes and 'timely correction' is assured.

Case Study of Tribal Development Block—BASTAR

Although Bastar district has been divided into a number of districts, our purpose is served only by treating the erstwhile district of Bastar as an area of tribal study. Over 65% of the total population of Bastar district is tribal. Some of the tribes form a compact region, each conforming with physical division of the territory.

Location and Space Relations. Bastar district is situated in the southern corner of Chhattisgarh. It is bounded by Odisha in the east, Maharashtra in the west and Andhra Pradesh in the south. It is located at a distance of about 160 km from the port of Vishakhapatnam on the Andhra Coast along the Bay of Bengal and 88 kms from Raipur-Bhilai industrial complex in the north. It lies on the leeward side of the Eastern Ghats and, therefore, is devoid of any oceanic influences from the east. It, thus, has an interior location.

The Bastar tribal block is over 288 kms in north-south and 200 kms in east-west direction. With its total area of 37,750 sq kms, it is one of the largest districts of India and is larger than some states of India.

Physiography. A large part of this district is a plateau area between Mahanadi valley in the north and the Godavari valley in the south. The general elevation of this plateau is 600 metres above the mean sea-level. We can divide the entire area into the following five physiographic divisions (**Fig. 14.5**).

(i) The Northern Mahanadi Plains. This is a part of Mahanadi basin and is 300 to 450 metres above the mean sea-level. It slopes north-wards and continues into Chhattisgarh plain of Drug and Raipur districts.

(ii) The Abujhmar Hills. The Abujhmar hills are located in the western part of the Bastar district. Their height varies from 450 to 750 metres above the mean sea-level. The area consists of high ridges and deep valleys created by numerous streams. Thus, it is a highly rugged and undulating area. The hills and valleys have created an effective physical barrier from all sides and have isolated the area from the rest of the region.

(iii) The North-western Plateau. It is marked by steep scarps to its north, south and west. Its elevation varies between 450 and 730 metres above the mean sea-level. Indrawati plain lies towards its south at a height of 400-600 metres above the mean sea-level.

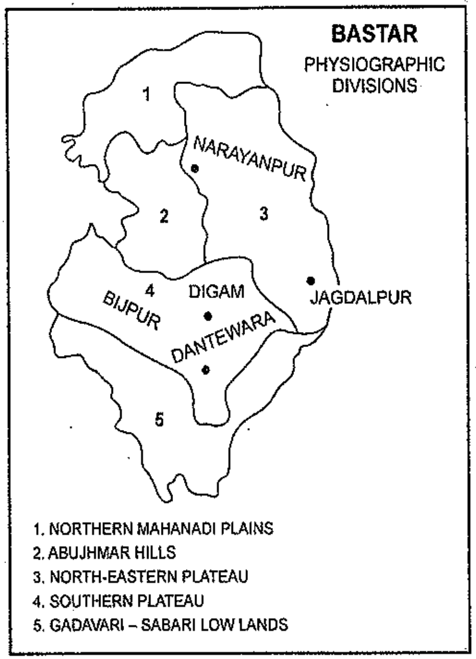

FIG. 14.5. Bastar : Physiographic Divisions

(iv)* The Southern Plateau.** This area is situated at an average height of 300 to over 750 metres above the mean sea-level. This plateau region has the Bailadila and Tikampalli hills in its middle. The small Dantewara plain lies in the north. Bailadila means ***'hump of a bullock' which is the highest hill in the Bastar district. It rises up to 1,200 metres above the mean sea-level. It has two parallel ridges which form physical barrier due to its height.

***(v)* The Godavari-Sabari Lowlands.** This lowland is just 150 to 300 metres above the mean sea-level and is a rolling plain except two hills in its south and along the southwest. It extends from the southern boundary of the district to the base of the southern plateau.

Drainage. The deep relationship between relief and drainage of Bastar district is easily seen by observing the lines of natural drainage separated by a number of hills (*See* **Fig. 14.5** and **14.6**). **Mahanadi** flows through this area, just after leaving its source beyond this district. Being in its upper reaches, it is still a small river in the extreme north of the district and a few tributaries join it from the south. **Godavari** drainage basin is the largest in the area. The main river flows only along the southern boundary of the district. There are high banks on its both sides. **Indrawati** and **Sabari** are the major tributaries of Godavari. ***Indrawati*** is the principal river flowing westwards through the middle of the area. ***Sabari*** flows along the south-eastern boundary of the district. Most of the rivers are perennial although the amount of water in these rivers fluctuates according to season (increasing in rainy season and decreasing in dry summers).

Climate. The whole of Bastar district has hot tropical monsoon type of climate. The mean annual temperature is 24.5°C and the average annual rainfall is about 120 cm. There are three distinct seasons of dry early summer, wet late summer and winter. Most of the rainfall is caused by the Arabian Sea branch of monsoon and only 8 cm of rainfall occurs in the winter season. The windward side of north-west and south-west of Bastar experiences more rainfall

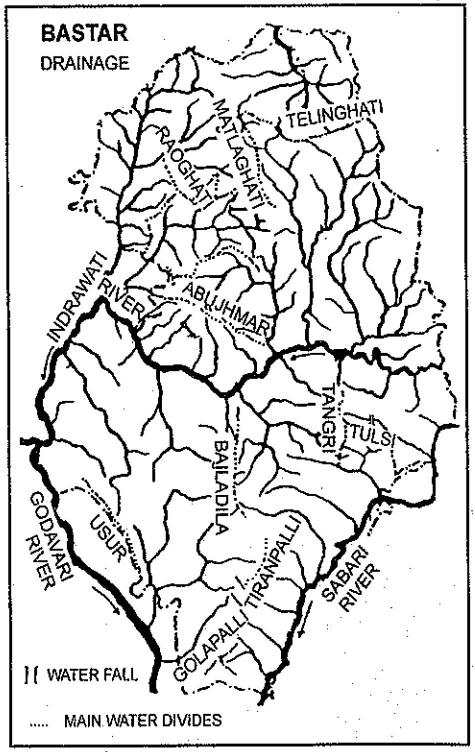

FIG. 14.6. Bastar Drainage

varying between 137 and 150 cms. The hills in the middle have created a rain-shadow area in the central Bastar and this area does not receive more than 120 cm of annual rainfall. Further east. It again increases to over 125 cm. Although there are no well-marked regional differences in climatic conditions, yet there are strong variations from one season to another.

The Resource Base. The two major resources of Bastar district are forests and minerals. The soils are thin and infertile and cultivated land is limited.

***(i)* Soil Resources.** Larger parts of the district have metamorphic and granite rocks which produce only poor red soil after weathering. The soil is thin in uplands and relatively deep in lowlands. It is converted into laterite soil on the uplands due to alternate dry and wet seasons of hot climate. Heavy rainfall has caused large-scale soil-erosion particularly on the bare hill slopes. The shifting agriculture, particularly on the Abujhmar hills, has further added to the loss of soil and vegetation cover. The vegetation does not add much humus to the soil.

***(ii)* Forest Resources.** The forests in Bastar are the most extensive resource. About three-fourth of its area is under natural forests. There are mostly moist deciduous forests consisting of hard woods. Teak, sal and laurels account for about 80% of the volume of wood found in these forests. The forests have not only provided protection to tribals of Bastar, but have also provided them with sound economic base for carrying out wood-based activities. Besides timber, these forests are the sources of gum, leaves, fruits, flowers and roots which are gathered by the tribal people.

***(iii)* Mineral Resources.** Bastar district is very rich in mineral resources particularly iron-ore. There are three vast tracts containing large quantities of iron-ore. These are :

(*a*) Raoghat hills in Narayanpur,

(*b*) Chargaon-Kondapakha-Haliladdi hills in the north-west, and

(*c*) Bailadila hills in Dantewara (now a separate district). The Raoghat hills situated on the northwestern border of north-eastern plateau have six bodies of iron-ore of high metallic content. The total reserves are estimated at 738 million tonnes. The Chargaon-Kondapakha-Haliladdi hills in north-western Bastar has about 83 million tonnes of ore having 56-59% metallic content.

The Bailadila range runs north-south along the western boundary of Dantewara. It is a 34 km long and 10 km wide range varying from 300 to 900 metres in altitude. It has an estimated iron-ore deposit of 1,153 million tonnes with 60 to 70% iron content. This iron-ore area is now opened up and linked with Vishakhapatnam port through which it is exported to Japan.

Besides iron-ore, Bastar has rich deposits of mica, limestone, bauxite, manganese, clays, glass sand and building stone. The utilization of most of these mineral resources is not being done due to low level of technology and the lack of modern skills among the tribal people.

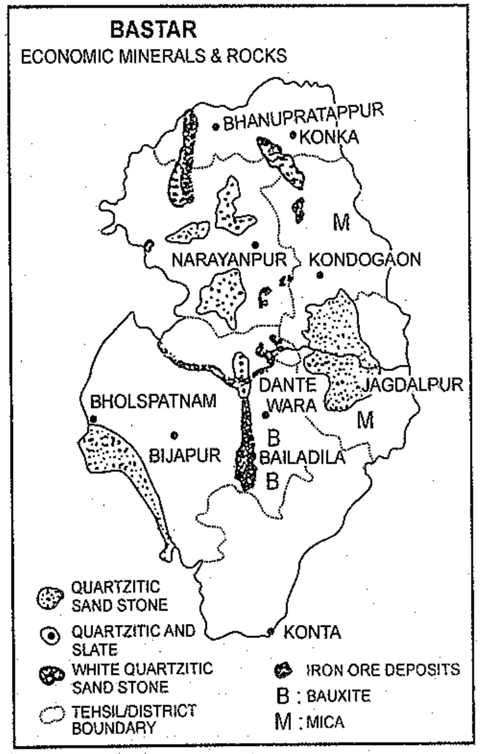

FIG. 14.7. Bastar : Economic Minerals and Rocks

Physiography and Human Life. The physiographic variations have led to the differences in human life and distribution of population. The lowlands offer many advantages for better agriculture and have comparatively higher density of population. The uplands are mostly covered by forests and have generally low density of population. But there are two exceptions to it. The southern plateau has been cleared off the forests for cultivation in spite of its wild hilly terrain. The other example is that of Abujhmar hills where cultivation is done on hill slopes instead of valleys. The Abujhmar tribes have settled on the lower margins of the upper hill slopes because there is more free air movement on hill slopes as compared to the valley bottom. These sites offer the advantages of nearness to forest upslopes, better drainage around the settlements and water points downslopes. Shifting agriculture is still practised in many areas.

The influence of physiography is clearly seen on the cropping pattern. Rice is grown in lowlands while millets and poor pulses are the main crops of the uplands. The topography has restricted the availability of underground water, hence no wells can be dug up particularly on higher slopes. Tanks, therefore, are the only source of collecting and storing water. High hills and steep slopes do not favour the construction of roads. Moreover, construction and maintenance of roads is very costly. There are cart tracks or a few fair-weather roads.

Climate and Human Life. With hot tropical monsoon type of climate and with little facility of canal and well irrigation, the agriculture is largely rainfed. About 90% of the net sown area is occupied by *kharif* (monsoon) crops when sufficient amount of water is available. The area under *rabi* crops is limited. In hot dry summers, agricultural productivity is at its minimum. During wet summer, enough fodder is available for the animals. Fishing is also carried on in some areas. As the winter temperature is comparatively higher in southern Godavari lowlands, *jowar* is grown both as *kharif* as well as *rabi* crops.

In hot dry summer season there is practically no agricultural activity and people gather forest produce and repair their thatched houses to withstand the heavy rainfall of the coming rainy season. The onset of rainy season brings diseases and cut off many villages from one another. Since the poor tribals have very little clothing, even the moderate winters are too severe to protect them from chill.

Population. More than two-thirds of the population of Bastar district belongs to Scheduled Tribes. Thus population is predominantly rural, living in small hamlets, in separate clearings in scattered forests and subsisting on farming wherever arable land is available. It is mainly concentrated in the lowlands or in basin shaped regions bordered by hills to provide them natural protection. The hills and forests are devoid of any population. The higher population concentrations are found in the Mahanadi basin (Kankar district), Indrawati basin (Jagdalpur), Kotri plain (Bhanupratappur), Dantewara plains (northern Dantewara) and Sabri plains (northern Konta). People are also concentrated in Kondagaon (north-eastern plateau) and southern Dantewara because these tracts are isolated basins providing a sort of privacy to the tribals. **Figure 14.8** shows the distribution of population in Bastar district.

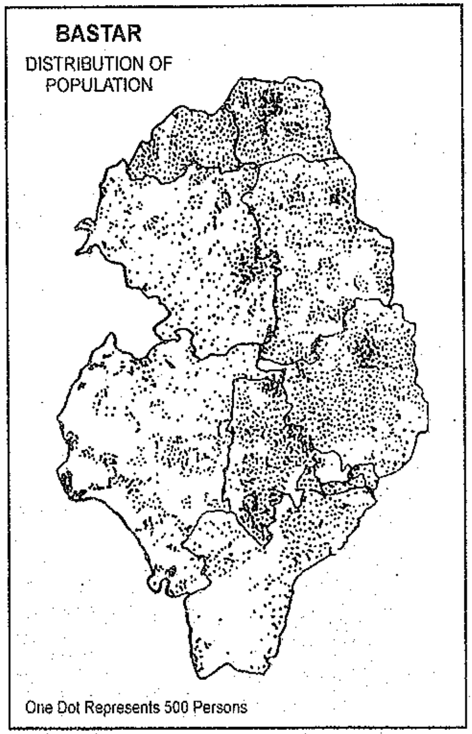

FIG. 14.8. Bastar : Distribution of Population-1991

Important Tribal Regions of Bastar District. The tribal population in Bastar district is not homogeneous. The physical isolation created by

difficult terrain has led the different tribal communities to live in their own worlds, developing their own customs, rituals and beliefs. Each one of the groups wants to preserve its identity and way of life. The whole district is divided into seven major cultural regions which are inhabited by numerically important major tribes. These regions differ amongst each other in respect of house types, food, dress, beliefs, language, customs and techniques, and tools which they use in the production process.

(*i*) The Abujhmar or Hill Maria Tribal Region. The Abujhmar hills are located in the middle of western part of this district. This is the remotest and most backward region in Bastar. The word '*Abujhmar*' means ***'the unknown highlands'*** and the Abujhmaria are living in the stone age even in this modem age. The ruggedness of the terrain, the thinness of soil and lack of rich resource base have kept these tribes economically very backward. They meet their economic needs from the local products and have very few material possessions.

They do not know the use of plough and depend on shifting agriculture (*penda*). They cultivate the

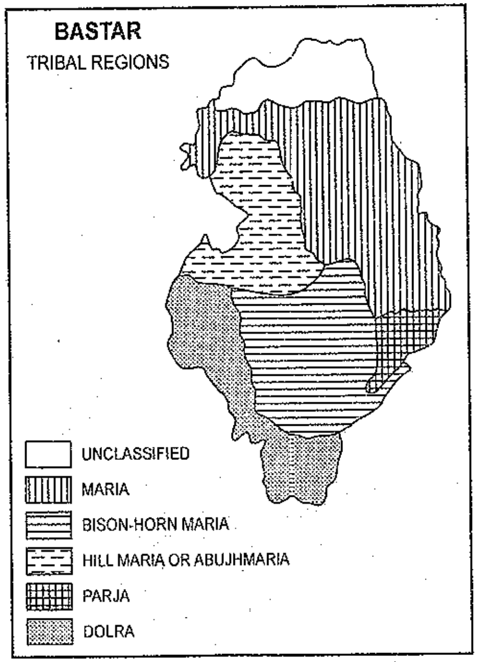

FIG. 14.9. Bastar : Tribal Regions

thin and poor upland soils and frequently shift the site of cultivation as deteriorating soils cannot sustain them for long. Their needs are small and population density is low. They are, therefore, averse to the modern development like roads, markets and other infrastructure. They are favourably inclined to accept such type of facilities as dispensary, poultry schemes and approach roads. There is a cultural barrier to change and it may take time to accept such changes.

(*ii*) The Maria Tribal Region. This is the biggest cultural region of Bastar district and extends over north-east plateau and its adjoining areas. This tribe is mainly engaged in subsistence agriculture and produce rice and millets. Kosra is the most important millet crop. They also gather sufficient quantity of forest produce from the surrounding areas. The Marias in central Jagdalpur and southern Kondagaon areas are culturally more advanced and are known as 'Raj Maria' tribes. The life-style of these tribes is changing fast. They are more open to the forces of market and their demands now include cloth, utensils and ornaments.

(*iii*) The Bhatra Tribal Region. Culturally, this region is also quite advanced. This is almost a flat area covering eastern part of Indrawati plain in Jagdalpur tehsil. Good soil and easy communications have favoured the cultural advancement of the people of this region. Their main occupation is agriculture. Although rice is the main crop, oilseeds, sugarcane as well as wheat are intensively grown. The proximity to Jagdalpur, the district headquarters of Bastar, have also influenced the life style of the people of this region. This town stands at the junction of Raipur-Vishakhapatnam National Highway with all-weather feeder roads to many places.

(*iv*) The Dolra Tribal Region. It is located in the Godavari-Sabri lowlands along the boundary of Andhra Pradesh and has been influenced by Andhra culture. The Dolra tribals are more advanced than the Bhatra tribals. They are fond of coconut oil but do not cultivate any oil-seeds. Rather they obtain coconut oil from the market. They collect *mahua* seeds from the local forests to obtain edible oil.

(*v*) The Parja (Dhurwa) Tribal Region. This region extends over the southern part of Jagdalpur and lies between north-eastern plateau and Sabari lowlands. The difficult terrain and thick forests have restricted the internal communication. Culturally, these tribes are less advanced than Bhatra and Maria. But Parja (Dhurwa) have been closely connected with the old ruling family of Bastar for long. They are, thus, advanced as compared to their Bison-Horn Maria neighbours. They have developed high skills in the bamboo work.

(*vi*) **The Bison-Horn Maria Tribal Region.** This is one of the most backward tribal regions of Bastar. It extends in Dantewara region and parts of Bijapur east and Konta north regions. These people use bison horns at the time of dancing which has given this name to them. The Dantewara basin is partly plain and partly plateau. They do not practise shifting agriculture but follow a system of rotation which they practise on the hill slopes and permanent cultivation on the valley floor. The highest number of murders and suicides in Bastar occur here. Another sign of backwardness is that a high proportion of plough animals—cows and bullocks, are often killed for beef. The construction of a railway line between Kirandul and Vishakhapatnam and mining of the iron-ore in Bailadila are two important developments in this region.

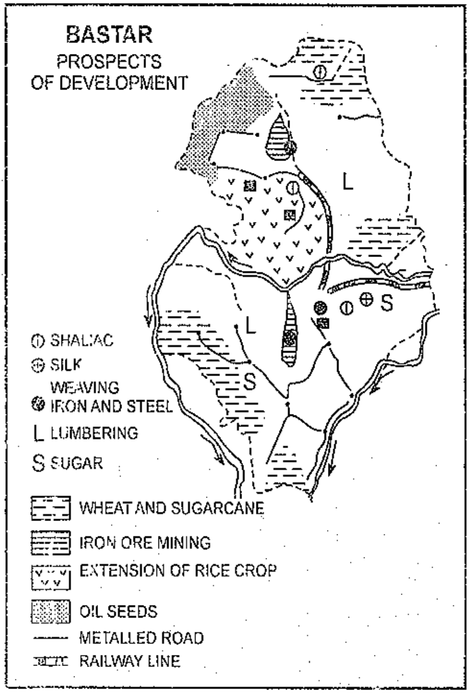

FIG. 14.10. Bastar : Prospects of Development

(*vii*) **An Unclassified Gond Tribal Region.** This region exists in the Mahanadi basin in the north extending over Kankar and Bhanupratappur. Its proximity to Chhattisgarh plain has helped in making better contacts with relatively advanced people of that area. This has resulted in economic and cultural advancement of these people. Its accessibility, low land relief and good soils are also instrumental in getting rid of backwardness. The economy of the region is fully agricultural. Rice is the dominant crop. The Kankar and Bhanupratappur are two nodal points which are connected with Raipur and Jagdalpur.

Planning the Development. Bastar has been attracting attention of the planners right from the beginning of the five- year plans. The two Special Multi-purpose Tribal Blocks, set up in the district for intensive development of tribal areas in 1956-57, were renamed as Tribal Development Blocks during the Third Five-Year Plan period. This strategy aimed at an integrated intensive programme covering all aspects of tribal life.

The idea of tribal development block emphasised the importance of soil-conservation, afforestation, social welfare, education, health, co-operation and communication. The opening of the Bailadila iron-ore mining and laying of railway and road network have ushered the era of economic development. The tribal people have welcomed the health facilities. Some changes in their consumption pattern and life style have been noticed. Agriculture and forestry are the two occupations of the people of this area. These two occupations have got to be strengthened. This requires suitable skills and enough inputs. Outside agencies may help in the economic development but the cultural heritage of the tribal people of this district will have to be safeguarded.

Failures of Development Plans. The Tribal Development Block could not deliver the desired result because blocks have been found to be too small an area for purposeful planning by the *Shilu Ao Committee*. Moreover, the development planning has been fragmented and some of the schemes which were introduced in tribal areas were actually meant for advanced communities. The employment-generating activities have not been taken up properly.

The active participation by the local people had been badly lacking. Most parts of the district are yet to be properly surveyed and the real potential of the area cannot be properly worked out. The land records are also not complete and up-to-date. The land laws should protect the ownership rights of the tribals. Care should be taken that outsiders with better skills and technology do not exploit the tribal people.

Multi-Level Planning

Planing is the process which may be conceived in the form of either single level or multi-level. In India, single level plan is formulated at the central level while in multi-level plan, states, districts, blocks and villages play their respective roles. Under the multi-level planning, formulation of the plans takes place at different levels and the combination of plans at different levels gives a macro system of planning. Multi-level planning may be defined as "*planning for a variety of regions which together form a system and subordinate systems.*" Multi-level planning is more effective than the single level planning because every region (state, district, block or village) is involved in the planning process and there is direct participation of the people at the grass root level.

History of Multi-level Planning in India

During the first three Five Year Plans, planning was mainly formulated by the Central Government and implementation of the plans was also the responsibility of the Central Government. These plans were prepared by the Planning Commission of India which was governed by the Central Government. Some State Governments prepared their own plans during the Fourth Five Year Plan. B.R. Mehta Committee (1957) and Administration Reforms Committee (1967) recommended planning at the district level. The Government of India issued guidelines for district level planning in 1969 and some states started preparing their own state level plans following these guidelines. For example, Maharashtra and Gujarat prepared state level plans in 1972 and 1979 respectively. Emphasis was laid on decentralization while preparing state level plans in 1972. During 1978 and 1983, the block level planning was encouraged. This enabled the concerned agencies to gain experience in multi-level planning and helped in concentrating on the proper utilisation of the local resources.

In 1977-78, Dantewala Committee and Ashok Mehta Committee were constituted to suggest ways and means for implementing plans in the right perspective. Dantewala Committee suggested that the plans should be implemented at the block level. The activities involved in the block level planning should include miner irrigation projects, poultry, soil conservation, water management, social facilities etc. According to Dantewala Committee, block should be basic unit for planning because it has small size having limited population. These factors are quite convenient for establishing a close contact between the planners and the people. Ashok Mehta Committee emphasized upon the role of Panchayati Raj and stressed upon planning at the village level. On the recommendations of these two committees more emphasis was laid on rural development and rural planning during the Six Five Year Plan (1978-83).

The Present Day Multi-Level Planning in India

At present planing is done at five different levels which are at the level of (1) Centre, (2) State, (3) Districts, (4) Blocks, and (5) Villages. Before the 73rd and 74th Constitutional amendments in 1992, the task of plan formulation was primarily carried out by the centre and the state governments and the other levels (namely district, block and village) of planning process came into picture only at the implementation stage. But after these Constitutional Amendments, the lower levels of planning have been duly recognised and financial assistance has been provided to multi-level planning. Different levels of planning are briefly described as under :

1. The Central Level Planning. Also called First Level Planning, this is the first and the foremost level of planning which is formulated by the Central Government,. The central plans are prepared by the Planning Commission of India headed by the Prime Minister. Its members are some central ministers and 3-4 planning experts. The final assent to the plan is granted by the President of India who acts on the advice of the Council of Ministers which is binding on the President.

The business of the government is transacted through a three tier set-up. The *first layer* is constituted by the Prime Minister, Cabinet Minister, Minister of State, Deputy Ministers and Parliamentary

Secretaries. The *second layer* is constituted by the secretariat organisation of the ministry with secretary as its head. The *third layer* consists of executive organisation of the department.

2. The State Level Planning. This is also known as Second Level Planning under which all the states are entitled to frame and execute their own plans aimed at economic growth and in the interest of the general public. The plan is prepared by the State Planning Commission headed by the Chief Minister and is sent to the State Governor for his assent on the advice of the Council of Ministers which is binding on the Governor. The Council of Ministers works through the secretariat which is headed by a secretary. The State Planing Commission, in addition to the Chief Minister, has some ministers and a few professional experts in planning which assists the Council of Ministers in the planning process. The Council of Ministers has various departments functioning under it. These departments can be classified into the following three categories :

1. Development departments (agriculture, animal husbandry, rural development, public works and industries).
2. Social welfare department (health, education and social welfare).
3. Coordinating departments (home, revenue, finance, and planning).

Like the Central Planning, the State Level Planning is also of five year. However, the finances for the State Level Planning are to be arranged by the concerned state although there is a provision for financial assistance and loans from the centre.

The Constitution of India has provision for division of powers between the Centre and the States with reference to planning so that the chances of confrontation between the two may be minimised. The Seventh Schedule and Article 246 of the Constitution of India gives three lists of subjects (*i*) ***Union List*** (containing 97 items), ***State List*** (containing 66 items), and ***Concurrent List*** (containing 49 items).

The Central Government enjoys the power to legislate on the subject given in the Union List whereas the State Governments have power to legislate on the subjects contained in the State list. But both the Central and State Governments have powers to legislate on the subjects contained in the Concurrent List. However, the Central Law prevails whenever there is a conflict between the Centre and the States. According to the Prevailing law, organised activities like minerals, industries, railways, and telecommunications come under the Centre's purview while agriculture, collection of land revenue, irrigation, power, public health, education, local self government and several other important subjects are the responsibilities of the State Governments.

3. The District Level Planning. This is the Third Level of Planning where local planning starts. The District Level Planning is the responsibility of the District Planning Committee which is directly under the control of the district collector (also known as deputy commissioner in some states). He is responsible for maintaining law and order in the district and also acts as a coordinator among various departments. The main departments are those of agriculture, irrigation, animal husbandry, fishing, dairying, forestry, education, health, public works, industries, cooperation, social welfare, transport, panchayati raj, etc. Besides there are offices of the autonomous bodies, like those of Electricity Board, State Road Transport etc. Municipality for Urban Planning and Gram Panchayat for Rural Planning play an important role.

4. Block Level Planning. The Block Level Planning is lower than the District Level Planning but higher than the Local or Panchayat Level Planning. This level of planning was started right in the First Five Year Plan. For planning purposes, each district was divided into a number of blocks. Each block consisted of about 100 villages and a population of about 60,000. Participation of the local people is very important and decisions by the local people are intended to use the local resources in a better way. This level of planning is executed by the *samiti* of the villagers headed by the Block Development Officer (BDO). The general supervision of blocks is done by ***Block Samitis*** under the chairmanship of the ***Block Pramukh*** and elected representatives.

The institutional set up consists of a Block Development Officer (BDO) and five extension officers each of whom assists the BDO in the field of agriculture, animal husbandry, co-operation panchayats and rural industries. Apart from this, there is an oversear, a social education organiser, a progress

assistant and village level workers on the staff. Also there are veterinary stockman, a medical officer, a sanitary inspector and a lady health visitor. Some states have an extension officer for programmes related to women and children.

The primary aim of the Block Level Planning is to understand the problems of the local people, to find ways and means to solve those problems and formulate as well as execute the development plans. Proper understanding of the local problems helps in optimum utilisation of the local resources. It generates employment opportunities and the way for planning. In fact the entire strategy of the Block Level Planning is based on employment planning, growth-centre planning and credit planning. The main activities of this type of planning include (*i*) agriculture and allied activities, (*ii*) soil conservation and water management, (*iii*) animal husbandry and poultry, (*iv*) fisheries, (*v*) forestry, (*vi*) processing of agricultural produce, (*vii*) organising input supply, credit and marketing, (*viii*) cottage and small scale industries, (*ix*) local infrastructure, (*x*) social services (drinking water supply, health and nutrition, education, housing, sanitation, local transport and welfare programme) and (*xi*) training of local youth and updating of skills of local population.

5. Local or Panchayat Level Planning. This is the lowest level of planning for which the Village Development Officer (VDO) and secretary are responsible. It is supervised by the *Gram Sabha* which is headed by the *Gram Pradhan*. It formulates plans for the welfare of the villagers. Funds are directly allocated from the centre for executing rural development programmes such as Integrated Rural Development Programme (IRDP) and Jawahar Rojgar Yojna (JRY). In addition, the *Panchayat* is also responsible for (*i*) promotion of agriculture; (*ii*) rural industries, (*iii*) health, (*iv*) maternity, women and child welfare, (*v*) common grazing grounds, (*vi*) village roads, tanks, wells, (*vii*) sanitation, and (*viii*) socio-economic development programmes.

DAMODAR VALLEY CORPORATION (DVC)

The Damodar river is a tributary of the Hugli river. It flows more or less in the west to east direction through Jharkhand and West Bengal. Its total length from its source in the hills of Chotanagpur plateau in Jharkhand to its confluence with Hugli in West Bengal is about 541 kms, 270 kms of which is in Jharkhand and the remaining 271 kms lies in West Bengal. In its upper reaches, it is known as Deonadi. It drains Ranchi, Hazaribagh, Dhanbad and Santhal Parganas districts of Jharkhand and Bankura and Bardhman districts of West Bengal. It takes a southerly turn from Bardhman town and joins river Hugli about 50 kms upstream from Kolkata. Damodar valley covers an area of 24,235 sq km in Jharkhand and West Bengal. Bokaro, Barakar, Konar are its important tributaries.

Physical Setting. Damodar valley runs through the middle of Chotanagpur Plateau in Jharkhand. It lies between the plateaus of Chotanagpur and Hazaribagh in the north and of Ranchi in the south. The average elevation of this plateau complex varies between 300 and 600 metres. The river originates at an altitude of 510 metres above sea-level and joins the Hugli at an altitude of less than 30 metres above the mean sea-level. It leaves plateau at a height of about 150 metres and reaches the plains in Bardhman district (**Fig. 14.11**).

The Damodar valley is a rift valley or a sunken trough, bounded by broken and tilted edges of the plateaus. As there are sudden descents from one level of plateau surface to the other, the whole topography of the surrounding area has an undulating nature. The break points, where tributary streams join the main Damodar river, have provided suitable sites for power houses. The residual hills of hard rocks left here and there in the basin have been joined to construct dams across the streams. The undulating nature of topography and faulted nature of strata have also favoured the extraction of coal.

Climate. The region receives annual rainfall of about 125 cms. This is monsoon rainfall which is concentrated between June and September. As the area lies in the path of tropical cyclones from the Bay of Bengal, there are chances of stormy rainfall many a times. Generally, the amount of rainfall is more in upper slopes than at the valley floor and more in the west than in the east.

Hydrology and Water-Power Development. The erratic monsoonal rainfall and heavy downpour due to tropical cyclones poses serious problem of

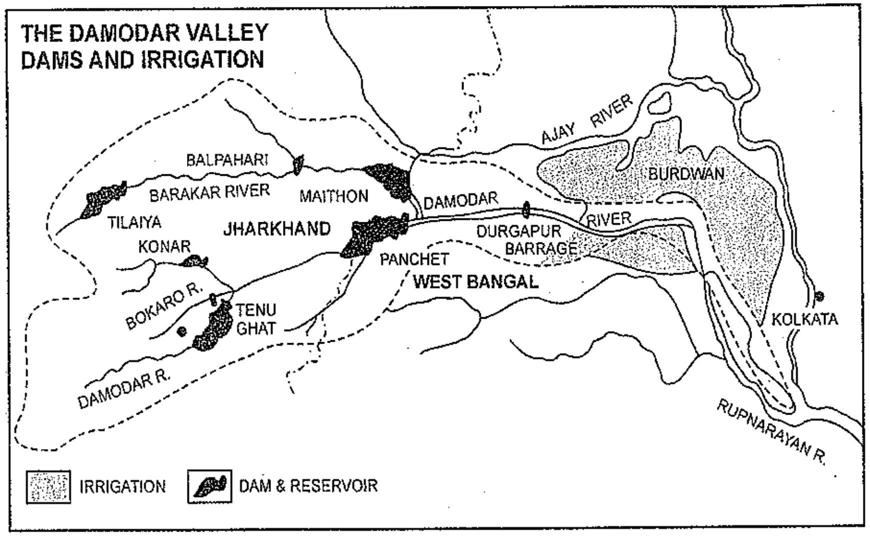

FIG. 14.11. The Damodar Valley : Dams and Irrigated Area

floods. The channel of the river is unable to accommodate the flow of water during the rainy season. The rocks suffer weathering in the hot and humid climate causing much erosion over sandstones and slates. This adds to the load of debris which often chokes the channel and aggravates the flood situation. The deforestation in the upper hills has made the problem more complicated. As soon as the total drainage converges and crosses through a narrow bottleneck amidst the rocks at Asansol and emerges on the plains near Bardhman, the heavy amount of sediments choking its peak flow is burst open. The plains below Bardhman get submerged under flood waters, sometimes to a depth of 2 to 2.5 metres causing great damage to life and property. Thus, the river Damodar became notorious for its floods and was known as ***'River of Sorrow'*** or ***'Sorrow of Bengal'*** and even ***'Sorrow of region'***. Its notoriety was demonstrated by the devastating floods in 1823, 1848, 1856, 1859, 1863, 1882, 1890, 1898, 1901, 1905, 1907, 1913, 1916, 1923, 1935 and 1943. While major floods occur at intervals, minor floods are experienced almost every year. The sediments brought by the Damodar create the problem of sedimentation in the Hugli which, in turn, endangers the Kolkata port.

In order to control the floods and other related problems, the Central Government, in consultation with the state governments of the then Bihar and West Bengal, worked out a unified development project for Damodar basin. The Damodar Flood Enquiry Committee suggested a comprehensive plan. This plan was based on the memorandum submitted by W.L. Voorduin, an engineer with the Tennessee Valley Authority (TVA) in the USA. The Damodar Valley Corporation (DVC) was established on 18th February 1948 to execute the Damodar Valley Project. The original plan was to construct seven major dams. These dams were Aiyar and Panchet Hill on the Damodar river; Maithon, Belpahari and Tilaiya on the Barakar river; Konar on the Konar river and Bokaro on the Bokaro river. But the DVC has constructed only four dams (Tilaiya, Maithon, Konar and Panchet). These dams are briefly described as under : **[Fig. 14.11]**

(*i*) Tilaiya Dam. This dam has been constructed on Barakar river. The construction on this dam was started in 1950 and completed in 1953. Its length is 366 metres and the maximum height above the river bed is 30 metres. Its gross storage capacity is 395 million cubic metres and its live storage capacity is 321 million cubic metres. It is the only concrete dam in the area. Two power stations of 2000 kW each have been set up here. The dam provides irrigation facilities to forty thousand hectares of land.

(*ii*) Konar Dam. It has been constructed on Konar river in Hazaribagh district of Jharkhand. It is 3,549 metres long and its maximum height above river bed is 49 metres. It is an earthen dam with concrete spillway. Its gross storage capacity is 337 million cubic metres and live storage capacity is 276 million cubic metres. Construction on this dam started in 1950 and it was completed in 1955. It has an installed capacity of ten megawatts. Bokaro steel plant and Bokaro thermal plant receive hydroelectric power and clean water respectively from this dam. It provides irrigation to 45,000 hectares of agricultural land.

(*iii*) Maithon Dam. It has been constructed on Barakar river, a little upstream from the confluence of rivers Damodar and Barakar. It is 994 metres long and its maximum height above the river bed is 49 metres. Its gross storage capacity is 1,357 million cubic metres. Construction on this dam was started in 1951 and completed in 1958. It has an installed capacity of 60 megawatts.

(*iv*) Panchet Hill Dam. This is also an earthen dam with concrete spill-way which is constructed on the river Damodar. Construction started on this dam in 1952 and was completed in 1959. This dam is 2,545 metres long and its maximum height above the river bed is 49 metres. Its gross storage capacity is 1,497 million cubic metres while its live storage capacity is 1,307 million cubic metres. It has an installed capacity of 40 megawatts and it irrigates about 28 lakh hectares of agricultural land.

Durgapur Barrage. The Durgapur barrage located at about 23 kms from Raniganj has been created for the storage of irrigation water. It is 831 metres long and about 12 metres high. It stores the water from Konar, Tilaiya, Maithon and Panchet Hill dams. The bulk of the water for storage is provided by Maithon and Panchet hill dams. This irrigation water is regulated through a network of canals extending over an area of about 5,000 sq kms in Bankura, Bardhman, Hugli and Haora districts in West Bengal. The barrage was completed in 1955. About 4 lakh hectares of land is irrigated mainly along the left bank in Bardhman and Hugli districts. The hilly nature of the terrain in Jharkhand has restricted the irrigated area.

The left bank of Damodar canal is navigation-cum-irrigation canal connecting Kolkata with the Damodar valley coal-fields. It is 137 kms long which carries 20 lakh tonnes of goods annually.

Benefits from the Project. Damodar Valley Project is a big landmark in the economic development of this region. Following are the main benefits drawn from the project :

(*i*) Flood control in the flood prone areas of Jharkhand and West Bengal.

(*ii*) Irrigation facilities to about 5.15 lakh hectares of land.

(*iii*) Installed capacity of 2,60,000 kW of hydro-electricity at various dam sites.

(*iv*) Check on soil-erosion through regulated flow of water.

(*v*) Additional land reclamation for agriculture.

(*vi*) Navigation in Damodar river, its tributaries and channels.

(*vii*) Promotion of public health through control on malaria and other diseases as a result of proper drainage of water.

(*viii*) Encouragement to fishing in the reservoirs and other water bodies.

(*ix*) Promotion of tourism.

(*x*) The project has provided a broad industrial base to the area.

Soils. Soils in the Damodar Valley are heavy clays and loams. They are deep and heavy on flat coal layers or low-lying tracts and light, coarse and thin in the uplands. Most of the land in the upper part of the basin in Chotanagpur region of Jharkhand is of relatively low fertility. The terrain is undulating and lacks irrigation facilities.

Forests. Over 40% of the region in Chotanagpur is under forests. There are valuable forest products. Besides *sal* wood, minor produce is collected from a number of other trees. Forest cover is poor on high hill slopes, having only palm, *ber*, *sabai* grass, *dhak*, bamboo and the thorny plants.

Soil-Conservation and Afforestation. The Damodar Valley Corporation has been assigned the task of soil-conservation and afforestation. The main objective of soil conservation and afforestation in the catchment area is to reduce the soil erosion and save the reservoirs from heavy siltation. The problem of soil-erosion is being tackled on watershed basis. The measures adopted for soil-conservation are survey of soils taking into account the various 'physio-chemical properties of the soils, degree of slope, extent of erosion, present land use and suitability of irrigation', demonstration of better methods of land management and assessing the soil-fertility.

Afforestation within the catchment of Damodar valley is being carried out by the Forest Division of the Corporation as well as the forest departments of the state governments of Jharkhand and West Bengal.

Agriculture. The agricultural pattern is similar to that prevailing in other parts of Chotanagpur plateau in Jharkhand. For most parts of the Damodar basin, it is one-crop culture, *i.e.*, only one crop is grown in one agricultural year. Rice is the main crop of lowlands while uplands are more suitable for maize and pulses. These crops are just sufficient to meet the local requirements only.

The agricultural productivity of the area is low. The population density is not very high but limited nature of arable land available to the peasants has brought down the land-man ratio. There is only 0.1 to 0.4 hectares of land of poor type of net sown area for each individual peasant. In Jharkhand portion, besides some fairly big stretches of cultivated blocks in the lower portion of upper valley floor, Dhanbad district in its lower portion has the most extensive cultivation, amounting to 23% of its total area. The progress of coal mining, its heaps, mining settlements, a dense network of communication lines, thick forests and disturbance of local drainage because of huge mining operation, have all damaged the basin's cultivation.

Mineral Resource Base. The Damodar valley region is the most mineralised region of our country. As a matter of fact, the Chotanagpur plateau, in which this valley is located, is known as the *'mineral heartland of India'* **[Fig. 14.12].** Some important minerals are briefly described as under :

Coal. The Gondwana sedimentary rocks in the valley contain rich coal deposits. The richest, largest and most productive coal-fields lie in this region. The Damodar valley has about 60% of the country's reserves of medium grade coal and produces about half the output of coal in India. Most of the coal-fields are situated in the main valley of Damodar to the north of the river. Following are the important coal-fields of this area.

(i) **Raniganj Coal-Fields.** The coal mining in India started at Raniganj over a century ago. In this way, it is the oldest coalfield in India. Raniganj coal-fields spread over 1,500 sq km across Burdwan, Purulia and Bankura in West Bengal. A large quantity of coal from Raniganj is used for producing thermal power at Bandel, Durgapur and New Kashipore. The

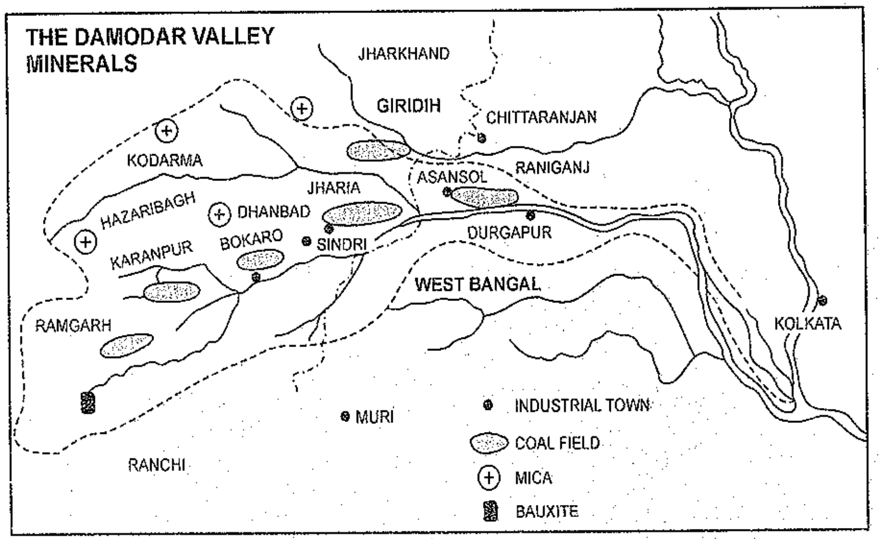

FIG. 14.12. Damodar Valley : Minerals

total reserves of this field are estimated at 13,290 lakh tonnes of high grade bituminous coal.

(ii) **Jharia Coal-Field.** Jharia is the most important of all the coal-fields of India with regard to reserves and production. It has total reserves of about 1,698.5 crore tonnes and produces about 20% of India's coal. It spreads over an area of 440 sq kms lying entirely in Dhanbad district.

(iii) **Bokaro Coal-Field.** This is the third important coal-field after Jharia and Raniganj. It is located in Hazaribagh district of Bihar. It has total reserves of 4,47,737.3 lakh tonnes and it produces about 6.2% coal of India.

(iv) **Ramgarh Coal-Field.** This is located in upper Damodar valley in Hazaribagh district and spreads over an area of 100 sq kms. Its reserves are estimated at 10,592 lakh tonnes.

(v) **Karanpura Coal-Field.** This coalfield spreads over an area of 1,522 sq kms in Hazaribagh, Ranchi and Palamau districts. The total reserves are estimated at 1,88,686 lakh tonnes and its production accounts for nearly 6% of India.

(vi) **Chandrapura.** It is more or less a part of Bokaro coal-field. The coal from this field is used in the Chandrapura thermal power station.

Other Minerals. Apart from coal, this region produces a large variety of other minerals, such as iron-ore, bauxite, copper, lead, mica and manganese. Fire clay is an important mineral, capable of resisting high temperature and a raw material for the manufacture of fire bricks and other refractories. This region produces about 10% of India's total production. Graphite in Dhanbad, sands in Damodar, crystalline limestone in the western parts, iron-ore in Dhanbad and scattered quartz elsewhere are also important.

Thermal Power. Thermal power stations have been set-up at Bokaro, Chandrapura, Durgapur, Sindri, Jamshedpur, Burnpur and Sitapur based on the locally available coal. They meet the power requirements of most parts of the Damodar river drainage basin.

Development of Transport Infrastructure. The region has a dense network of railways and roadways. Towards the lower part of Damodar basin, there is a clear convergence of railways from north, north-west, west and south-west. It has the locational advantage of being near to Kolkata. Dhanbad has become the focus of convergence of rails and roads. The grand chord line joining Delhi and Kolkata passes through the northern part of the Damodar valley. This line is now fully electrified. Besides this, many short railway lines criss-cross this area. A number of routes diverge towards west of Asansol. The watershed between the Ajai and the Damodar rivers is not very prominent, hence the railway link to Patna follows it and a branch line links Giridih. The railway line linking Kolkata-Asansol to Gaya-Patna passes through the upper Barakar river valley.

In the upper portion of the valley, the railway line from Dehri-On-Son via Daltonganj runs along the coal-fields belt. A branch line extends southwards to Jamshedpur via Muri. The recession of the scarp-slopes of Ranchi plateau has provided a passage through which routes to Jamshedpur are provided. The western part of the Damodar valley is hilly, forested and thinly populated. Therefore, it represents an undeveloped country-side while eastern part has recorded economic development.

In addition to railways, there is a network of major and minor roads. In more difficult terrain, where rail links cannot be provided, roads have been constructed negotiating the scarps. Sher Shah Suri Marg runs almost parallel to the Grand Chord Railway line in the Dhanbad section of the region. The industrial towns, collieries and washeries have been linked by local roads.

Industrial Development. The rich mineral resources of the region have provided a solid base for the rapid and widespread industrialization of the area. The Damodar valley presents a full industrial landscape which is comparable to any advanced country of the world. The valley is full of large and medium-sized factories. The Sindri fertilizer factory and cement factories at Sindri and Khalari, coal-washeries in Dhanbad, engineering works at Kumardhubi, refractory works at Dhanbad, glass and lead smelting factory works at Tundoo, aluminium factories near Asansol and at Muri, copper smelting at Ghatshila, locomotives at Chittaranjan and steel plants at Durgapur, Bokaro and Jamshedpur combine to make it a great industrial region. Government has contributed a lot towards the industrial growth of the region by setting a number of public sector undertakings. Durgapur and Bokaro steel complexes, Heavy Engineering Corporation Ltd. at Ranchi, Sindri Fertilizer Plant and Indian Explosives near Hazaribagh provide some such examples. Six industrial complexes have emerged over time in the Damodar valley region. These are : (*a*) Durgapur industrial complex having thermal power plant, coke oven, iron and steel, mining machinery and cement machinery and electrical industries; (*b*) Asansol-Kulti-Burnpur industrial complex with steel factory at Burnpur, Chittaranjan Locomotives, Kulti Foundry Works, and Kumardhubi Engineering Works; (*c*) Dhanbad-Sindri-Jharia industrial area having Sindri Fertilizer Industry, chemical and coal-based industries; (*d*) Bokaro industrial area consisting of steel plant, thermal plants at Bokaro and Chandrapura along with coal washeries; (*e*) Ramgarh-Patratu area with Indian explosives and thermal power plants; and (*f*) Ranchi industrial township with HEC, HMT and foundry plants.

The mining industry has always occupied the place of pride in this region. This is abundantly clear from the structure of the work force in the area. Of the total work force, about 4.8% in Dhanbad, 6.3% in Santhal Parganas, 8.7% in Giridih and 9.8% in Hazaribagh district is engaged in mining.

With the availability of more hydro-electric and thermal power, more industries such as steel plants, coal-washeries, industries based on coal and its by-products and some forest-based industries are likely to grow and the Damodar valley will become large size industrial region of India.

The People. There are large variations in the population density of the Damodar valley. The upper catchment area is hilly and forested where low population density is found. In contrast, the lower part of the valley supports high population density and has experienced more urbanisation. The process of urbanisation is closely related to the rate of industrialisation. As such, the areas having more industries are more urbanised. Nearly 51.3% of the total population in Dhanbad has been recorded as urban. Purbi Singhbhum (52.9%) and Bardhman (35.4%) are other districts. Santhal Parganas and Bankura have low proportion of urban population, which have recorded 6.9% and 7.6% urban population respectively. A major part of the population especially of the Chotanagpur plateau is tribal which has its own problems of development.

The Problems. The Damodar Valley Project was primarily conceived for flood control and this target has not been achieved fully. Heavy floods did occur in 1959, 1970-71 and 1978, though their ferocity has been much reduced. Only four dams have been constructed in place of the original suggestion of seven dams. The over-utilisation of forest and lack of afforestation have aggravated siltation in the dams. Thus, the first line of defence in the form of forests and the second line of defence in the form of dams have failed to eliminate the problem of floods altogether. Hydroelectricity is to be supplemented by thermal electricity because the flood-control dams cannot be taken as power-generating dams in view of the creation of flood cushion before monsoon every year. However, the DVC has been an important example of integrated regional development. Its efficiency can be improved with better management and foresight.

Comparison of Damodar Valley with Ruhr Valley. There are so many similarities between Damodar Valley of India and Ruhr Valley of Germany. Damodar valley produces about 60% of India's coal and Ruhr valley provides 80% of Germany's coal. Both the areas have high grade bituminous coal. Both the areas have high level growth of coal-based industries. The other industries are also fairly developed. Transport facilities in the shape of railways, roadways and waterways are abundantly available to both the areas. Looking at these similarities, the Damodar river basin is often called as the '*Ruhr of India*'.

NATIONAL CAPITAL REGION

Delhi, the national capital of India, has registered a phenomenal growth in population in the twentieth century, especially after independence. **Table 14.3** gives an idea of population growth of Delhi.

The vast economic opportunities available in Delhi have attracted large number of migrants not only from its immediate neighbourhood but also from the far-off places in the country. This large-scale influx of people has put heavy strain on infrastructural facilities of the city which include among other things, housing, employment, transport, electricity, water, sewerage, education, medical treatment, etc. The concept of National Capital

Region was conceived to reduce pressure of increasing population on these infrastructural facilities. Any strategy of containing the growth of Delhi within limits will have to be taken within the regional frame in which Delhi exists. The region in the immediate hinterland of Delhi, within which the development had to be planned in order to release pressure from Delhi, is known as '*National Capital Region*'. The Master Plan of Delhi was prepared in 1959 and was finally approved by the Government of India in 1962. The Master Plan contained amongst others a recommendation of setting a statutory NCR Planning Board. Initially, this board was constituted as an advisory body which was reconstructed in 1973.

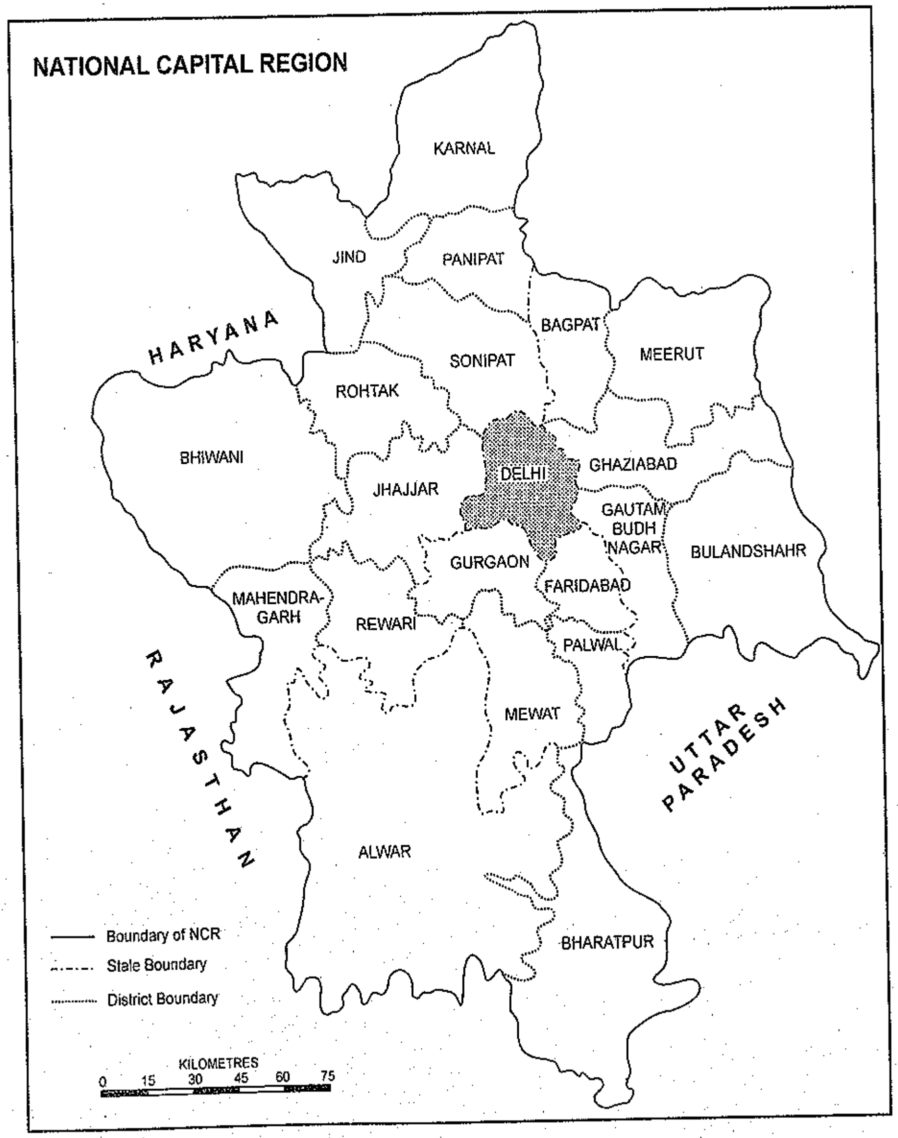

FIG. 14.13. National Capital Region

Its task was of coordinating the development of urban and rural areas in the National Capital Region under a comprehensive regional plan and to secure the collaboration of the concerned state governments in implementing the plan.

TABLE 14.3. Population of Delhi Urban Area

Census Year	Population
1901	2,14,115
1911	2,37,944
1921	3,04,420
1931	4,47,442
1941	6,95,684
1951	14,37,134
1961	23,89,408
1971	36,47,023
1981	57,29,283
1991	83,75,188
2001	1,38,50,507
2011	1,67,53,235

However, it was only in 1985 that a statutory organisation, named as National Capital Region Planning Board could be instituted through the enactment of NCRPB Act with a view to plan, implement and supervise regional development planning in the NCR. The plan was prepared on the basis of expert studies and deliberations between central and the agencies of the concerned state governments and was finally approved by the NCRPB on November 3, 1988 for its immediate implementation.

The Physical Extent of NCR. The National Capital Region extends over the Union Territory Delhi and adjoining parts of Haryana, Uttar Pradesh and Rajasthan. The administrative units constituting the NCR are as under :

(*i*) Union Territory of Delhi (1,483 sq km)

(*ii*) Haryana sub-region comprising 13 districts of Faridabad, Gurgaon, Mewat, Rohtak, Sonepat, Rewari, Jhajjar, Panipat, Palwal, Mahendragarh, Bhiwani, Karnal and Jind.

(*iii*) The Uttar Pradesh sub-region comprising five districts of Meerut, Ghaziabad, Gautam Budh Nagar (NOIDA), Bulandshahr and Bhagpat.

In September 2014, there had been a demand for the inclusion of Saharanpur, Shamli, Muzaffarnagar, Bijnor and Hapur areas of Uttar Pradesh into the National Capital Territory. It is argued that all these areas are within a 100 km radius of Delhi NCR and rightly deserve to an integral part of NCR.

(*iv*) The Rajasthan sub-region comprising two districts Alwar and Bhratpur. 'With an area of 8,380 sq km. Alwar is the largest district in NCR.

Notes : (*i*) Mahendragarh and Bhiwani districts of Haryana and Bharatpur district of Rajasthan were included in the NCR in July 2013.

(*ii*) Karnal and Jind districts of Haryana were included in NCR on January 20, 2014.

The total area of the NCR as is over forty six thousand sq km which is more than the total area of Haryana. The NCR substains a population of about 47.97 millions according to 2011 census which is more than population of Odisha. It accounts for about 7.4 per cent of the GDP of India.

Aims and Objectives

The aims and objectives of the NCRPB can be summed up in the following points :

(*i*) to contain the growing population of Delhi within the manageable limits through integrated development of all the components of the NCR.

(*ii*) to divert the population to ring towns like Faridabad, Ghaziabad, Ballabhgarh, Gurgaon, Bahadurgarh, Sonepat, Narela, Loni, Modinagar.

(*iii*) to re-model the pattern and functional character of the settlement within the NCR through guided growth so as to enable them to play a constructive and co-operative role in the planned development of the NCR.

(*iv*) to decentralise economic activities through proper development of ring towns and also through certain checks in the Delhi metropolitan area.

(*v*) to make arrangements for dispersal of industries and decentralisation of public undertakings including government offices from Delhi to the ring towns.

(*vi*) to provide cheap and efficient transportation system for dispersal of population and economic activities, and

(*vii*) to accomplish a balanced and harmonious growth of urban and rural component of the NCR.

Main Problems of NCR

(*i*) In-migration. There is large scale in-migration both from within and without the NCR. Approximately 2 lakh in-migrants move into the NCR every year from outside.

(*ii*) Widening Gap between Demand and Supply of Essential Sources. The gap between demand and supply of essential services like water, power, transport, waste disposal, waste treatment and management of solid waste is widening at rapid rate because demand for these services is always outpacing the supply.

(*iii*) Congestion. Delhi is suffering from the acute problem of congestion and rapidly growing slum areas.

(*iv*) Increasing Employment Opportunities. Delhi is acting as a '*great magnet*' to attract job seekers of all the categories which is great '*pull factor*' for in-migrants. It leads to over population and allied problems.

(*v*) Collapse of Infrastructure. The perennial and heavy inflow of population has put heavy burden on the infrastructure which is collapsing under its weight.

(*vi*) Deteriorating Quality Life. Due to ever growing demand by the fast growing population and limited supply of almost all essential commodities, the quality of life is fast deteriorating.

(*vi*) Increase in Crime Rate. Most of the in-migrants are unskilled or semi-skilled workers. They do not get proper job and resort to all sorts of crimes.

Planning Strategies and Proposals

The regional plan for NCR listed the following strategies and proposals for meeting the challenges in this area :

(*i*) To decelerate the growth of Delhi city.

(*ii*) To control the growth rate of Delhi Metropolitan area.

(*iii*) To develop regional centres with infrastructure and adequate network of services.

(*iv*) To bring down the population growth rate of NCR to 1.2 per cent per annum from the existing 3 to 4 per cent per annum.

(*v*) To bring down the volume of in-migration to 84,000 per annum as against the existing inflow of 2 lakh per annum.

(*vi*) To diversify the functional character of other towns of the NCR.

(*vii*) To revitalise the economy of stagnating urban centres of the NCR.

(*viii*) To select priority towns and develop them on priority basis for a balanced development of the NCR.

(*ix*) To integrate rural-urban development process within the NCR.

(*x*) To develop selected regional centres namely Meerut, Bulandshahr, Panipat, Rewari, Alwar, Bhiwadi Complex, Khurja Complex, Dharuhera, Rohtak, Palwal, Karnal, Jind etc. to accommodate Delhi-bound potential migrants by creating employment opportunities and the secondary and tertiary sectors in these regional centres.

(*xi*) To develop a number of sub-regional centres at focal points as such divisional headquarters, agricultural markets, service centres, and industrial centres.

The Tasks Ahead

(*i*) Distribution of Population. The development of some nodal points in NCR is necessary to regulate the population. Some nodal points have already been identified. These are Meerut, Hapur, Bulandshahar, Khurja, Palwal, Rewari-Bhiwadi-Dharuhera Complex, Rohtak, Panipat, Karnal, Jind and Alwar. These centres have the potential to attract migrants.

(*ii*) Dispersal of Economic Activities. The dispersal of economic activities is the basic necessity to reduce the population pressure on Delhi. This requires the generation of employment opportunities in different towns of the NCR. The economic activities for which the dispersal plan is envisaged are industries, Central Government and public sector offices, wholesale and distributive trade and commerce. Medium and large-scale industries have to be restricted in Delhi and incentive for their dispersal have to be given in the form of industrial estates in the selected towns. The government offices and public enterprises which do not perform ministerial functions, protocol functions and liaison functions should be shifted outside Delhi. The wholesale trade which does not serve the consumers in Delhi should also be shifted elsewhere in the NCR.

(*iii*) Land Use in the NCR. Agriculture is the main economic activity in the NCR. Growing urbanisation is fast encroaching upon the agricultural land, thus adversely affecting the agricultural output. Urban settlement should be allowed only on less fertile, barren or wastelands. With the reduction in agricultural land only intensification of agriculture will maintain our food production. The development and conservation of forest area as well as social forestry will have to be encouraged. Care should be taken that development does not harm the environment. The sites of the scenic beauty, archaeological sites, parks, national parks, bird sanctuaries within the region will be developed and strengthened in order to provide recreational avenues. A buffer zone of green belt between Delhi Urban Area and Delhi Metropolitan Area has been proposed to be created. The Aravalli hills extending from Delhi to Alwar provides ideal extent for developing a natural forest through conservation.

(*iv*) Regional Transport System. Cheap and efficient transportation network increases the flow of passengers and goods and helps in their dispersal. There is proposal to have one inner grid of roads in the NCR connecting Sonipat-Bagpat-Meerut-Hapur-Bulandshahar-Sikandarabad-Faridabad-Rohtak-Gurgaon-Jhajjar-Gohana-Sonipat. The outer grid will link Panipat-Muzaffar-nagar-Meerut-Hapur-Bulandshahar-Khurja-Palwal-Rewari-Jhajjar-Gohana-Rohtak- Panipat.

There is proposal also to develop regional rail bypass connecting Meerut-Hapur-Bulandshahar-Khurja-Palwal-Sohna-Rewari-Jhajjar and Rohtak. The metre gauge railway line in Rajasthan and Haryana sectors, has been converted into high capacity broad gauge system. The EMU services on the ring system of rail tracks may increase the flow of commuters and materials.

To improve the transportation system and to reduce the pressure of passengers on it, Delhi introduced Metro Rail System way back in 2002 and the first 8.3 km long Metro Rail between Shahdara and Tis Hazari was started on December 29, 2002. Today, it has a vast network and its services are available for almost all parts of Delhi. Metro Rail services to some of the satellite towns like Gurgaon, NOIDA and Faridabad has been started and some other towns such as Bahadurgarh and Ghaziabad are also expected to be connected by Metro Rail.

A Highway Corridor Zone is proposed with a minimum width of 500 metres inclusive of green buffer on either side of the right-of-way (ROW) along the National Highway (NH) 1, 2, 8, 10, 24, 58 and 91 converging at Delhi to enable the planned and regulated development along the stretches of these highways that are outside the controlled/development/regulated areas. In addition to the above, the Highway Corridor Zones along the NH 71, 71 A, 7IB, 119, 93, 235, 11A and Expressways have been proposed.

The Yamuna Express Highway from Delhi to Agra has offered fast movement of road traffic and greater connectivity between the two cities. The Kundli-Manesar-Palwal (KMP) expressway has been approved and is under construction.

Planning the Physical Infrastructure. The infrastructure in the NCR will have to be properly developed if it is to function as one integrated region. Uninterrupted power supply in adequate quantity is essential in all the urban and rural areas for industries, transport and for domestic use. The Narora Atomic Power Plant may help in meeting the power shortage to some extent. Power tariff will have to be adjusted in such a way that Delhi becomes less attractive for industrial and commercial power. Another important element of infrastructure is the availability of drinking water to urban and rural areas. Efforts will have to be made to provide drinking water in sufficient quantity. The strict enforcement of Water Pollution Control Act, 1974 and Environmental Protection Act, 1986 may go a long way to restrict the wastage of this cyclic resource. The problem of sanitation, sewerage disposal and storm water drainage will have to be tackled in the urban areas as a first priority. Low-cost sanitation systems may be introduced in urban areas where such a facility does not already exist. The NCR Planning Board is considering to adopt the model of Sulabh International for the disposal of sewerage.

Counter Magnets

Counter-magnet towns are identified as those that can be developed as alternative centres of growth and attract migrants to them rather than Delhi. Promoting growth of counter magnet towns are the principal components of the strategy to reduce both migration and population explosion in the Delhi metropolitan area.

These towns are located in six states—Uttarakhand, Madhya Pradesh and Punjab, in addition to Uttar Pradesh, Haryana and Rajasthan, which are already part of the national capital region.

The criteria for selecting counter magnet towns are : that they should not be within approximately 250 kilometres from Delhi, should have their own established roots and potential of growth and should not be centres of either religious, strategic or environmental importance.

The major counter magnets are Hisar, Ambala, Yamuna Nagar, Karnal in Haryana, Bareilly, Moradabad, Saharanpur, Allahabad, Kanpur in Uttar Pradesh, Patiala, Ludhiana, Bhatinda in Punjab, Jaipur, Kota, Sikar, Ajmer in Rajasthan, Gwalior in Madhya Pradesh and Dehradun in Uttarakhand.

Regional Planning and Development of Island Territories

India has two groups of islands which are treated as Union Territories. In the Bay of Bengal are the Andaman and Nicobar Islands while the Lakshadweep Islands are located in the Arabian Sea. The island territories and the planning strategies for their socio-economic development are briefly described as under :

The Andaman and Nicobar Islands Union Territory. The Andaman and Nicobar archipelago comprising of 572 islands, islets and rocks is situated about 1200 km off the south-eastern coast of India in the Bay of Bengal. Together they constitute one of the Union Territories of India, and are divided into two districts. Andaman group of islands is in the north of 10° channel while Nicobar group of islands is in the south of this channel. The two are separated by about 160 km of sea. Of the 550 islands in the Andaman group, only 26 are inhabited. The Nicobar group has 22 islands out of which 10 islands are inhabited. The total area of this Union Territory is 8249 sq km out of which Andaman Islands account for 6408 sq km and Nicobar Islands spread over 1841 sq km.

Being close to the equator and surrounded by the sea on all sides, these islands have equatorial type of climate. The precipitation is heavy and often exceed 200 cm annually. Both north-east and south-west monsoons bring rainfall to these islands. It rains for about eight months in a year. The temperature is moderate and relative humidity is high. Heavy rainfall is also caused by the tropical cyclone.

These islands are believed to be a continuation of Arakan Yoma mountain range of Myanmar and have undulating terrain with ridges in north-south direction although a few hills run in east-west direction also. Deep inlets and creeks exist between the main ridges. There are a few flatlands and perennial streams. Ground water reserve is limited and soil is mostly acidic and poor in nutrients. The soil types vary from clay to loamy sand.

The cumulative land area is 8,24,900 hectares out of which 7,49,400 hectares, including 1,097,046 hectares of tribal reserve area is under forest cover. These islands are blessed with a unique luxuriant rainforest canopy comprising of evergreen tropical rainforest canopy comprising of Indian, Myanmarese, Malaysian and endemic floral strain. So far, about 2,200 varieties of plants have been recorded out of which 200 are endemic and 1,300 do not occur in the mainland India. The North Andaman is characterised by the wet evergreen type, with plenty of woody climbers. The Middle Andamans harbour mostly moist deciduous forests while the South Andaman forests have a perfused growth of epiphytic vegetation, mostly ferns and orchids. The Nicobar Islands also have a rich variety of evergreen tropical rainforests.

Andaman Forest abound in plethora of timber species numbering 200 or more, out of which about 30 varieties are considered to be commercial. The major commercial timber species are Gurjan and Padank. The holy Rudraksha and aromatic Dhoop/Resin trees also occur here. These islands have about 50 varieties of mammals, 270 varieties of birds and 225 species of butterflies.

The original inhabitants of Andaman and Nicobar Islands, account for only 12 per cent of the total population. The main aborigines of Andaman group of islands are Sentinelese, Jarawas, Onges, and Great Andamanese of Nagrito origin; whereas the Nicobarese and Shompens are off-shoots of Mongoloid stock and live in the Nocobar group of Islands. The Sentinelese are the sole inhabitants of the North Sentinel Island, about 34 km west of South Andaman. They live in complete isolation, are hostile and semi-nomadic. The Jawaras live in the reserve forest belt of about 639 sq km in the western coast of South and Middle Andaman. The Ongnes live in Little Andaman, an island 130 km south of Port Blair. The vanishing Great Andamanese are settled at Strait Island which is about 46 km from Port Blair. The Shompens inhabit 119 sq km in the interior forest area of Great Nicobar. As per 2011 census figures, the total population of the Union Territory of Andaman and Nicobar Islands is 3,79,944 with a population density of 46 persons per sq km.

Out of a total area of 8,24,900 hectares, only 48,700 *i.e.* 5.9 per cent is used for agriculture. It shows that aborigines are mainly living in forests and little importance is given to agriculture. Paddy is the main food crop and major part of its cultivation is in the Andaman group of Islands. Pulses, oilseeds and vegetables are also grown. Coconut and arecanut are the major cash crops.

There is no major industry although 1375 small scale, village and handicraft units are working. Two fish processing units are export oriented. Three shell and wood based handicraft units are also functioning. The small scale industrial units are manufacturing polythene bags, PV conduit pipes and fittings, paints and varnishes, fibre glass, flour, soft drinks and beverages, shell crafts, bakery, rice milling, furniture, etc. There are only four medium-sized industrial units. The Andaman and Nicobar Islands Integrated Development Corporation is doing a lot for the development of these islands and is taking active part in promoting tourism, fisheries and industrial financing. It also functions as the authorised agency for Alliance Air/Jet Airways.

The development of the Andaman and Nicobar islands is closely related to their strategic location in the Bay of Bengal. These island are extensive enough to be developed as a strong naval base and associated industries. Deep sea fishing can be launched form these locations and related industries can be set up here to diversify and enrich the economy of the people living there. Strong linkage with the mainland is necessary in any programme of development. The efficiency of distribution channels of goods and services from Port Blair to different islands also needs to be improved.

Lakshadweep. Lakshadweep is a group of islands of coral origin in the Arabian Sea. The total area of the Union Territory is 32 sq km. The main islands are Minicoy (4.53 sq km), Androth (4.32 sq km), Karavathi (3.49 sq km), Kadamath (3.03 sq km) Agathi (2.73 sq km) and Amini (2.51 sq km), Minicoy by virtue of its strategic location, is important for the navel defence of the country. All the islands have low level and rise no more than 5 metres above sea level. There are not much variations in the climate and weather remains muggy throughout the year. Beneath a thin layer of vegetal humus there is fine coral sand extending at the surface of all the islands. The average distance from the Kerala coast varies from 200 to 300 km and the shortest distance from Calicut is 108.78 km.

According to census of India 2011, the total population of this Union Territory is 64,429 and only one-fourth of the area is inhabited. However these islands have the fifth highest density of population which was 2013 persons per sq km in 2011. The inhabitants of these islands are ethnically similar to the Kerala's Malayali people, and were influenced by the Arab Traders. However, the people of Minicoy are different from these of other islands. They are descendants of early settlers from Sri Lanka who were originally Buddhists and were later converted to Islam. More than 95 per cent of the people follow Islam.

Cultivation of coconut is the main agricultural activity and coconut is the main wealth of the people. The total area under coconut cultivation is about 2,600 hectares. Another perennial crop is bread fruit, citrus fruit, drumsticks, coarse grains, pulses, vegetables etc. are grown in kitchen gardens. Agriculture Department introduced the use of artificial manures, vegetable seeds and agricultural implements during the Third Five Year Plan (1961-66). Paddy cultivation was started on experimental basis in 1967.

There are no large scale industries but household industries like coir-spinning and copra making form the backbone of the economy. Coir Training-cum-Production Centres have been established where improved methods of coir twisting have been introduced. Fishing is also an important activity. Some hosiery and handloom factories have also been set up. The scenic beauty of these islands attracts tourists, both domestic and international. The only airport is the Agathi Aerodrome in Agathi Island which connects these islands to the mainland by air. The inter island transport is by boats or helicopters.

Development Strategies

The inhabitants of islands in the Bay of Bengal and Arabian Sea are suffering from the perpetual problem of poverty, hunger, starvation, malnutrition, illiteracy, unemployment, housing and are leading a low standard of living. The tribals of these islands have been an extremely exploited lot for the last so many years by the non-tribals. Considering the prevailing condition, the Government of India initiated special steps to improve the living conditions of these people. Some major steps are described as under :

1. Most of the people living especially in the Andaman and Nicobar Island are tribals who heavily depend on forests. As such it is necessary to conserve the forest wealth of these islands. Also it is necessary to develop more national parks and biosphere reserves.
2. There are mangrove swamps and wetlands in the creeks and inland waters which are facing great threat due to the increasing interference of man. These ecosystems are in a delicate balance and this balance has to be maintained at any cost.
3. Most of the islands both in the Bay of Bengal and in the Arabian Sea are of coral origin which are at risk of destruction. These coral ecosystems need to be conserved.
4. Soils are at great risk of erosion and degradation due to heavy rainfall in these islands. This problem can be solved to a great extent by afforestation.
5. Forest based cottage industries and handicrafts should be encouraged because these industries have great potential of providing employment to the inhabitants of these islands.
6. The natural beauty of these islands has great potential to attract tourists from far and wide places, both domestic and foreign. This potential should be harnessed to its maximum so that the living standard of the local people is improved.
7. The buildings should be made earthquake proof because the Andaman and Nicobar group of Islands lies in the highest seismic risk zone V according to Indian Standards.
8. Coastal creeks, attols and bays in the coasts of these islands offer great opportunities to develop fisheries. Thus fishing can provide large scale employment and all possibilities of developing fisheries should be explored.
9. Although a large number of tribes are living in these islands, their population is fast declining. Jarawa, Janget, Orge, Sentinelese etc. are some of such tribes. **Table 14.4.** gives a desperate picture of population of some of the tribes which are struggling for their survival.

TABLE 14.4. Population of Tribals in Andaman and Nicobar Islands

Name of the Tribe	Estimated Population
1. Jarawa	350
2. Shompen	250-300
3. Sentinelese	250
4. Orge	98
5. Great Andamanese	39

Source : Samudrika (2001) pp. 14-15.

10. Plantation of coconut, arecanut, coincona, tea, pineapple etc. should be encouraged as they can enhance the income and living standard of these people.

If the above mentioned steps are taken together, they can complement one another and help in improving the living conditions of the inhabitants of these island groups.

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Water Resources

Water is one of the most precious natural resources and a key element in the socio-economic development of a country. A person can live without food for a month, but only for for a week without water. Nothing will quench thirst the way water can. Water is an essential part of the modern day life. It is used for drinking, bathing, washing, irrigation, industries and a host of other purposes.

About 71 per cent of the earth's surface is covered by water and that is why our earth is called the '*watery planet*'. In fact earth is the only planet in the entire solar system which contains water and sustains life. No other planet in the solar system has, so far, shown any trace of water and all the planets, except the earth, are lifeless. But water on the earth surface is distributed in such a way that only a small fraction of total water available on the earth is useful for human consumption (**Table 15.1**).

TABLE 15.1. Earth's Water Resources

Distribution of Water on Earth	
Oceans, saline lakes	97.20%
Ice caps, glaciers	2.15%
Lakes, rivers, streams	0.0085%
Atmosphere, biosphere	0.00015%
Ground water	0.64%

TABLE 15.2. Use of Water

Agriculture	93.37
Municipal and Rural water supplies	3.73
Industries and power generation	1.26
Livestock	1.08
Others	0.56
Total	**100.00**

INDIA'S WATER RESOURCES

Rainfall is the main source of fresh water in India. From precipitation alone (including snowfall), India receives 4,000 km^3 water. Of this, monsoon rainfall from June to September alone accounts for about 3,000 km^3. A good part of it is lost through the process of evaporation and plant transpiration. Large part of water percolates into the ground and is available to us in the form of ground water.

Different authorities have given different estimates about India's water resources. According to the Ford Foundation Team (1959), India has one of the largest supplies of water in the world. A broad assessment of water resources places the total average annual surface run-off as varying from 1,633 BCM to 1,881 BCM (Billion Cubic Metre). According to **K.L. Rao** (1975), the total quantity of water in our river systems is 1,644.5 BCM. The estimates made by the Ministry of Water Resources have put the overall water resources of the country at 1,869 km^3 (or 1,869 BCM). Due to various constraints of topography and uneven distribution of water resource over space and time, the total utilisable water resource is assessed as 1,122 km^3 out of which 690 km^3 is surface water and 432 km^3 is ground water. Obviously water is available in two different forms, *viz.*, (1) surface water, and (2) ground water.

Surface Water

Surface water is available on the surface of the earth in the form of rivers, lakes, ponds, canals, etc.

TABLE 15.3. Surface Water Resources in Major River Basins of India

Basin	Averege annual Run-off km^3	Utilisable Flow km^3	Storage completed km^3
1. Indus	73	46	14.52
2. Ganga	501	250	37.4
3. Brahmaputra	537	24	1.09
4. Barak Sub-basin	60	—	—
5. Mahanadi	67	50	8.93
6. Brahmani	36	18.1	4.29
7. Godavari	119	76	17.27
8. Krishna	68	58	32.23
9. Cauvery	21	19	7.25
10. Penner	6.81	6.81	2.37
11. Narmada	41	34.5	3.02
12. Tapi	18	14.5	8.68
13. Sabarmati	3.8	1.91	1.3
14. Mahi	41	34.5	30.02

Source : India 1992 : A Reference Annual, p. 418.

However, rivers comprise the most important source of surface water. India is blessed with a large number of major, medium and small size rivers. As many as 13 of them are classified as major rivers whose total catchment area is 252.8 million hectares (m. ha). This is about 83 per cent of the total area of all drainage basins. Of the major rivers, the Ganga-Brahmaputra-Meghna system is the biggest with catchment area of about 110 million hectares (m. ha) which is more than 43 per cent of the catchment area of all major rivers in the country. The other major rivers with catchment area more than 10 m. ha are those of the Indus (32.1 m. ha), Godavari (31.3 m. ha), Krishna (25.9 m. ha), and Mahanadi (14.2 m. ha). The catchment area of medium rivers is about 25 m. ha. It is worth mentioning that about 40 per cent of utilisable surface water resources are in the Ganga-Brahmaputra-Meghna system. An idea of magnitude of our water resources can be had from **Table 15.3**.

Interlinking the Rivers

Although India has vast surface water resources, the same are very unevenly distributed over time and space. While some river basins have vast catchment areas and carry enormous quantity of water, others are small and have comparatively small quantity of water. Most of the Himalayan rivers are large and originate in the snow covered high altitude areas of the Himalayan ranges. As such they carry sufficient water throughout the year and are called ***perennial rivers***. In contrast, the rivers of the peninsular India are seasonal. They carry no or very little water in the dry summer season. During the rainy season, most of the rivers are flooded and large part of water flows down the slope to the sea. Thus much of precious water is wasted and is not available for use. As against this most rivers have insufficient flow of water during the dry season and acute scarcity of water is felt in almost all parts of the country. Besides there is a chronic problem of floods in one part and droughts in other part of the country. Even dry areas like Rajasthan and Gujarat may have floods and wet areas like West Bengal may confront a situation of drought. Keeping these and many more problems in mind, the idea of interlinking rivers through inter-basin linkages or through national grid has been mooted. Such projects aim at reducing disparities in different river basins by transferring water from 'surplus' basins to 'deficit'

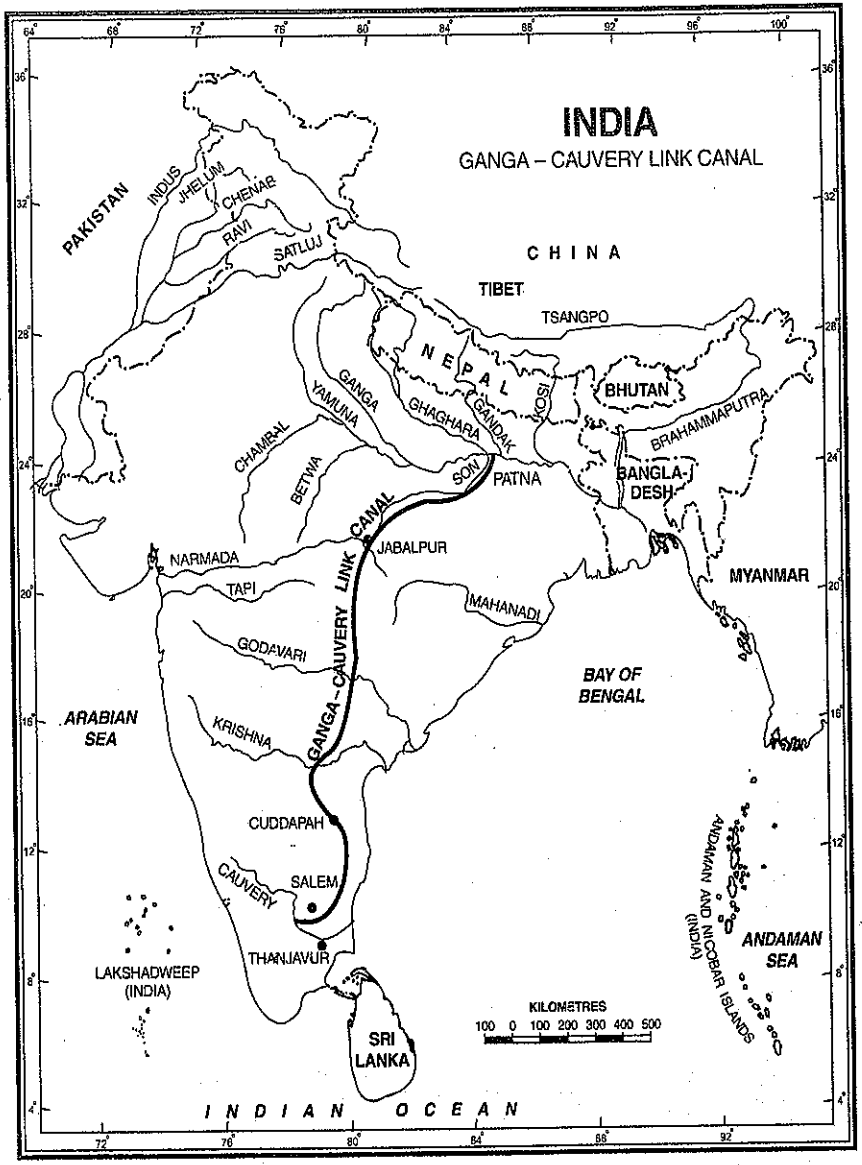

FIG. 15.1. Ganga-Cauveri Link Canal

basins. Some of the important projects are briefly described as under :

The Ganga-Cauvery Link Canal

This project was prepared by the United Nations team at the request of the Government of India. It was proposed by the then irrigation minister **Dr. K.L Rao** in 1950s. The project aimed at reducing the impact of floods in the Ganga basin and supply water to central and eastern parts of the country which suffer from chronic problem of water shortage. This link canal was to take off near Patna, pass through the basins of the Son, the Narmada, the Tapi, the Godavari, the Krishna and the Pennar rivers, and join the Cauvery upstream of the Grand Anicut. Water from Patna barrage will be lifted by large pumps to a point near the boundary of the basins of the Ganga and the Narmada from where it will be distributed by gravity via dug up canals or through existing rivers to the west or south. Flood waters of the Narmada and the Godavari could also be used. However, it was pleaded that water from the Ganga for the inter-basin transfer could be drawn only during four months of rainy season from July to October when the flow of water in the Ganga river exceeds 2,850 cumecs (1,00,000 cusecs).

The proposed Ganga-Cauvery Link Canal was to have been 2,640 km long, withdrawing 60,000 cusecs, from the flood flows of the Ganga for about 150 days in the year, and would have involved a lift of a substantial part of water over 450 metres. From Patna, water would be pumped into a series of reservoirs between water sheds of the Narmada and the Son. From Bargi reservoir on the Narmada (423 m), a linked aqueduct will carry water to south utilising the natural course of the Wainganga, Pranhita and crossing the Krishna and the Pennar to Cauvery upstream the Upper Anicut. It is also proposed to supply about 300 cumecs (10,000 cusecs) of the Ganga water to different parts of Bihar, Uttar Pradesh, Jharkhand, Chattisagarh and Madhya Pradesh by pumping additional water during the lean season. Water would also be diverted to partially meet the demands of chronically drought prone areas of Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Andhra Pradesh, Telangana, Karnataka and Tamil Nadu.

The scheme has been thoroughly examined and found impractical because of the huge financial costs and very large energy requirements. Moreover environmental issues put great hindrances in the way of this project. However, the idea survives in the popular mind and comes up whenever water scarcity is felt and conflicts (such as Cauvery dispute) become acute.

The Brahmaputra-Ganga Link Canal

The Brahmaputra is a mighty river and carries a discharge of 3,500 to 5,000 cumecs even during lean period of dry summer. This is because its catchment area receives heavy annual rainfall. The amount of water flowing in this river is more than the requirements of the people living in its basin area. In contrast the lower Ganga basin faces scarcity of water, particularly in the summer season. This unbalanced distribution of water can be rectified by diverting the surplus water of the Brahmaputra basin to the water scarcity areas of the lower Ganga basin.

The Brahmaputra-Ganga link canal project involves the construction of a diversion barrage at Dhubri in Assam and a 320 km long feeder canal to link the Dhubri barrage with the Farakka barrage. A part of the feeder canal will pass through Bangladesh territory for which India will have to reach an agreement with that country. However, this will benefit Bangladesh also because a part of water available in the feeder canal can be used for irrigation or for augmenting the water flow in the Padma river. It is also expected to boost inland navigation in both the neighbouring countries. It is estimated that when completed, this project will be able to divert about 1,150 cumecs of water from the Brahmaputra at Dhubri to the Ganga at Farakka. It will require lifting of water by 10 to 15 metres at suitable intermediate sites.

Experts in various allied fields have grave misgivings regarding the feasibility of this project in view of huge expenditure involved, resource crunch and lack of proper understanding between the concerned neighbouring countries.

National Water Grid

This is the largest ever thought of project of linking all major rivers of India with the help of a network of canals. The idea of linking rivers across India to solve flood, drought, power and other water related problems of the country is not new. It has been mooted in different forms for the last few decades. Sir Arthur Cotton, who pioneered the development of water resources in Southern India from 1839 onwards, had proposed a plan for interlinking of Indian rivers for inland navigation. A small portion of the plan was implemented but was abandoned later in favour of railways. In 1974, the famous engineer of Mumbai, Captain Deen Shaw, presented his scheme to link Indian rivers by constructing a chain of canals. In August, 1980, a National Perspective Plan (NPP) for interlinking of rivers was framed by the Ministry of Water Resources. A National Water Development Agency (NWDA) was set up in July, 1982 to carry out further studies. In 2002, the Hon'ble Supreme Court of India ordered the central government to complete the project in 10 years. Keeping in view the order of the Supreme Court, the Government of India

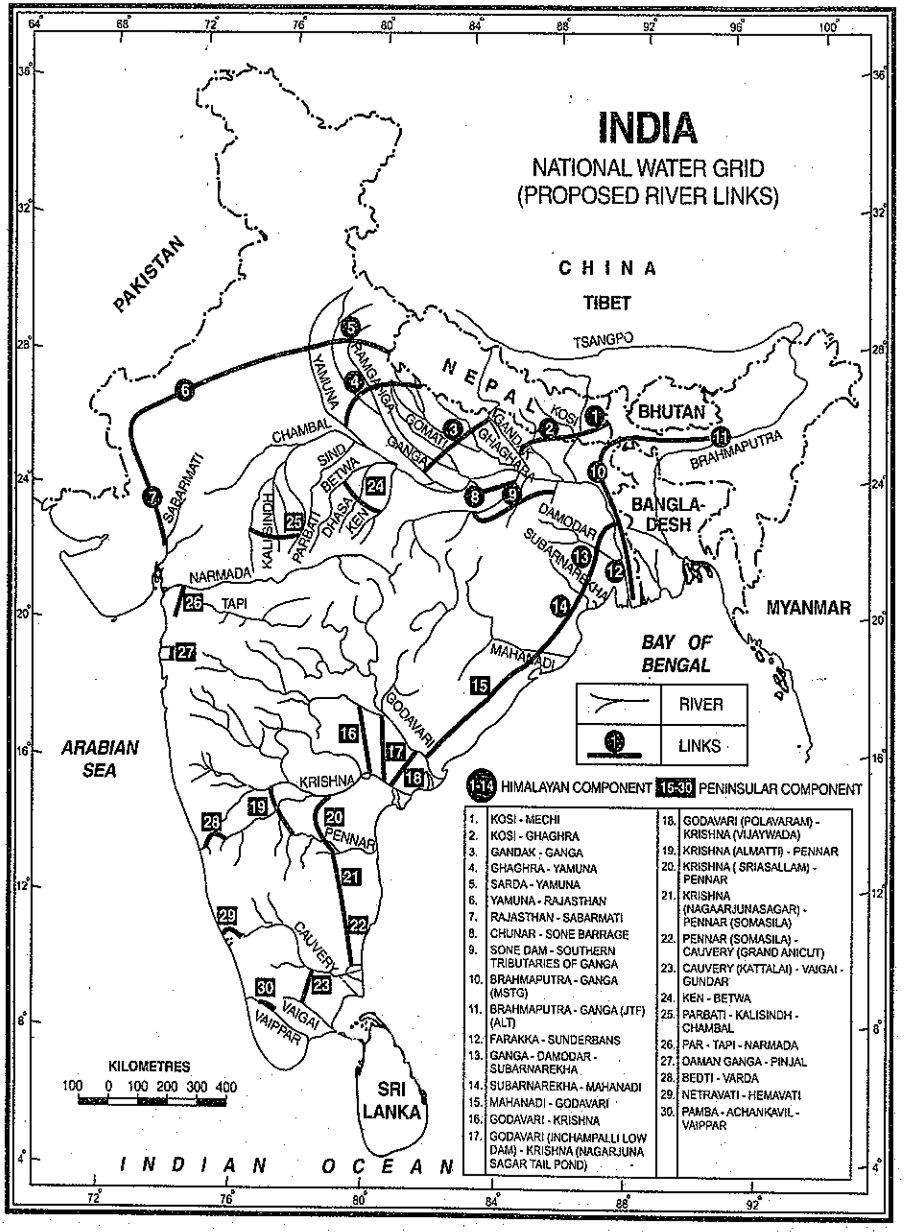

FIG. 15.2. India : Proposed River Links (The Garland Canal System)

constituted a committee in December 2002 to prepare a detailed report of the project. The project envisages linking 26 major rivers of India by constructing 30 different link canals. The National Perspective Plan as well as the NWDA studies have two components of the project *viz.*, (*a*) Himalayan Rivers Development Component and (*b*) Peninsular Rivers Development Component (**Fig. 15.2**). The two can be linked on the Mahanadi.

(a) The Himalayan Rivers Development Component

The Himalayan Rivers Development Component envisages construction of storage reservoirs on the principal tributaries of Ganga and Brahmaputra in India, Nepal and Bhutan alongwith interlinking canal systems to transfer surplus flows of the eastern tributaries of the Ganga to the west, apart from linking of the main Brahmaputra and its tributaries with the Ganga and the Ganga with the Mahanadi. The Himalayan Rivers Development Component shall provide additional irrigation and generation of hydropower, besides providing substantial flood control in the Ganga and Brahmaputra basins. It would also provide the necessary discharge for augmentation of flows at Farakka to flush Kolkata port and enhance the inland navigation facilities across the country.

The Himalayan Component is based on multi-purpose storage giving benefits of hydropower and flood control, besides diverting water to downstream links. NWDA have taken up 11 Himalayan links for study. These include Manas-Sankosh-Tista-Ganga link to transfer Brahmaputra waters to Eastern Ganga Basin. This link envisages high dams on Manas and Sankosh and very large canals running through densely forested as well as populated areas cutting across major drainages and narrow strip of land north of Bangladesh. Other lines proposed are Kosi-Ghaghara, Gandak-Ganga, Ghaghara-Yamuna and Sarda-Yamuna to supplement the supplies of the Ganga and the Yamuna and further transfer water west to Rajasthan and Gujarat.

Under the Himalayan Component, NWDA has already completed water balance studies at 19 diversion points, toposheet studies of 16 storage sites and 19 link alignments and prepared pre-feasibility reports of 14 proposed water transfer links. The feasibility report for these links have already been completed.

(b) The Peninsular Rivers Development Component

This component has four major parts but more important are interlinking the Mahanadi-Godavari-Krishna-Cauvery and the diversion of a few west-flowing rivers towards the peninsular basin across the Western Ghats. It will ease the water situation in the peninsula. The link from Mahanadi would require construction of Manibhadra dam. The Mahanadi-Godavari link would cut across east-flowing drainages. It does not involve any lifting of water. The Godavari is joined by two major tributaries, Indravati and Penganga downstream of the major storage at Shri Ramsagar. Even after meeting downstream basin requirements, the Godavari has surplus water in this reach which can be stored in the available dam site of Inchampalli. The benefits to those rehabilitated from low yield unirrigated farming to high yield irrigated land are so large that the project deserves high priority in implementation. After irrigating about 11.5 lakh hectares of dryland between the Godavari and the Krishna, there will still be about 3 km^3 water left which can be transferred to Cauvery basin and relieve it from occasional shortages. It will also help to resolve the bitter dispute between Tamil Nadu and Karnataka over the water of the Cauvery river.

Under the Peninsular Component, the Agency has already completed data collection and the balance studies of 137 basins/sub-basins and at 77 identified diversion points, toposheet studies of 72 identified storages and 30 toposheet studies of link alignments, and prepared pre-feasibility reports of 17 water transfer links. Presently, the work of field surveys and investigations for preparation of feasibility reports of link schemes is on hand. Feasibility reports of these links have already been completed.

The implementation of the inter-basin water transfer link schemes can be taken up in a phased manner depending on the priorities of the Government and availability of funds. But before this, certain other steps, *viz.*, negotiations and agreements amongst the states involved in interbasin transfer, preparation of Detailed Project Reports (DPRs), techno-economic appraisal of DPRs and investment clearance of the schemes, funding arrangements and fixing of agencies for execution, etc., would be necessary. In order to expedite the process of arriving at consensus amongst the States, a Group headed by Chairman, Central Water Commission has been formed, so that the work of preparation of Detailed Project Reports could be started. This Group is expected to work independently and on a continuous basis.

If and when completed, this project will give following benefits :

(*i*) Surplus water from the eastern rivers will be transferred to water deficit areas of central, south and western parts of the country.

(*ii*) Flood problem, particularly in Bihar and Assam will be solved to great extent.

(*iii*) 34,000 megawatt (34 million kW) hydroelectricity would be produced. This electricity will be used for irrigation and other purposes.

(*iv*) The implementation of the programme of interbasin water transfer is expected to provide additional irrigation benefit of 35 Mha which will be over and above the ultimate irrigation potential of about 140 mha envisaged from major, medium and minor irrigation projects.

(*v*) Chronically drought affected areas will get sufficient water for irrigation, drinking and other purposes.

(*vi*) As much as 1275.74 billion cubic metre (BCM) water wastefully flowing in rivers originating in the glaciers of the Himalayas will be properly used.

(*vii*) The project will provide ample opportunities for inland navigation and thus reduce pressure on rail and road transport.

(*viii*) It will be of great help in resolving inter-state water disputes.

(*ix*) A minimum flow of water will be ensured in water deficit rivers.

However, the project has been criticized on several grounds and several experts have questioned even the feasibility of such a gigantic project. Following are some of the objections raised against the project.

(*i*) The project will involve a huge cost of ₹ 5,60,000 crore or $ 120 billion which amounts to a quarter of the country's current GDP. A developing country like India can hardly afford such a huge investment in just one project.

(*ii*) The project will entail the construction of several major dams and lengthy canals cutting across various river basins. This is not an easy task and will require engineering skills of high calibre.

(*iii*) The project aims at transferring water from water surplus rivers to water deficit rivers. But hydrologists believe that there are hardly any surplus waters anywhere in the country.

(*iv*) The construction of big dams and long canals will destroy forested areas, fertile soils and agricultural lands and disturb the ecological balance.

(*v*) No provision worth the name, has been made to resettle the displaced people. An estimate of over 30 million people have been displaced by development projects since Independence.

(*vi*) Some experts have expressed doubt about the capability of the project. For example, if water available in the deficit Sabarmati basin is only 300 cubic metres per capita (CMPC), then it is difficult to comprehend how a further 1,400 CMPC can be brought from a surplus basin to solve the problem.

(*vii*) Alternative measures of managing and conserving water resources can prove to be more useful than the proposed project of interlinking the rivers. According to the Central Ground Water Board (CGWB), 37 BCM of ground water can be recharged locally at only ₹ 24,500 crore. Then what is the validity of investing ₹ 5,60,000 crore in obtaining a mere 175 BCM from interlinking of rivers.

(*viii*) Jayanta Bandhopadhyay of Centre for Development and Environment Policy at the Indian Institute of Management (Kolkata) questions the validity of such a project involving high cost and comparatively little

returns. According to him, arresting the natural flow of rivers on this gigantic scale could spell "the death knell" of mangroves in the Delta region of West Bengal and Bangladesh and some of the richest fisheries could be lost forever. Salinity would also make inroads into the region, affecting thousands of hectares of arable land. Also the link scheme did not envisage carrying water to some of the most deprived sections of population, including tribals and those living in the highlands.

(*ix*) Neighbouring countries like Bangladesh and Nepal have not been consulted although these countries, along with China, would be affected by the project.

(*x*) Dr. Bharat Singh, Professor Emeritus, Water Resources Development IIT, Roorkee has simply termed it "*A big dream of little logic*". According to him, "there is no convincing argument which can justify taking up the river linking project in its entirety."

In spite of the above mentinoed difficulties, efforts are being made for interlinking some of the rivers where geographical conditions permit the feasibility of such projects and where cost factors are also within the means. The links namely (*i*) Ken-Betwa link, (*ii*) Parbati-Klisindh-Chambal link, (*iii*) Godavari (Polavaram), Krishna (Vijayawada) link, (*iv*) Dhamanganga-Pinjal link and Par-Tapi-Narmada link have been identfiied as priority links.

1. Ken Betwa Link. A tripartile Memorandum of Understanding (MoU) was signed between the Union Minister of Water Resources and Chief Ministers of Uttar Pradesh and Madhya Pradesh on 25th August, 2005 for preparation of detailed project report of Ken-Beta link and the report was completed by the National Water Development Agency (NWDA) in December 2008. It was decided that the report will be prepared in two phases. Phase-I of the project was completed in April, 2010 and the work on phase II is in progress.

2. Parbati-Kalisindh-Chambal Link. Efforts are being made to arrive at consensus between Madhya Pradesh and Rajasthan for the preparation of detailed project report concerning Parbati-Kalisindh-Chambal link. The Rajathan government has asked for the revision of Hydrology which the National Water Development Agency (NWDA) has already accomplished.

3. Par-Tapi-Narmada Link and Damanganga-Pinjal Link. These two projects are concerned with the states of Gujarat and Maharashtra and both the states have given their concurrence for the projects. Detailed project report is being prepared.

4. Godavari (Polvaram)-Krishna (Vijayawada) Link. Planning Commission has given investment clearance for this project of the Government of Andhra Pradesh has taken up the project as per their own proposal.

5. Mahanadi-Godavari-Krishna-Pennar-Cauvery-Vaigai-Gundar Link System. The consesus building for eight more links under Mahanadi-Godavari-Krishna-Pennar-Cauvery-Vengai-Gundur Linkage System has been initiated with the concerned states for preparing detailed project report. The National Water Development Agency (NWDA) has received 36 proposals of Inter-State links from 7 States out of which Pre-feasibility Reports (PFRs) of 15 intra-state links have been completed.

Ground Water

A part of the rain water percolates in the rocks and soils and is available to us as ground water. The assessment of water resources in India dates back to 1949. **Dr. A.N. Khosla** (1949) estimated the total average annual run-off of all river systems in India as 167.4 m. ha m (million hectare metre) based on empirical formula which included both surface and ground waters. Since then, several attempts have been made to assess the ground water resources in the country. The National Commission on Agriculture (1976), assessed the total ground water of the country as 67 m. ha m, excluding soil mixture. The usable ground water resource was assessed as 35 m. ha m of which 26 m. ha m was considered as available for irrigation. The first attempt to estimate the ground water resources on scientific basis was made in 1979 when a High Level Committee, known as Ground Water Over Exploitation Committee was constituted by Agriculture Refinance and Development Corporation (ARDC). Based on the norms for ground water resources computation recommended by this committee, the State Governments and the Central Ground Water Board computed the gross ground water recharge as 46.79 m. ha m and the net recharge (70% of the gross) as 32.49 m. ha m. The norms recommended by the Ground Water Estimation Committee (1984) are currently utilized by the Central Ground Water Board and the State Ground Water Departments to compute the ground water resources. Based on the recommendations of this committee, the annual replenishable ground water resources in the country work out to be 45.33 m. ha m. Keeping a provision of 15% (6.99 m. ha m) for drinking, industrial and other uses, the utilisable ground water resource for irrigation was computed as 38.34 m. ha m per year.

The methodologies adopted for computing ground water resource are generally based on the hydrological techniques. The main items of supply and disposal of ground water are listed below :

1. Items of supply to ground water reservoir

(*i*) Precipitation infiltration to the water table.

(*ii*) Natural recharge from streams, lakes and ponds.

(*iii*) Ground water inflow into the area under consideration.

(*iv*) Recharge from irrigation, reservoirs and other schemes especially designed for artificial recharge.

2. Items of disposal from ground water reservoir

(*i*) Evaporation from capillary fringe in areas of shallow water table, and transpiration by vegetation.

(*ii*) Natural discharge by seepage and spring flow to streams, lakes and ponds.

(*iii*) Ground water outflow.

(*iv*) Artificial discharge by pumping or flowing wells or drains.

TABLE 15.4. Basin-wise Ground Water Resource Potential

Sl. No.	Basin	Total replenishable Ground water resource (Million hectares metre per year)	Utilisable ground water for irrigation (Million hectares metre per year)	Level of ground water development (per cent)
1.	Indus	2.55	2.17	79.29
2.	Ganga	17.17	14.59	30.79
3.	Kuchchh and Saurashtra composite	1.39	1.14	39.75
4.	Khambat Composite	0.79	0.67	30.21
5.	Narmada	1.19	1.01	15.31
6.	Tapi	0.82	0.67	20.19
7.	Subaranrekha	0.22	0.19	8.81
8.	Brahmani with Baitarni	0.59	0.50	5.16
9.	Mahanadi	2.13	1.81	4.32
10.	North-East composite	2.28	1.94	13.53
11.	Godavari	4.68	3.94	14.98
12.	Krishna	2.66	2.23	29.11
13.	Penner	0.50	0.43	31.52
14.	Madras composite and south Tamil Nadu composite	2.09	1.78	45.94
15.	Cauveri	1.36	1.16	44.72
16.	Western Ghat composite	1.83	1.54	19.61
17.	Brahmaputra	2.79	2.37	2.12
18.	Meghna	0.18	0.15	3.21
	Total	**45.22**	**38.28**	**27.82**

Source : India 1992 : A Reference Annual, p. 419.

As per estimates made in late 1980s and early 1990s total replenishable ground water resources have been estimated at 45.22 million hectare metres per year. Of this 38.28 million hectare metres is utilisable for irrigation. The stage of ground water development is about 28% of the utilisable ground water resources.

According to the Planning Commission, the total water resources are about 178 million hectare metres but because of limitations of physiography, topography, geology, dependability, quality and the present state of technology, only a fraction of it could be utilised. The demand for water for irrigation is increasing rapidly due to rapid increase in population and new technology will have to be developed for making optimum use of the available water resources.

Central Ground Water Board has stopped computing river basin-wise ground water data and instead data according to political divisions, *i.e.*, states/union territories is published now. According to the latest data published by the Central Ground Water Board in 2009, the total replenishable ground water resource in the country is more than 433 BCM/year. Of this, the ground water available for irrigation is about 221.42 BCM/year. Provision for other uses including domestic and industrial purposes is about 21.89 BCM/year. The level of ground water development is 61 per cent.

Table 15.5 shows that there are large variations at the level of states/union territories so far as total replenishable ground water resource is concerned. It varies from 75.25 BCM/year in Uttar Pradesh to 0.044 BCM/yr in Mizoram. In addition to Uttar Pradesh, Andhra Pradesh, Assam, Madhya Pradesh, Maharashtra and West Bengal are some of the large states which have total replenishable ground water resource more than 30 RCM/hr. Among the other states are Bihar, Punjab and Tamil Nadu which have more than 20 BCM/yr. replenishable ground water resource. States with 10 to 20 RCM/yr. replenishable ground water resource are Chhattisgarh, Gujarat, Haryana, Karnataka, Odisha and Rajasthan. States with small replenishable ground water resource of less than one BCM/hr. are Goa, Himachal Pradesh, Manipur, Mizoram and Nagaland. All the Union Territories put together have less than one BCM/yr. replenishable ground water.

Similar variations are observed in the availability of ground water resources for irrigation. As expected, Uttar Pradesh has the largest ground water resources for irrigation which is as much as 46.00 BCM/year. The other states with large ground water resources for irrigation are Andhra Pradesh, Gujarat, Haryana, Punjab, Madhya Pradesh, Maharashtra, Tamil Nadu, Rajasthan and West Bengal. Each of these states has more than 10 BCM/year ground water resources for irrigation.

Entirely different picture emerges when we look at the stage of ground water development. Haryana, Punjab and Rajasthan receive less than 40 cm annual rainfall and are deficient in surface water resources. As such, these states exploit more than 100 per cent of the available ground water for irrigation. Large scale exploitation of ground water is done with the help of tube wells. The demand for ground water for irrigation started increasing in Punjab and Haryana with the advent of Green Revolution in 1960s. The change in cropping pattern has further increased demand for ground water to irrigate the fields. The region is climatically more suited to wheat but farmers' preference for rice crop has changed the entire scenario. This has led to over exploitation of ground water resources and the ground water level is falling rather alarmingly. In fact these three states draw more water, especially for irrigation, than the amount of water replenished in natural course. If this trend of over exploitation of ground water continues unabated, these states will be left with no ground water. Experts have expressed apprehension that *granary of today will be barren land tomorrow.* Rajasthan is a desert area where the rainfall is scanty and the available ground water resources are meagre in comparison with the size of the state. Gujarat, adjoining Rajasthan, also receives less rainfall and has to depend upon ground water resources. This state has developed over 75 per cent of her ground water resources. Uttar Pradesh and Bihar in the Ganga valley are rich fertile tracts where intensive irrigation is required to sustain agriculture. Uttar Pradesh and Bihar have developed over 72 per cent of their ground water resources. West Bengal is comparatively better placed with respect to rainfall and is less dependent on ground water resources.

In the south, Tamil Nadu also has high level of 80 per cent of ground water development. Here, ground water is primarily used to irrigate the rice crop.

Most of the north-eastern hill states like Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Sikkim have very low level of ground water development. None of these states has level of ground water development more than ten per cent.

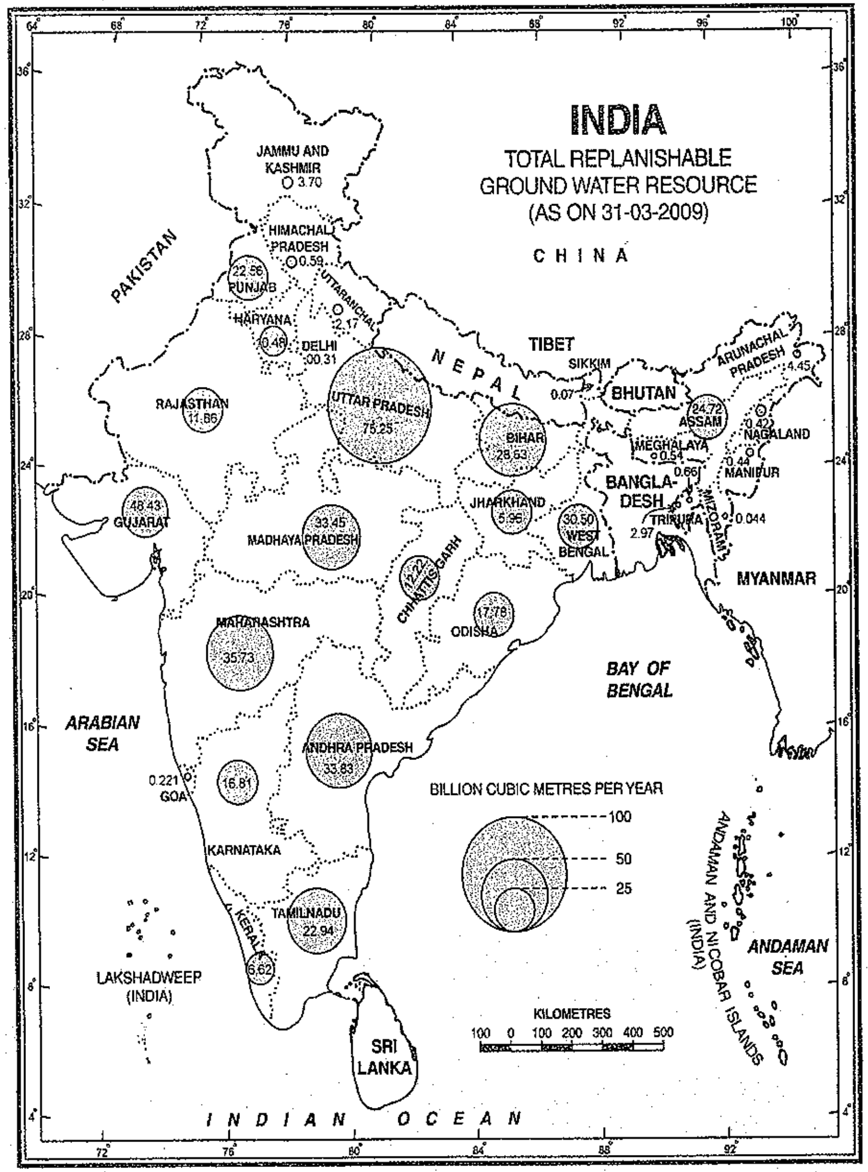

FIG. 15.3. India : Ground Water Resource

TABLE 15.5. State-wise Ground Water Resources Availability, Utilization and Stage of Development as on 31st March, 2009 Annual Groundwater Draft

Sl. No.	States/UTs	Annual Replenishable Ground Water Resource BCM/yr	Natural Discharge during non-Monsoon season BCM/yr	Net Annual Ground Water Availability BCM/yr	Irrigation BCM/yr	Domestic and Industrial uses BCM/yr	Total BCM/yr	Stage of Ground Water Development (%)
1	2	3	4	5	6	7	8	9
	States							
1.	Andhra Pradesh	33.83	3.07	30.76	12.61	1.54	14.15	46
2.	Arunachal Pradesh	4.45	0.45	4.01	0.002	0.001	0.003	0.07
3.	Assam	30.35	2.537	27.81	5.333	0.69	6.026	22
4.	Bihar	28.63	2.42	26.21	9.79	1.56	11.36	43
5.	Chhattisgarh	12.22	0.64	11.58	3.08	0.52	3.60	31
6.	Delhi	0.31	0.02	0.29	0.14	0.26	0.40	138
7.	Goa	0.221	0.088	0.133	0.014	0.030	0.044	33
8.	Gujarat	18.43	1.08	17.35	11.93	1.05	12.99	75
9.	Haryana	10.48	0.68	9.80	11.71	0.72	12.43	127
10.	Himachal Pradesh	0.59	0.06	0.53	0.23	0.08	0.31	58
11.	Jammu & Kashmir	3.70	0.37	3.33	0.15	0.58	0.73	22
12.	Jharkhand	5.96	0.55	5.41	1.17	0.44	1.61	30
13.	Karnataka	16.81	2.00	14.81	9.01	1.00	10.01	68
14.	Kerala	6.62	0.59	6.03	1.30	1.50	2.81	47
15.	Madhya Pradesh	33.95	1.70	32.25	16.66	1.33	17.99	56
16.	Maharashtra	35.73	1.93	33.81	15.91	1.04	16.95	50
17.	Manipur	0.44	0.04	0.40	0.0033	0.0007	0.0040	1
18.	Meghalaya	1.2343	0.1234	1.1109	0.0015	0.0002	0.0017	0.15
19.	Mizoram	0.044	0.004	0.039	0.000	0.0004	0.0004	1
20.	Nagaland	0.42	0.04	0.38	—	0.008	0.008	2.14
21.	Odisha	17.78	1.09	16.69	3.47	0.89	4.36	26
22.	Punjab	22.56	2.21	20.35	33.97	0.69	34.66	170
23.	Rajasthan	11.86	1.07	10.79	12.86	1.65	14.52	135
24.	Sikkim	—	—	0.046	0.003	0.007	0.010	21
25.	Tamil Nadu	22.94	2.29	20.65	14.71	1.85	16.56	80
26.	Tripura	2.97	0.23	2.74	0.09	0.07	0.16	6
27.	Uttar Pradesh	75.25	6.68	68.57	46.00	3.49	49.48	72
28.	Uttarakhand	2.17	0.10	2.07	1.01	0.03	1.05	51
29.	West Bengal	30.50	2.92	27.58	10.11	0.79	10.91	40
	Total States	**432.43**	**33.73**	**398.70**	**221.29**	**21.83**	**243.14**	**61**
	Union Territories							
1.	Andaman & Nicobar	0.310	0.012	0.298	0.0006	0.010	0.011	4
2.	Chandigarh	0.022	0.002	0.020	0.000	0.000	0.000	0.000
3.	Dadra & Nagar Haveli	0.059	0.003	0.056	0.001	0.007	0.009	15
4.	Daman & Diu	0.012	0.001	0.011	0.008	0.003	0.011	99
5.	Lakshadweep	0.0105	0.0070	0.0035	0.0000	0.0026	0.0026	74
6.	Puducherry	0.171	0.017	0.154	0.121	0.029	0.150	98
	Total UTs	**0.59**	**0.04**	**0.54**	**0.13**	**0.05**	**0.18**	**34**
	Grand Total	**433.03**	**35.03**	**399.06**	**221.42**	**21.89**	**243.32**	**61**

Source : http/cgwb.gov.in

Arunachal Pradesh, Manipur, Mizoram, and Nagaland have negligibly low level of ground water development. These areas receive sufficient amount of rainfall and are thickly forested. Moreover, agriculture is not as intense as in Punjab and Haryana. The topographical constraints also hinder ground water development. Under such circumstances, it is neither desirable nor feasible to develop ground water

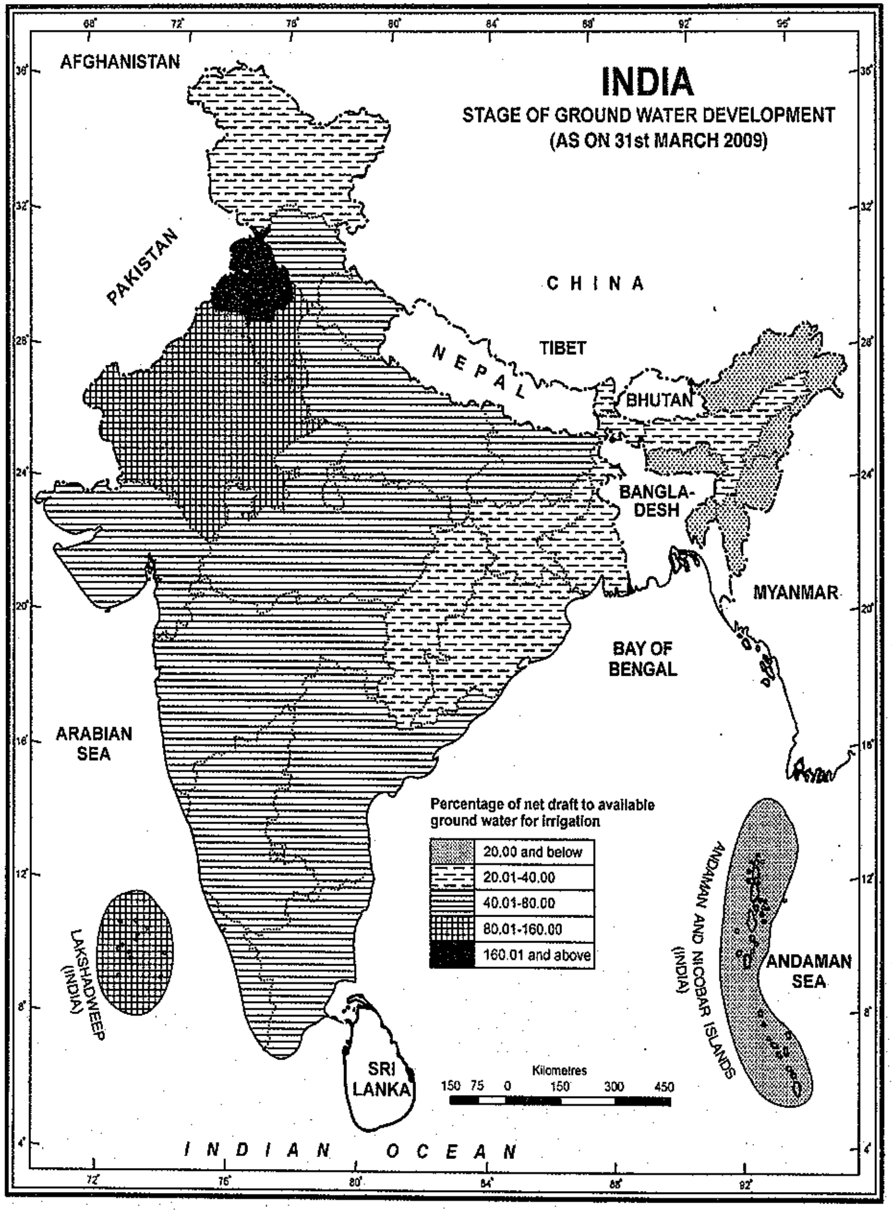

FIG. 15.4. India : Level of Ground Water Development

resources. Goa also receives sufficient rainfall and surface water resources are enough to meet the requirement. Therefore, the ground water resources are not much exploited. Hilly and mountainous terrain in Jammu and Kashmir is not much favourable for developing ground water resources. Surprisingly, Himachal Pradesh and Uttarakhand have developed more than half of their ground water resources.

Most of the peninsular plateau area is composed of hard rocks and is not much favourable for exploiting ground water resources. Most of the states located in the peninsular plateau area have moderate level of ground water development which varies from 20 to 50 per cent. The major states of this category are Andhra Pradesh, Bihar, Chhattisgarh, Goa, Jharkhand, Karnataka, Kerala, Odisha, and Maharashtra. **Figure 15.4** shows the spatial distribution of level of ground water development.

It is estimated that in India, 85 per cent of rural and over 50 per cent of urban water supplies depend upon ground water for meeting drinking and domestic water needs. Increasing demand for water in agriculture sector puts heavy strain on our water resources and ground water resources are over-exploited. In some districts of Punjab and Haryana, the ground water level is falling at an alarming rate of over one metre per year.

The Central Ground Water Board (CGWB) has emphasized that ground water has emerged as the prime source of drinking water and irrigation. It is estimated that 92 per cent of the present ground water withdrawal is being used for irrigation. Thus contributing largely to the ***food security of the country.*** Ground water is the principal source of drinking water especially in rural areas and significantly in urban areas. These facts have resulted in continuous increase in ground water over exploited areas. The Central Ground Water Board as categorised the assessment units as ***'over exploited'***, ***'critical'*** and ***'semi-critical'*** based on the stage of ground water development and long-term water level declining trend during 1995-2004. **Table 15.6** shows that out of 5,723 assessment units (Blocks/Mandals/Talukas), 839 have been categorized as over exploited, *i.e.*, the annual ground water extraction exceeds the annual replenishable resource. In addition, 226 are critical *i.e.* the stage of ground water development is 90 to 100 per cent of annul replenishable resource with significant decline in long-term water trend in both pre-monsoon and post-monsoon period. There are 550 semi-critical units, where the stage of ground water development is more than 70 per cent.

TABLE 15.6. Categorization of Blocks/Mandals/Talukas with respect to ground water exploitation (As per March 2009 Estimates)

No. of assessed units	Safe		Semi-critical		Critical		Over Exploited	
	No.	%	No.	%	No.	%	No.	%
5723	4078	71	550	10	226	4	839	15

Source : India 2013 A Reference Annual, p. 963.

Hydrological Situation

India is a vast country having diversified geological, climatological and topographic set up, giving rise to divergent ground water situations in different parts of the country. The prevalent rock formations, ranging in age from the Archaean to the Recent, which control occurrence and movement of ground water, are widely varied in composition and structure. Variations of land forms varying from the rugged mountainous terrain of the Himalayas to the flat and featureless alluvial plains of the northern river valleys and coastal tracts, and aeolian deserts of Rajasthan are no less important. The topography and rainfall virtually control runoff and ground water recharge.

The high relief areas of the northern and north-eastern regions, the Aravali range of Rajasthan, and peninsular regions with steep topographic slope and characteristic geological set-up offer high run-off and little scope for rain water infiltration. The ground water potential in these terrains are limited to intermontane valleys.

The large alluvial tract in the Indus-Ganga-Brahmaputra plains, extending from Punjab in the west to Assam in the east, constitutes one of the largest and the most potential ground water reservoir in the world. The acquifer systems are extensive, thick, hydraulically interconnected and moderate to high yielding. To the north of this tract, all along the Himalayan foot hills, occur the linear belt of Bhabar piedmont deposits, and the Tarai belt down the slope with characteristic autoflowing conditions.

Almost the entire peninsular India is occupied by a variety of hard and fissured formations with patches of semi-consolidated sediments in narrow intracratonic basins. Rugged topography, compact and fissured nature of the rock formation, combine to give rise to discontinuous acquifers with limited to moderate yield potentials. The near surface, weathered mantle forms the all important ground water reservoir, and the source for circulation of ground water through underlying fracture systems. In the hard rock terrain, deep weathered pediments, low-lying valleys and abandoned river channels generally

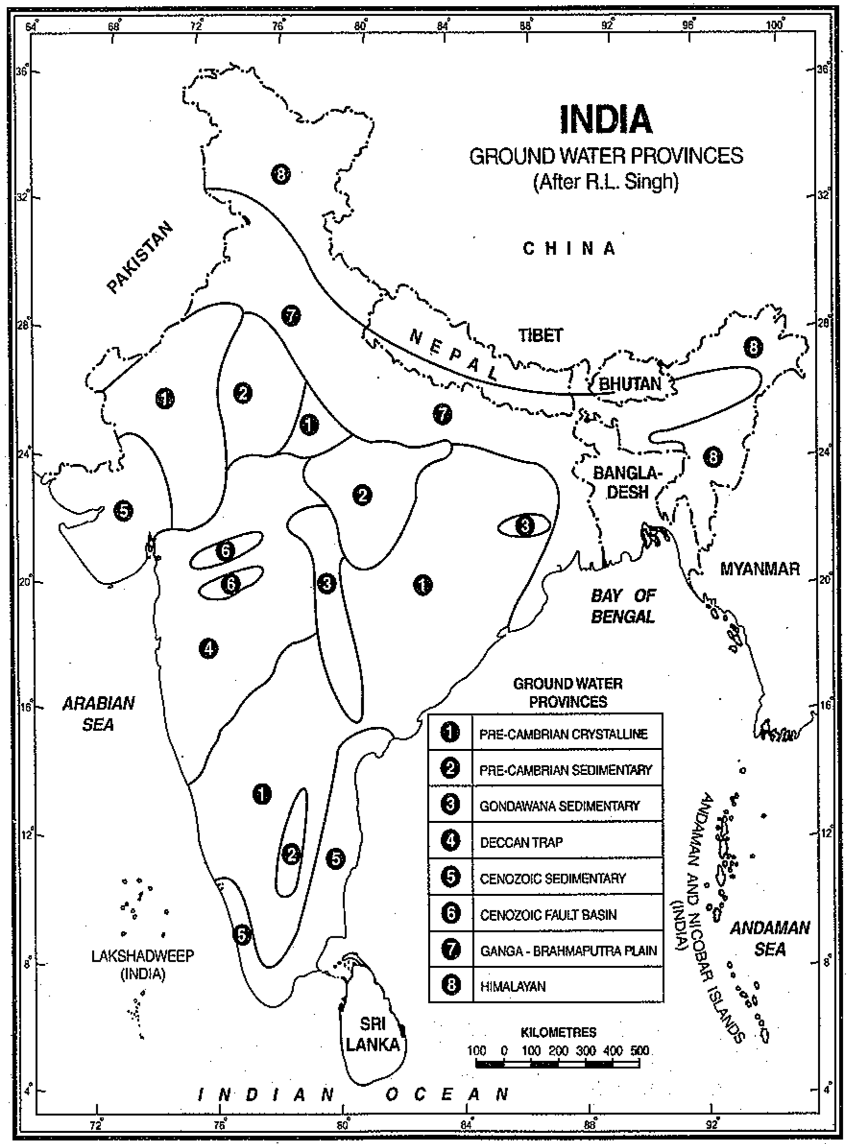

FIG. 15.5. India : Ground Water Provincees (After R.L. Singh)

contain adequate thickness of porous material, to sustain ground water development under favourable hydrometeorological conditions. Generally, the potential water saturated systems occur down to 100 metre depth. The friable semi-consolidated sandstones also form moderate yielding aquifers and auto flowing zones in these formation are not uncommon.

The coastal and deltaic tracts in the country form a narrow linear strip around the peninsular plateau. The eastern coastal and deltaic tract and the estuarine areas of Gujarat are receptacles of thick alluvial sediments. Though highly productive aquifers occur in these tracts, salinity hazards impose quality constraints for ground water development.

The above description leads as to the conclusion that the ground water resources are influenced by a number of natural conditions of which climate (particularly rainfall and temperature), relief features (topography), geological structure and hydrological setup are of outstanding significance. Accordingly Dr. R.L. Singh (1971) has divided India into 8 ground water provinces (**Fig. 15.5**), described as under :

1. **Pre-Cambrian Crystalline Province.** It extends over half of the country's geographical area covering Tamil Nadu, Andhra Pradesh, Telangana, Karnataka, Maharashtra, Dandakaranya, Bundelkhand and Aravali range. This province is deficient in ground water resources.
2. **Pre-Cambrian Sedimentary Province.** It extends over Cuddapah and Vindhyan basins where the rocks belong to Cuddapah and Vindhyan systems. This province is also not much suitable for ground water development and contains inadequate amount of ground water.
3. **Gondwana Sedimentary Province.** The Gondwana sedimentary rocks of the Barakar and Godavari river basins contain good aquifers of ground water.
4. **Deccan Trap Province.** These are 1,200 metre thick covering of impermeable basalt over the surface which obstructs percolation of water. As such, the whole province is deficient in ground water resources. The only aquifers preserved are in the fractures where secondary porosity develops in the weathered *moorums* at times, in the intertrappean beds sandwiched between two impermeable strata as also in the vesicles and amygdales.
5. **Cenozoic Sedimentary Province.** This province includes the Andhra Pradesh, Tamil Nadu, Kerala and Gujarat coasts. These areas have tertiary sandstones and the province as a whole has good acquifers.
6. **Cenozoic Fault Basin.** The rift zone of the Narmada, the Purna and the Tapi provides good resource of ground water in its 80-160 metre thick alluvial cover of sand, silt and clay.
7. **Ganga-Brahmaputra Alluvial Province.** This is the richest ground water province of the country. The bhabar, tarai and the axial belts are well defined. The streams disappearing in the unassorted materials of the bhabar zone seep out in the tarai belt. Moreover, the ground water table is also high.
8. **Himalayan Province.** This complex structural and geographic unit is not very significant with respect to ground water resources. Local springs are common but wells are a rare feature.

Water Scarcity

While water is a renewable resource, it is at the same time a finite resource. The total quantity of water available on the globe is the same as it was thousands of years ago. It is important to appreciate the fact that only 3 per cent of the world's water is fresh and roughly one-third of it is inaccessible. The rest is very unevenly distributed and the available supplies are increasingly contaminated with wastes and pollution from industry, agriculture and households.

Over the years, increasing population, growing industrialisation, expanding agriculture and rising standards of living have pushed up the demand for water. Efforts have been made to collect water by building dams and reservoirs and creating ground water structures such as wells. Recycling and desalination of water are other options but cost involved is very high. However, there is a growing realisation that there are limits to '*finding more water*' and in the long run, we need to know the amount of water we can reasonably expect to tap and also learn to use it more efficiently.

It is the human nature that we value things only when they are scarce or are in short supply. As such we appreciate the value of water once the rivers, reservoirs, ponds, wells, etc. run dry. Our water resources have now entered an era of scarcity. It is estimated that thirty years from now, approximately once-third of our population will suffer from chronic water shortages. The increasing demands on fresh water resources by our burgeoning population and diminishing quality of existing water resources because of pollution and the additional requirements of serving our spiralling industrial and agricultural growth have led to a situation where the consumption of water is rapidly increasing and the supply of fresh water remains more or less constant. It may be maintained that the water available to us is the same as it was before but the population and the consequent demand for water has increased manifold. The consequences of scarcity will be more drastic in arid and semi-arid regions. Water shortage will also be felt in rapidly growing coastal regions and in big cities. Several cities are already, or will be, unable to cope with the demand of providing safe water and sanitation facilities to their inhabitants.

Indicators of water stress and scarcity are generally used to reflect the overall water availability in a country or a region. When the annual per capita of renewable fresh water in a country or a region falls below 1,700 cubic metres, it is held to be situation of *water stress*. If the availability is below 1,000 cubic metres, the situation is labelled as that of *water scarcity*. And when the per capita availability falls below 500 cubic metres, it is said to be a situation of *absolute scarcity* (Engelman and Roy, 1993). These are also the findings of a study conducted by the Tata Energy Research Institute (TERI). This concept has been propounded by Malin Falkenmark on the premise that 100 litres a day (36.5 cubic metres a year) is roughly the minimum per capita requirement for basic household needs and to maintain good health, roughly 5 to 20 times that amount is needed to satisfy the requirement of agriculture, industry and energy.

At the time of Independence, *i.e.*, in 1,947, the per capita availability of water in India was 6,008 cubic metres a year. It came down to 5,177 cubic metres a year in 1951 and to 1,820 cubic metres a year in 2001. As per figure released by Ministry of Water Resources, India's per capita availability of water has been pegged at 1,541.5 cubic metres a year, including non-personal consumption, such as irrigation—notches below the international threshold of 1700 cubic metre a year. India has only 4 per cent

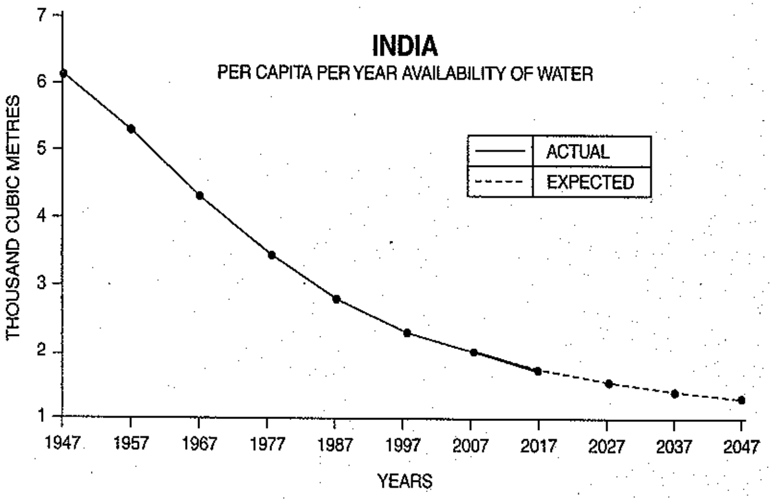

FIG. 15.6. India : Declining availability of water

of the world's water resources, and she has to support over 17 per cent of the world's population and over 15 per cent of livestock. According to mid term appraisal (MTA) of the 10th Plan, per capita availability of water is likely to fall down to 1,340 cubic metre in 2025 and 1,140 cubic metre in 2050. **Figure 15.6** shows the probable trends in per capita water availability for hundred years from 1947 to 2047. The problem of water shortage is further complicated when we look at the areal distribution of water resources with reference to population. From as high as 18,417 cubic metres in the Brahmaputra valley, per capita water availability comes down to a low of 411 cubic metres in the east-flowing rivers between Pennar and Kanniyakumari. Even within the Ganga basin, the availability varies from 740 cubic metres in the Yamuna to 3,379 cubic metres in the Gandak basin (Chitale, 1992).

According to 2011 Census figures 85.5 per cent of India's households have access to safe drinking water (tap/hand pump/tubewell). At 91.4 per cent, urban people are better placed than 82.7 per cent rural households. Punjab has the highest percentage of 97.6 households enjoying the facility of safe drinking water. As much as 96.7 per cent rural and 98.9 per cent urban households in Punjab have access to safe drinking water. Meghalaya is the worst placed where only 44.7 per cent of the total households have access to safe drinking water. The figures for rural and urban areas are 35.1 and 79.5 per cent respectively. Among the Union Territories, Chandigarh is the best placed where 99.3 per cent of the households have access to safe drinking water, while the people of Lakshadweep are very unlucky where only 22.8 per cent of the total households have access to safe drinking water (**Table 15.7**).

However, the above description regarding percentage of households having access to safe drinking water could be misleading and the real picture emerges only when we look at the individual cities. A survey conducted by Tata Institute of Social Science (TISS) showed 50 lakh households in Mumbai, Delhi, Kolkata, Hyderabad, Kanpur and Madurai are water deficient (see **Table 15.8**). World Health Organisation (WHO) specifies that minimum water requirement should be 100-200 litres per day. That is way above the average urban figure, 90 litres.

TABLE 15.7. Access to Safe Drinking Water in Households in India in 2011 (per cent)

Sl. No.	States/Union Territories	Total	Rural	Urban
1.	Jammu & Kashmir	76.8	70.1	96.1
2.	Himachal Pradesh	93.7	93.2	97.8
3.	Punjab	97.6	96.7	98.9
4.	Chandigarh	99.3	98.7	99.4
5.	Uttarakhand	92.2	89.5	98.7
6.	Haryana	93.8	92.0	96.7
7.	Delhi	95.0	87.9	95.2
8.	Rajasthan	78.1	72.8	94.3
9.	Uttar Pradesh	95.1	94.3	97.9
10.	Bihar	94.0	93.9	94.7
11.	Sikkim	85.3	82.7	92.2
12.	Arunachal Pradesh	78.6	74.3	91.3
13.	Nagaland	53.8	54.6	51.8
14.	Manipur	45.4	37.5	60.8
15.	Mizoram	60.4	43.4	75.8
16.	Tripura	67.5	58.1	91.9
17.	Meghalaya	44.7	35.1	79.5
18.	Assam	69.9	68.3	78.2
19.	West Bengal	92.2	91.4	93.9
20.	Jharkhand	60.1	54.3	78.4
21.	Odisha	75.3	74.4	79.8
22.	Chhatisgarh	86.3	84.1	93.9
23.	Madhya Pradesh	78.0	73.1	92.1
24.	Gujarat	90.3	84.9	97.0
25.	Daman & Diu	98.7	97.8	99.0
26.	Dadra & Nagar Haveli	91.6	84.3	98.4
27.	Maharashtra	83.4	73.2	95.7
28.	Andhra Pradesh	90.5	88.6	94.5
29.	Karnataka	87.5	84.4	92.3
30.	Goa	85.7	78.4	90.4
31.	Lakshadweep	22.8	31.2	20.2
32.	Kerala	33.5	28.3	39.4
33.	Tamil Nadu	92.5	92.2	92.9
34.	Puducherry	97.8	99.6	97.0
35.	Andaman & Nicobar Islands	85.5	78.2	98.1
	All India	**85.5**	**82.7**	**91.4**

Source : Economic Survey 2012-13, p. A. 126

TABLE 15.8. Number of Water Deficient Households

City	Number of water deficient households
Mumbai	17,35,756
Delhi	14,73,114
Kolkata	4,36,905
Ahmedabad	4,29,199
Hyderabad	4,13,881
Kanpur	3,29,714
Madurai	1,48,533

Source : Tata Institute of Social Sciences (TISS) Survey, 2005.

Table 15.9 shows that several cities particularly the southern cities are most water deficient. Chennai and Bengaluru suffer from 53.8 and 39.5 per cent deficiency respectively. Andhra Pradesh too has extremes : deficiency is a moderate 24.2 per cent in Hyderabad, an alarming 91.8 per cent in Vishakhapatnam. In the north, Delhi records 29.8 per cent water deficiency and Lucknow, 27.3 per cent. Central India is more water- deficient than the north with wide regional variations. For example, Bhopal is 26.4 per cent water-deficient while Indore and Jabalpur record rates of 72.8 and 65.4 per cent deficiency respectively. Mumbai in the west, with deficiency rate of 43.3 per cent, is similarly situated as Kolkata which clocks at 44 per cent.

TABLE 15.9. Demand, Supply and Deficiency of Water in Selected Cities of India in Million Litres per Day (MLD)

City	Demand	Supply	Deficiency (%)
Mumbai	4,300	3,600	43.3
Delhi	3,830	2,950	29.8
Kolkata	2,258	1,568	44.0
Chennai	3,000	1,950	53.8
Hyderabad	956	770	24.2*
Indore	318	184	72.8
Bengaluru	1,200	860	39.5
Lucknow	560	440	27.3
Jabalpur	239	144.5	65.4
Vishakhapatnam	305	159	91.8**

*least deficient **most deficient

Source : Abdul Shaban (2005), "Water Consumption Patterns in Domestic Households in Major Cities in India, Tata Institute of Social Sciences (TISS), Mumbai.

WATER WOES IN INDIA

- The number of households has increased from 24.1 crore in 2001 to 33.1 crore in 2011 and per capita availability of water has reduced from 1820 cubic metres/yr in 2001 to 1545 cubic metre/yr—notches below the international threshold of 1700 cubic metres/yr.
- 30% of rural Indians lack drinking water supply (World Bank, UNICEF).
- According to National Sample Survey Office (NSSO), 57% of the rural women in India have to walk up to 5 km every day to fetch potable water as compared to just 21% in Urban areas.
- Following findings of the report released by National Sample Survey Office (NSSO) in August, 2014 are worth noting :
  (*a*) 54% of rural woman in India had to travel between 200 metres and 5 kilometres daily to fetch drinking water in 2012.
  (*b*) They walked 20 minutes a day, on an average, and spend another 15 minutes at the source of water.
  (*c*) Every second woman in rural India walked average 173 km to fetch potable water in 2012 making her track 25 km longer than what it was in 2008-09.
  (*d*) Every second woman has to spend 210 hours in a year for fetching water which means a loss of 27 days' wages for these households. Collectively, these women cover 64,000 times the distance between the earth and the moon.
  (*e*) Water crisis is imminent in villages because of over harvesting of ground-water resources. About 80% of the country's drinking water needs are met by groundwater.
  (*f*) 75% of the women in states like Chhattisgarh, Manipur, Odisha and Jharkhand have to travel long distances for drinking water. Time taken for this exercise is highest in Jharkhand (40 minutes) followed by Bihar (33 minutes) and Rajasthan (30 minutes).
- India records worlds highest per capita water-borne diseases even more than some of the lest developed nations.
- In most of the large cities about one-third of water never reaches the consumer because of leaks and poor maintenance. According to Centre for Science and Environment, over 35% of water in Delhi and about 30% in Mumbai is lost because of leakage.
- India is home to 17.5% of world's population but has only 4% of water.

Nearly 40 per cent of water demand in urban India is met by ground water. So ground water tables in most cities are falling at alarming rate of 2-3 metres per year. Another factor is water leakage. Delhi loses at least 35 per cent of its water due to leakages in its 83.0 km long pipeline network. Mumbai loses about 30 per cent of its water due to leakage.

Water Disputes and Conflicts

Any commodity which is in short supply is likely to cause disputes and conflicts and water shortage is no exception. Water disputes and conflicts are taking place at the national (inter-state) and international levels in the present day world. Experts believe that the biggest potential destabiliser in the world is water scarcity. Former UN Secretary General, Boutros Bautros Ghali had warned in 1980s that future wars could be fought over water. His successor Kofi Annan was also worried about the fierce competition over water resources that contained the seeds of violent conflicts. Ismael Serageldin, vice president, World Bank, had predicted in 1995 that "if wars of this century were fought over oil, the wars of the next century will be fought over water." Whereas 'oil' had been the bone of contention in many wars of the yester years, the prediction of Mrs. Elizabeth Dowdeswell the "*Major clashes over dwindling supplies of water may well constitute the source of future conflicts between nations*", seems to be coming true, with the waging national and international disputes over water sharing, blowing up to the proportion of an imminent Third World War. It is now feared that "*Third World War if fought, will not be fought for territorial gains or political supremacy but for water.*"

Potential conflicts are likely where rivers and lakes are shared by more than one country. The Nile, the Jordan, the Indus, the Ganga, the Brahmaputra and the Mekong are some of these. In times of water stress and shortages, regions will face water refugees from one region to the other within the country or between two countries.

There could be wars for control of water supplies; or water resources or systems used as a weapon during military conflict; or used as political goal; terrorists could threaten using water resources as a weapon of coercion. Water systems themselves could be targets of military action. Then, with multinational giants having entered the business of supplying water privately for profit, there could be wars for entrepreneurial control. With mismanagement of water resources, mighty rivers can become mere rivulets, unable to reach the sea. With taps run dry and crops wither away, there would be upheavals—mixed as they would be with regional, caste, sectarian and communal colour. All this may be difficult to imagine, but this is calamity about to happen. It is nightmare about to come true.

Inter-state River Water Disputes in India

Most rivers of India are plagued with interstate disputes. Almost all the major rivers of the country are inter-state rivers and their waters are shared by two or more than two states. After independence, demand for water had been increasing at an accelerated rate due to rapid growth of population, agricultural development, urbanisation, industrialisation, etc. These developments have led to several inter-state disputes about sharing of water of these rivers. Following interstate river water disputes are worth mentioning.

(*i*) Cauvery water dispute between Tamil Nadu, Karnataka and Kerala.
(*ii*) The Krishna water dispute between Maharashtra, Karnataka and Andhra Pradesh.
(*iii*) The Tungabhadra water dispute between Andhra Pradesh and Karnataka.
(*iv*) The Aliyar and Bhivani river water dispute between Tamil Nadu and Kerala.
(*v*) The Godavari river water dispute between Andhra Pradesh, Madhya Pradesh, Chhattisgarh, Odisha and Karnataka.
(*vi*) The Narmada water dispute between Gujarat, Maharashtra, Madhya Pradesh and Rajasthan.
(*vii*) The Mahi river dispute between Gujarat, Rajasthan and Madhya Pradesh.
(*viii*) The Ravi and Beas river water dispute between Punjab, Haryana, Himachal Pradesh, Rajasthan, Jammu and Kashmir and Delhi.
(*ix*) The Satluj-Yamuna Link canal dispute between Punjab, Haryana and Rajasthan.

(x) The Yamuna river water dispute between Uttar Pradesh, Haryana, Himachal Pradesh, Punjab, Rajasthan, Madhya Pradesh and Delhi.

(xi) The Karmanasa river water dispute between Uttar Pradesh and Bihar.

(xii) The Barak river water dispute between Assam and Manipur.

Efforts are made to resolve disputes through negotiations amongst the basin states with the assistance of the Central Government. Many of these interstate river water disputes have been settled on the basis of equitable apportionment which is the universally accepted principle. Adjudication through appointment of water disputes tribunals is also resorted to as and when required. So far, the following tribunals have been appointed to resolve inter-state water disputes :

(i) The Godavari Water Disputes Tribunal
(ii) The Krishna Water Disputes Tribunal
(iii) The Narmada Water Disputes Tribunal
(iv) The Ravi and Beas Water Disputes Tribunal
(v) The Cauvery Water Disputes Tribunal
(vi) New Krishna Water Disputes Tribunal

The first three Tribunals have given their final reports.

Cauvery Water Disputes Tribunal gave its interim order in June 1991. The Ravi and Beas Tribunal submitted its report in January, 1987. A further reference was made to the Tribunal comprising of a suo-moto reference by the Central Government and references received from the Governments of Punjab, Haryana, and Rajasthan seeking explanation/guidance on certain points in the report. The New Krishna Water Disputes Tribunal was set up on April 2, 2004.

Central Government has also received request from the State Government of Goa in August 2002 for the constitution of Tribunal for adjudication of water disputes relating to Madei inter-state river among the states of Goa, Karnataka and Maharashtra. Subsequently, Goa expressed the desire in June, 2003 to settle the disputes through negotiations.

In developing country like India, the inter-state river water disputes have to be resolved quickly and amicably. This is most urgent for the proper utilisation of water resources and economic growth.

International Cooperation

Several big rivers of India like the Indus, the Ganga and the Brahmaputra flow through the territory of some neighbouring countries also in addition to their flow through the Indian territory. These rivers call for cooperation between India and her neighbouring countries. India has taken several initiatives to create an atmosphere of cooperation and mutual understanding with the neighbouring countries. A few examples are described below :

1. The Indus Water Treaty. This treaty is concerned with sharing of the waters of the Indus and its tributaries between India and Pakistan. Signed by the two concerned countries on September 19, 1960, this treaty was reached through the arbitration of International Bank of Reconstruction and Development. According to the provisions of this treaty, India has the exclusive rights to use the waters of three eastern rivers (Sutluj, Beas and Ravi), leaving out remaining three rivers (Chenab, Jhelum and Indus) to Pakistan which will also take care of water requirements of the Indian states of Jammu and Kashmir. However, India can utilise only 20 per cent of the total discharge of the Indus river system under the regulations of the Indus Water Treaty.

2. India-Bangladesh Cooperation. An Indo-Bangladesh Joint Rivers Commission (JRC) is functioning since 1972, the year that country came into being. This Commission was set up to ensure the most effective joint efforts in maximising the benefits from common river systems.

The signing of the Treaty between India and Bangladesh on the Ganga water sharing at Farakka on 12th December, 1996, ushered a new era of cooperation in water resources sector between the two countries. Under the agreement India and Bangladesh would share alternately for 10 days each 35,000 cusecs of waters during the lean season (1 March to 15 May) to fulfill their water needs. Since the signing of this Treaty, sharing of the lean season flow of the Ganga waters and Farakka during 1970 to 2005 has been carried out to the satisfaction of both the countries.

Discussions are also continuing for sharing of waters of the Tista river.

Existing system of transmission of flood forecasting data on major rivers like Ganga, Tista,

Brahmaputra and Barak during the monsoon season from India to Bangladesh is continuing.

3. India Nepal Cooperation. A Nepal-India Joint Committee on Water Resources (JCWR) is functioning with the mandate to act as Umbrella Committee of all committees groups. A Treaty on Integrated Development of Mahakali was signed between India and Nepal in February, 1996 which came into force in June 1997 (*Mahakali Treaty*). Pancheshwar Multipurpose Project on river Mahakali (known as Sarda in India) is the centrepiece of Mahakali Treaty. Agreement has also been reached with Nepal to take up the joint field investigations, studies and preparation of Detailed Project Report of Sapta Kosi High Dam Multipurpose Project and Sun Kosi Storage Dam-cum-Diversion Scheme.

For dealing with the problems of inadvertent inundation caused by the construction of various works on the border rivers between India and Nepal, a Standing Committee on Incubation Problems (SCIP) between India and Nepal is also functioning since 1986. This committee has been set up for identifying the problem areas and suggest possible solutions on a continuing basis.

4. India-China Cooperation. A Memorandum of Understanding (MoU) between India and China was signed in the year 2002. It makes provision of hydrological information, namely rainfall, water level, discharge and other relevant information on Yaluzangbu/Brahmaputra river in flood season by China to India from 1 June to 15 October every year. The Chinese side had started transmitting the relevant data in June, 2002. The information received from China is very useful for making advance forecasts for floods in the Brahmaputra river in India. The Government of India has also taken up the matter with China for establishing additional hydrological stations on Langquinzagbu (Satluj) and Palongzangbu tributary of Brahmaputra.

5. India-Bhutan Cooperation. A Joint Expert Team (JET) consisting of officials from India and Bhutan is functioning since 1979 to review the progress and other requirements of the "Comprehensive Scheme for Establishment to Hydro-meteorological and Flood Forecasting Network on rivers common to India and Bhutan." A network of 35 hydro-meteorological/meteorological stations is established in Bhutan. Data received from these stations is used by India for flood forecasting. Bhutan has agreed to join a sub-regional plan for sharing river waters and power with India and Bangladesh. That country is willing to divert 12,000 cusecs of water from the Sankosh river to the Tista river and from the Tista to Farakka barrage to be shared by India and Bangladesh. India has also agreed to purchase 4,000 megawatt of hydroelectricity from Bhutan. This power strengthens our National Power Grid and meets the power needs of the north-eastern region.

Conservation of Water Resourses

Water is an important natural resource and is the very basis of our life. We use water for drinking, irrigation, industry, transport and for the production of hydro-electricity. Water is a *cyclic resource* which can be used again and again after cleaning. The best way to conserve water is its judicious use. A large quantity of water is used for irrigation and there is an urgent need for proper water management in irrigation sector. Over-irrigation through canals has led to waterlogging in western Uttar Pradesh, Punjab, Haryana and Hirakud command area. Seepage along the canals can be checked by lining them. The overdraft by tube-wells has resulted in lowering of water table in a number of villages in Haryana, Punjab and western Uttar Pradesh. In arid areas, wherever water has been brought for irrigation, saline and alkaline tracts have emerged, rendering the soil infertile. Wasteful use of water should be checked. Sprinkler irrigation and drip irrigation can play a crucial role in conserving scarce water resources in dry areas. Drip irrigation and sprinkless can save anywhere between 30 to 60 per cent of water. Only 0.5 per cent—nearly half of this in Maharashtra—is under drip irrigation and 0.7 per cent under sprinklers. There is large-scale pollution of water as a result of industrialisation and urbanisation. This trend has got to be checked. Although one-eighth of India is declared as flood prone, there are several thousand villages in India which do not have potable drinking water. The basins should be treated as one unit for planning water utilization. Dry farming should be practiced in dry areas. The experimentation under the National Watershed Development Programme for Rainfed Agriculture is being carried on since 1986-87.

22nd March is observed as "World Water Day" out of 1992 UN Resolution.

There is a great demand of water in industries and the industrial sector offers great opportunities to conserve water. The economy in water-use in this sector will have two benefits. Firstly, the saved water may be used to meet the demand in other sectors. Secondly, the affluents thrown in the water bodies will be less. Water in most industries is used for cooling purposes, thus, it is not necessary to use fresh potable water. Instead, the recycled water may be used for this purpose. By using the recycled water over and over again, fresh water can be conserved.

Demand of water for domestic use can also be reduced. For example, in most urban areas about 12.5 litres of water is used in one flushing. In some cities cisterns requiring only 5 to 7 litres of water in one flushing are now used. Thus if each urban individual adopts smaller cisterns, the amount of water consumption for flushing can be reduced to half. Similarly, if raw water is used for cleaning, gardening, etc., a lot of fresh potable water can be saved. Water used in kitchen sink, wash basin and in bathroom can be collected into a tank and reused for flushing toilet and for gardening also.

Rain Water Harvesting

Rain water harvesting is one of the most effective methods of water management and water conservation. It is the term used to indicate the collection and storage of rain water used for human, animals and plant needs. It involves collection and storage of rain water at surface or in sub-surface aquifer, before it is lost as surface run off. The augmented resource can be harvested in the time of need. Artificial recharge to ground water is a process by which the ground water reservoir is augmented at a rate exceeding that under natural conditions of replenishment. The collected water is stored and pumped in a separate pipe distribution. This is a very useful method for a developing country like India in reducing the cost and the demand of treated water and also economising the treatment plants operation, maintenance and distribution costs.

Need

- To overcome the inadequacy of surface water to meet our demands.
- To arrest decline in ground water levels.
- To enhance availability of ground water at specific place and time and utilize rain water for sustainable development.
- To increase infiltration of rain water in the subsoil which has decreased drastically in urban areas due to paving of open area.
- To improve ground water quality by dilution.
- To increase agricultural production.
- To improve ecology of the area by increase in vegetation cover etc.

Advantages

- The cost of recharge to sub-surface reservoir is lower than surface reservoirs.
- The aquifer serves as a distribution system also.
- No land is wasted for storage purpose and no population displacement is involved.
- Ground water is not directly exposed to evaporation and pollution.
- Storing water under ground is environment friendly.
- It increases the productivity of aquifer.
- It reduces flood hazards.
- Effects rise in ground water levels.
- Mitigates effects of drought.
- Reduces soil erosion.

The New Delhi-based Centre for Science and Environment estimates that merely capturing the rain water and run off on 2 per cent of India's land area could supply 26 gallons of water per person. As such much effort is being made to popularize the concept of rain water harvesting at the grass roots level.

Potential Areas

- Where ground water levels are declining on regular basis.
- Where substantial amount of aquifer has been de-saturated.
- Where availability of ground water is inadequate in lean months.
- Where due to rapid urbanization, infiltration of rain water into subsoil has decreased drastically and recharging of ground water has diminished.

Methods and Techniques

The methods of ground water recharge mainly are :

Urban Areas

Roof top rain water/storm run off harvesting through

(*i*) Recharge Pit
(*ii*) Recharge Trench
(*iii*) Tubewell
(*iv*) Recharge Well

Rural Areas

Rain water harvesting through

(*i*) Gully Plug
(*ii*) Contour Bund
(*iii*) Gabion Structure
(*iv*) Percolation Tank
(*v*) Check Dam/Cement Plug/Nala Bund
(*vi*) Recharge Shaft
(*vii*) Dugwell Recharge
(*viii*) Ground Water Dams/Subsurface Dyke

Urban Areas

In urban areas, rain water available from roof tops of buildings, paved and unpaved areas goes waste. This water can be recharged to aquifer and can be utilized gainfully at the time of need. The rain water harvesting system needs to be designed in a way that it does not occupy large space for collection and recharge system. Roof top rain water harvesting can be a very effective tool to fight the problem of water shortage particularly in urban areas. Roof top rain water harvesting depends upon the amount of rainfall and the roof top area. More the amount of rainfall, more is the harvested water from roof top. Similarly, larger amount of roof top rain water is harvested from roofs with large area. **Table 15.10** gives the amount of harvested water from roof top in cubic metres in relation to the amount of rainfall in millimetres and the roof top area in square metres.

A few techniques of roof top rain water harvesting in urban areas are described as under :

(i) Roof Top Rainwater Harvesting through Recharge Pit

- In alluvial areas where permeable rocks are exposed on the land surface or at very shallow depth, roof top rain water harvesting can be done through recharge pits.
- The technique is suitable for buildings having a roof area of 100 sq m and are constructed for recharging the shallow aquifers.
- Recharge pits may be of any shape and size and are generally constructed 1 to 2 m wide and 2 to 3 m deep which are back filled with boulders (5-20 cm), gravels (5-10 mm) and coarse sand (1.5-2 mm) in graded form—boulders at the bottom, gravels in between the coarse sand at the top so that the silt content that will come with runoff will be deposited on the top of the coarse sand layer and can easily be removed. For smaller roof area, pit may be filled with broken bricks/cobbles.

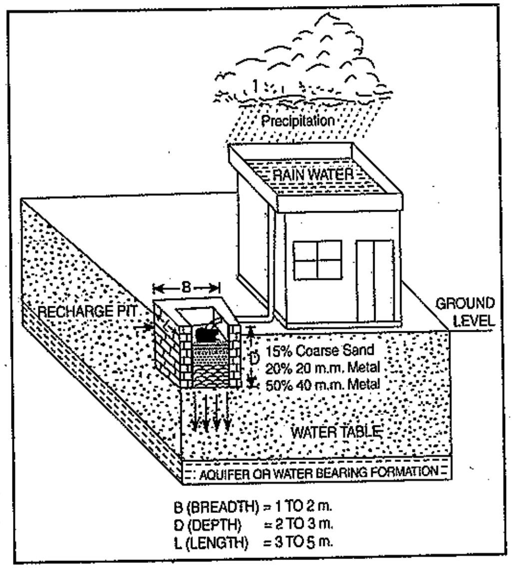

FIG. 15.7. Roof top rain water harvesting through recharge pit

- A mesh should be provided at the roof so that leaves or any other solid waste/debris is prevented from entering the pit and a desilting/collection chamber may also be provided at the ground to arrest the flow of finer particles to the recharge pit.
- The top layer of sand should be cleaned periodically to maintain

TABLE 15.10. Availability of Rain Water through Roof Top Rain Water Harvesting

Rainfall (mm)	100	200	300	400	500	600	800	1000	1200	1400	1600	1800	2000
Roof top area (sqm)	Harvested Water from Roof top (cum)												
20	1.6	3.2	4.8	6.4	8	9.6	12.8	16	19.2	22.4	25.6	28.8	32
30	2.4	4.8	7.2	9.6	12	14.4	19.2	24	28.8	33.6	38.4	43.2	48
40	3.2	6.4	9.6	12.8	16	19.2	25.6	32	38.4	44.8	51.2	57.6	64
50	4	8	12	16	20	24	32	40	48	56	64	72	80
60	4.8	9.6	14.4	19.2	24	28.8	38.4	48	57.6	67.2	76.8	86.4	96
70	5.6	11.2	16.8	22.4	28	33.6	44.8	56	67.2	78.4	89.6	100.8	112
80	6.4	12.8	19.2	25.6	32	38.4	51.2	64	76.8	89.6	102.4	115.2	128
90	7.2	14.4	21.6	28.8	36	43.2	57.6	72	86.4	100.8	115.2	129.6	144
100	8	16	24	32	40	48	64	80	96	112	128	144	160
150	12	24	36	48	60	72	96	120	144	168	192	216	240
200	16	32	48	64	80	96	128	160	192	224	256	288	320
250	20	40	60	80	100	120	160	200	240	280	320	360	400
300	24	48	72	96	120	144	192	240	288	336	384	432	480
400	32	64	96	128	160	192	256	320	384	448	512	576	640
500	40	80	120	160	200	240	320	400	480	560	640	720	800
1000	80	160	240	320	400	480	640	800	960	1120	1280	1440	1600
2000	160	320	480	640	800	960	1280	1600	1920	2240	2560	2880	3200
3000	240	480	720	960	1200	1440	1920	2400	2880	3360	3480	4320	4800

Source : Rainwater Harvesting Techniques to Augment Ground Water (2003), Central Ground Water Board, Ministry of Water Resources.

- By-pass arrangement be provided before the collection chamber to reject the first showers.

(ii) Roof Top Rain Water Harvesting through Recharge Trench

- Recharge trenches are suitable for buildings having roof area of 200-300 sq m and where permeable strata is available at shallow depths.
- Trench may be 0.5 to 1 m wide, 1 to 1.5 m deep and 10 to 20 m long depending upon availability of water to be recharged.
- These are back filled with boulders (5-20 cm), gravels (5-10 mm) and coarse sand (1.5-2 mm) in graded form—boulders at the bottom, gravel in between and coarse sand at the top so that the silt content that will come with runoff will be deposited on the top of the sand layer and can easily be removed.
- A mesh should be provided at the roof so that leaves or any other solid waste/debris is prevented from entering the trench and a desilting/collection chamber may also be provided on ground to arrest the flow of finer particles to the trench.
- By-pass arrangement be provided before the collection chamber to reject the first showers.
- The top layer of sand should be cleaned periodically to maintain the recharge rate.

(iii) Roof Top Rain Water Harvesting through Existing Tubewells

- In areas where the shallow aquifers have dried up and existing tubewells are tapping deeper acquifer, roof top rain water harvesting through existing tubewell can be adopted to recharge the deeper aquifers.
- PVC pipes of 10 cm diameter are connected to roof drains to collect rain water. The first roof runoff is let off through the bottom of drain pipe. After closing the bottom pipe, the rain water of subsequent rain showers is taken through a T to an online PVC filter. The filter may be provided before water enters the

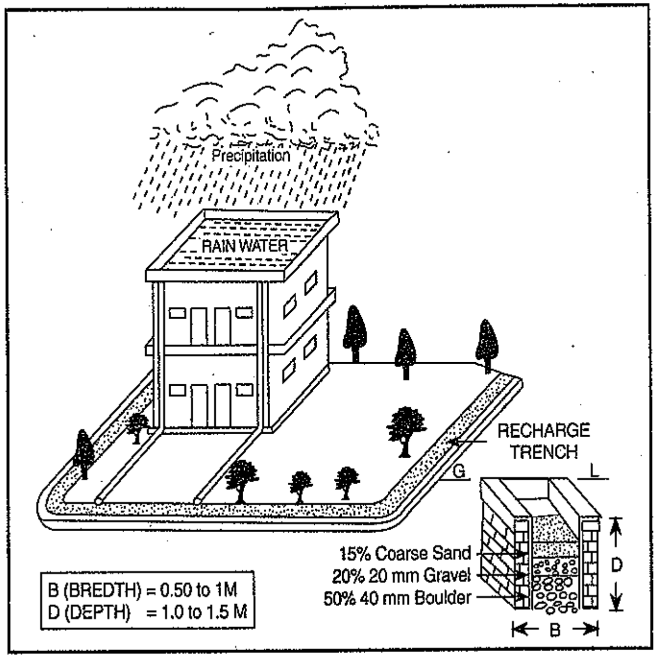

FIG. 15.8. Roof top rain water harvesting through recharge trench

tubewell. The filter is 1-1.2 m in length and is made up of PVC pipe. It's diameter should vary depending on the area of roof, 15 cm if roof area is less than 150 sq m and 20 cm if the roof area is more. The filter is provided with a reducer of 6.25 cm on both the sides. Filter is divided into three chambers by PVC screens so that filter material is not mixed up.

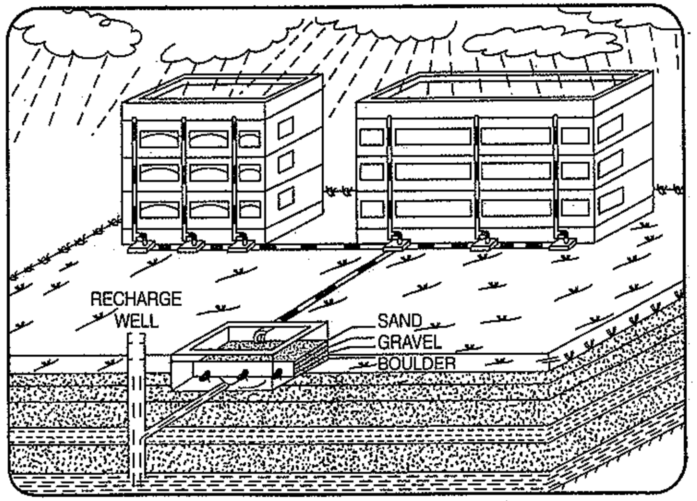

FIG. 15.9. Roof top rain water harvesting through existing tubewells

The first chamber is filled up with gravel (6-10 mm), middle chamber with pebbles (12-20 mm) and last chamber with bigger pebbles (20-40 mm).

- If the roof area is more, a filter pit may be provided. Rain water from roofs is taken to collection/desilting chambers located on ground. These collection chambers are interconnected as well as connected to the filter pit through pipes having a slope of 1 : 15. The filter pit may vary in shape and size depending upon available run off and are back-filled with graded material, boulder at the bottom, gravel in the middle and sand at the top with varying thickness (0.30-0.50 m) and may be separated by a screen. The pit is divided into two chambers, filter material in one chamber and other chamber is kept empty on accommodate excess filtered water and to monitor the quality of filtered water. A connecting pipe with recharge well is provided at the bottom of the pit for recharging of filtered water through well.

(iv) Roof Top Rain Water Harvesting through Trench with Recharge Well

- In areas where the surface soil is impervious and large quantities of roof water or surface runoff is available within a very short period of heavy rainfall, the use of trench/pits is made to store the water in a filter media and subsequently recharge to ground water through specially constructed recharge wells.
- This technique is ideally suited for area where permeable horizon is within 3 m below ground level.
- Recharge well of 100-300 m diameter is constructed to a depth of at least 3 to 5 m below the water level. Based on the lithology of the area well assembly is designed with slotted pipe against the shallow and deeper aquifer.
- A lateral trench of 1.5 to 3 m width and 10 to 30 m length, depending upon the availability of water is constructed with the recharge well in the centre.
- The number of recharge wells in the trench can be decided on the basis of water availability and local vertical permeability of the rocks.
- The trench is backfilled with boulders, gravels and coarse sand to act as a filter media for the recharge wells.
- If the aquifer is available at greater depth say more than 20 m, a shallow shaft of 2 to 5 m diameter and 3-5 metres deep may be constructed depending upon availability of runoff. Inside the shaft a recharge well of 100-300 mm dia is constructed for recharging the available water to the deeper aquifers. At the bottom of the shaft a filter media is provided to avoid choking of recharge well.

Rural Areas

In rural areas, rain water harvesting is taken up considering watershed as a unit. Surface spreading techniques are common since space for such systems is available in plenty and quantity of recharged water is also large. Following techniques may be adopted to save water going waste through slopes, rivers, rivulets and nalas.

(i) Rain Water Harvesting through Gully Plug

- Gully plugs are built using local stones, clay and bushes across small gullies and streams running down the hill slopes carrying drainage to tiny catchments during rainy season.
- Gully plugs help in conservation of soil and moisture.
- The sites for gully plugs may be chosen whenever there is a local break in slope to permit accumulation of adequate water behind the bunds.

(ii) Rain Water Harvesting through Contour Bund

- Contour bunds are effective method to conserve soil moisture in watershed for long duration.
- These are suitable in low rain fall areas where monsoon run off can be impounded by constructing bunds on the sloping ground all along the contour of equal elevation.

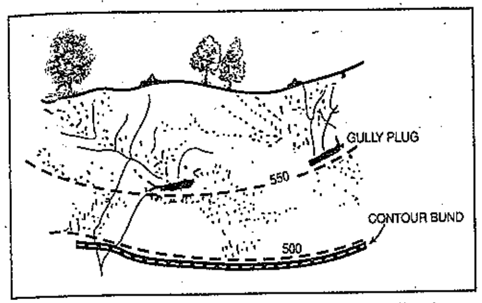

FIG. 15.10. Rain water harvesting through gully plug and contour bund

- Flowing water is intercepted before it attains the erosive velocity by keeping suitable spacing between bunds.
- Spacing between two contour bunds depends on the slope of the area and the permeability of the soil. Lesser the permeability of soil, the close should be spacing of bunds.
- Contour bunding is suitable on lands with moderate slopes without involving terracing.

(iii) Rain Water Harvesting through Gabion Structure

- This is a kind of check dam commonly constructed across small streams to conserve stream flows with practically no submergence beyond stream course.
- A small bund across the sream is made by putting locally available boulders in a mesh of steel wires and anchored to the stream banks.

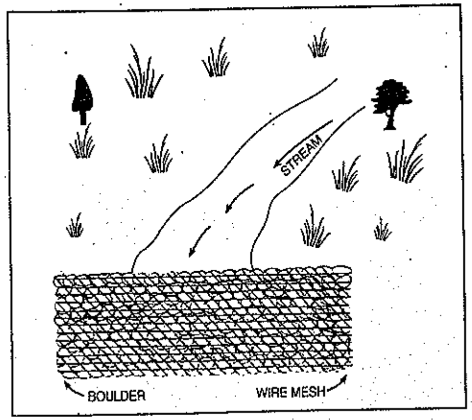

FIG. 15.11. Rain water harvesting through Gabion Structure

- The height of such structures is around 0.5 m and is normally used in the streams with width of less than 10 m.
- The excess water over flows this structure storing some water to serve as source of recharge. The silt content of stream water in due course is deposited in the interstices of the boulders in due course and with growth of vegetation, the bund becomes quite impermeable and helps in retaining surface water run off for sufficient time after rains to recharge the ground water body.

(iv) Rain Water Harvesting through Percolation Tank

- Percolation tank is an artificially created surface water body, submerging in its reservoir a highly permeable land so that surface runoff is made to percolate and recharge the ground water storage.
- Percolation tank should be constructed preferably on second to third order streams, located on highly fractured and weathered rocks which have lateral continuity down stream.
- The recharged area down stream should have sufficient number of wells and cultivable land to benefit from the augmented ground water.
- The size of percolation tank should be governed by percolation capacity of strata in the tank bed. Normally percolation tanks are designed for storage capacity of 0.1 to 0.5 MCM. It is necessary to design the tank to provide a ponded water column generally between 3 and 4.5 m.
- The percolation tanks are mostly earthen dams with masonry structure only for spillway. The purpose of the percolation tanks is to recharge the ground water storage and hence seepage below the seat of the bed is permissible. For dams upto 4.5 m height, cut off trenches are not necessary and keying and benching between the dam seat and the natural ground is sufficient.

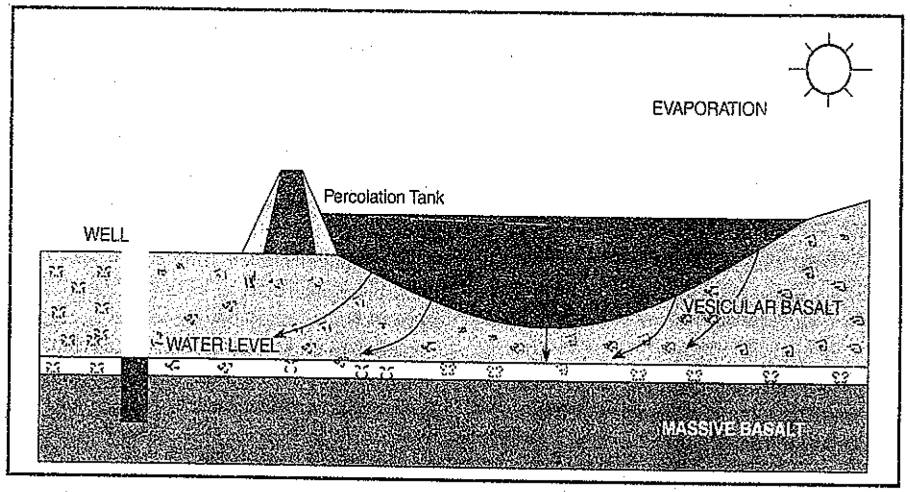

FIG. 15.12. Rain water harvesting through Percolation Tank

(v) Rain water Harvesting through Check Dams/Cement Plugs/Nala Bunds

- Check dams are constructed across small streams having gentle slope. The site selected should have sufficient thickness of permeable bed or wheathered formation to facilitate recharge of stored water within short span of time.

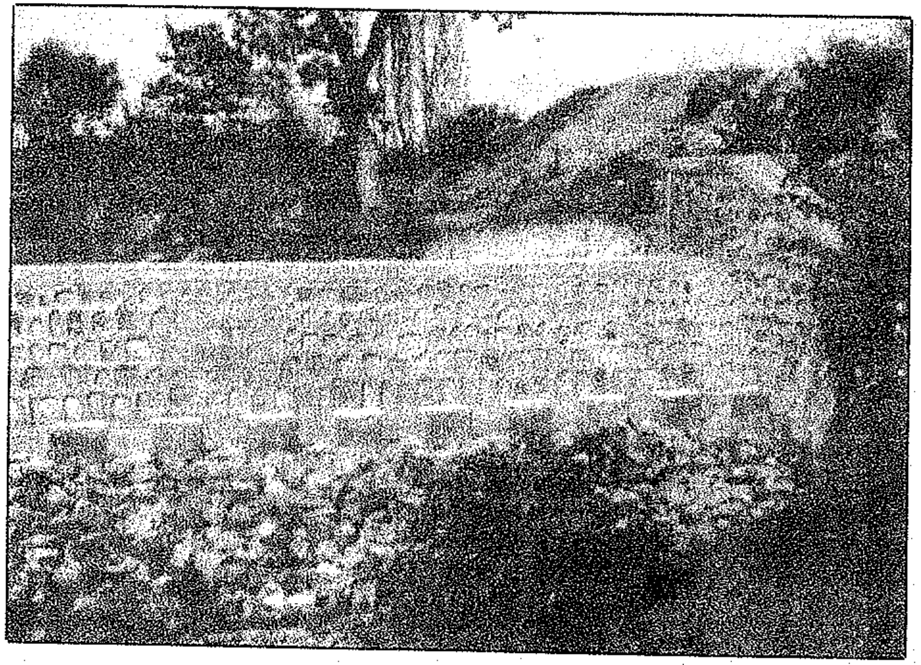

FIG. 15.13. Rain water harvesting through check dams/cement plugs/nala bunds

- The water stored in these structures is mostly confined to stream course and the height is normally less than 2 m and excess water is allowed to flow over the wall. In order to avoid scouring from excess run off, water cushions are provided at downstream side.
- To harness the maximum run off in the stream, series of such check dams can be constructed to have recharge on regional scale.
- Clay filled cement bags arranged as a wall are also being successfully used as a barrier across small nalas. At places, shallow trench is excavated across the nala and absestos sheets are put on two sides. The space between the rows of asbestos sheets across the nala is backfilled with clay. Thus a low cost check dam is created. On the upstream side clay filled cement bags can be stacked in a slope to provide stability to the structure.

(vi) Rain Water Harvesting through Recharge Shaft

- This is the most efficient and cost effective technique to recharge unconfined acquifer overlain by poorly permeable strata.
- Recharge shaft may be dug manually if the strata is of non-caving nature. The diameter of shaft is normally more than 2 m.
- The shaft should end in more permeable strata below the top impermeable strata. It may not touch water table.
- The unlined shaft should be backfilled, initially with boulders/cobbles followed by gravel and coarse sand.
- In case of lined shaft the recharge water may be fed through a smaller conductor pipe reaching up to the filter pack.
- These recharge structures are very useful for village ponds where shallow clay layer impedes the infiltration of water to the aquifer.
- It is seen that in rainy season village tanks are fully filled up but water from these tanks does not percolate down due to siltation and tubewells and dugwells located nearby remain dried up. The water from village tanks gets evaporated and is not available for beneficial use.
- By constructing recharge shaft in tanks, surplus water can be recharged to ground water. Recharge shafts of 0.5 to 3 m diameter and 10 to 15 m deep are constructed depending upon availability of quantum of water. The top of shaft is kept above the tank bed level preferably at half of full supply level. These are back filled with boulders, gravels and coarse sand.
- In upper portion of 1 or 2 m depth, the brick masonry work is carried out for the stability of the structure.
- Through this technique all the accumulated water in village tank above 50% full supply level would be recharged to ground water. Sufficient water will continue to remain in tank for domestic use after recharge.

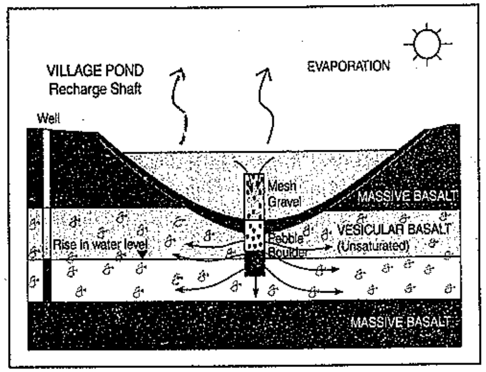

FIG. 15.14. Rain water harvesting through recharge shaft

(vii) Rain Water Harvesting through Dugwell Recharge

- Existing and abandoned dug wells may be utilized as recharge structure after cleaning and desilting the same.
- The recharge water is guided through a pipe from desilting chamber to the bottom of well or below the water level to avoid scouring of

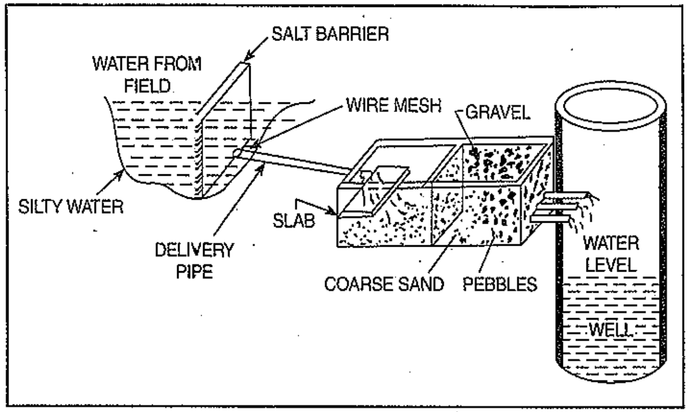

FIG. 15.15. Rain water harvesting through dugwell recharge

bottom and entrapment of air bubbles in the acquifer.

- Recharge water should be silt free and for removing the silt contents, the runoff water should pass either through a desilting chamber or filter chamber.
- Periodic chlorination should be done for controlling the bacteriological contaminations.

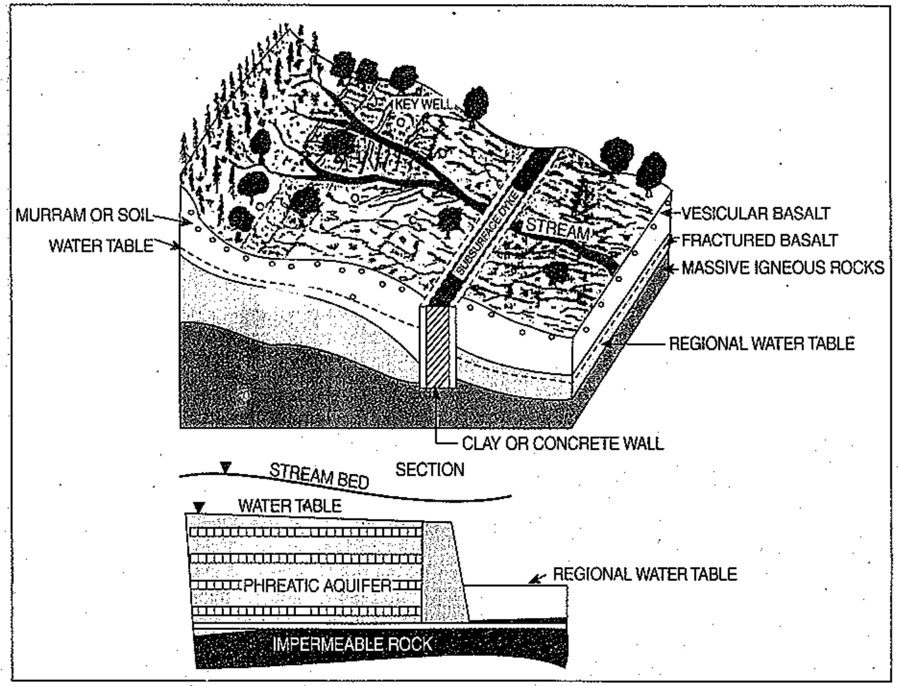

FIG. 15.16. Rain water harvesting through ground water dams or sub-surface dykes

(viii) Ground Water Dams or Sub-surface Dykes

- Sub surface dyke or under-ground dam is a subsurface barrier across stream which retards the base flow and stores water upstream below ground surface. By doing so, the water level in upstream part of ground water dam rises saturating otherwise dry part of aquifer.
- The site where sub-surface dyke is proposed should have shallow impervious layer with wide valley and narrow outlet.
- After selection of suitable site, a trench of 1-2 m wide is dug across the breadth of stream down to impermeable bed. The trench may be filled with clay or brick/concrete wall upto 0.5 m below the ground level.
- For ensuring total imperviousness, PVC sheets of 3,000 PSI tearing strength at 400 to 600 gauge or low density polythene film of 200 gauge can also be used to cover the cut out dyke faces.
- Since the water is stored within the aquifer, submergence of land can be avoided and land above the reservoir can be utilized even after the construction of the dam. No evaporation loss from the reservoir and no siltation in the reservoir takes place. The potential disaster like collapse of the dams can also be avoided.

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CHAPTER 16

Irrigation

Water is an important input for successful agriculture. Water may be available to crops in the natural course by rainfall or it may be supplied to the agricultural fields artificially by human efforts. *The process of supplying water to crops by artificial means such as canals, wells, tube-wells, tanks, etc. from the sources of water such as rivers, tanks, ponds or underground water is called irrigation.*

NEED FOR IRRIGATION

The geographical conditions, especially the nature of monsoon rainfall, in India make irrigation indispensable for sustainable agricultural development. Unfortunately, rainfall in India is **uncertain, unreliable, irregular, variable, seasonal and unevenly distributed.** The main rain bringing south-west monsoon often fails to keep its date. It may come either before or after the scheduled date of arrival. Normally speaking, the rainfall keeps its date of arrival and withdrawal only in one out of five years. The amount of rainfall may also vary greatly from the normal. Excess rainfall may cause floods but less rainfall forces the farmers to resort to irrigation. Ironically, the variability of rainfall is very high in areas of low rainfall. The north-western parts of the country, especially Punjab, Haryana, Rajasthan and western parts of Uttar Pradesh often suffer from high variability of rainfall. There are large variations in the spatial distribution of rainfall. On the one end of the scale, there are areas in Meghalaya which receive more than 1000 cm of annual rainfall while on the other end there are parts of the Thar Desert which receive less than 10 cm of rain in a year. Only 30.2 per cent of the cultivated area in India receives sufficient rainfall where the annual rainfall exceeds 100 cm. About 35.7 per cent of the cultivated area receives 75 to 100 cm of annual rainfall and 34.1 per cent of the cultivated area receives less than 75 cm of annual rainfall. Therefore, it is clear that about two thirds of the total cropped area needs irrigation facilities. Even in areas of high rainfall, irrigation is necessary to further increase farm productivity. Indian rainfall is characterised by *monsoon gaps*. Consequently it may not rain for two or more weeks during the rainy season and the crops may be badly damaged in the absence of irrigation facilities. The chief characteristic of the Indian monsoon is that it is seasonal. About 75 per cent of the rainfall in India is caused by the south-west monsoons which are active only for 3-4 months in a year. The remaining 8-9 months are marked by dry season when irrigation is badly needed for successful growing of the crops. The duration of dry season varies from 5 months in Kerala to over 9 months in the north-west India. Moreover, rainfall in most parts of India is torrential. As the popular saying goes, **it pours, it never rains in India.** This leaves little opportunity for soil to absorb water and much of the surface water goes waste. This loss of water by wasteful flow has to be compensated by irrigation.

Apart from the vagaries of monsoon rain as described above, there are certain crops such as rice, sugarcane, jute, cotton, chillies, etc. which require more water and have to be provided with irrigation even in areas of heavy rainfall. It is estimated that yields of irrigated crops are 50 to 100 per cent higher than that of the unirrigated crops under similar geographical conditions. With the introduction of high yielding varieties (HYV) of seeds and heavy doses of chemical fertilizers since the second half of 1960s, irrigation has become a very important ingradient of Indian agriculture. The ever increasing population leads to more intensive agriculture which needs more irrigation facilities, along with other inputs.

GEOGRAPHICAL FACTORS FAVOURING IRRIGATION

Certain geographical factors have helped in developing irrigation in different parts of India. The northern plain of India has extremely rich fertile soils deposited by the mighty rivers flowing from the Himalayan ranges. In fact, the Indo-Gangetic plain is considered to be one of the most fertile plains of the world. The slope of the land is so gentle that canals can carry the irrigation water to far off places. The soft and friable nature of the soil makes it easy to dig canals and to sink wells. The deep clay in the sub-soil acts as reservoir for rain water which percolates through the porous alluvium. There is thus, a large quantity of ground water which is taken out for irrigation through wells and tube wells. The area is blessed with a large number of perennial rivers which provide water for irrigation throughout the year. However, the rate of flow of water fluctuates with the change of season. In the Peninsular plateau area, the rocks are hard and the surface relief is uneven. Therefore, it is difficult to have canals and wells and tanks are used for irrigation.

Types of Irrigation Projects

Irrigation Projects in India are classified into three categories *viz.* Major, Medium and Minor Irrigation. Projects which have a Cultivable Command Area (CCA) of more than 10,000 hector are termed as ***Major Projects***, those Irrigation Projects which have a CCA of less than 10,000 hector but more than 2,000 hector are termed as ***Medium projects*** and those Irrigation Projects which have a CCA of 2,000 hector or less are known as ***Minor projects***.

TYPES OF IRRIGATION TECHNIQUES

Various types of irrigation techniques differ in how the water obtained from the source is distributed within the field. In general, the goal is to supply the entire field uniformly with water, so that each plant has the amount of water it needs, neither too much nor too little. The various irrigation techniques are as under :

Surface Irrigation. In surface irrigation systems, water moves over and across the land by simple gravity flow in order to wet it and to infiltrate into the soil. Surface irrigation can be subdivided into furrow, border strip or basin irrigation. It is often called flood irrigation when the irrigation results in flooding or near flooding of the cultivated land.

Localized Irrigation. Localized irrigation is a system where water is distributed under low pressure through a piped network, in a pre-determined pattern, and applied as a small discharge to each plant or adjacent to it. Drip irrigation, spray or micro-sprinkler irrigation and bubbler irrigation belong to this category of irrigation methods.

Drip Irrigation. Drip irrigation, also known as ***trickle irrigation***, functions as its name suggests. Water is delivered at or near the root zone of plants, drop by drop. This method can be the most water-efficient method of irrigation, if managed properly, since evaporation and runoff are minimized. In modern agriculture, drip irrigation is often combined with plastic mulch, further reducing evaporation, and is also the means of delivery of fertilizer.

Sprinkler Irrigation. In sprinkler or overhead irrigation, water is piped to one or more central locations within the field and distributed by overhead high-pressure sprinklers or guns. A system utilizing sprinklers, sprays, or guns mounted overhead on permanently installed risers is often referred to as a solid-set irrigation system. Higher pressure sprinklers that rotate are called rotors and are driven by a ball drive, gear drive, or impact mechanism. Guns are used not only for irrigation, but also for industrial applications such as dust suppression and logging. Sprinklers can also be mounted on moving platforms connected to the water source by a hose. Automatically moving wheeled systems known as traveling sprinklers may irrigate areas such as small farms, sports fields, parks, pastures, and cemeteries unattended.

Sub-irrigation. Sub-irrigation also sometimes called seepage irrigation has been used for many years in field crops in areas with high water tables. It is a method of artificially raising the water table to allow the soil to be moistened from below the plants root zone. Often those systems are located on permanent grasslands in lowlands or river valleys and combined with drainage infrastructure. A system of pumping stations, canals, weirs and gates allows it to increase or decrease the water level in a network of ditches and thereby control the water table. Sub-irrigation is also used in commercial greenhouse production, usually for potted plants. Water is delivered from below, absorbed upwards, and the excess collected for recycling.

GROWTH AND UTILIZATION OF IRRIGATION

Irrigation has been practised in India since ancient times. The Hindu monarchs, the Mughal emperors and the British rulers exhibited great engineering feats to develop irrigation at different times in the history of India. In the pre-Independence period, the undivided India had some of the best irrigation systems in the world. Much of the canal irrigated area of the Satluj and the Indus system went to Pakistan after partition.

Sustained and systematic programme for development of irrigation facilities was taken up with the advent of Planned Development in 1951. A broad-assessment of the area that can be ultimately brought under irrigation, both by surface and ground water, made by the various States in sixties has indicated that ultimate irrigation potential of the country would be of the order of 113 m.ha (million hectare). However, the ultimate potential is 139 m.ha, the increase being primarily due to upward revision in assessed potential of minor ground water schemes and minor surface water schemes. Minor irrigation projects have both surface and ground water as their source, while Major and Medium projects mostly exploit surface water resources.

SOURCES OF IRRIGATION

Different sources of irrigation are used depending upon the topography, soils, rainfall, availability of surface or ground water, nature of rivers (whether perennial or non-perennial), requirements of crops, etc. The main sources of irrigation used in different parts of the country are (*i*) Canals; (*ii*) Wells and tube wells (*iii*) Tanks and (*iv*) Others (Dongs, Kuhls, springs, etc.)

Highlights of area under irrigation in India by sources

- Net area under irrigation by all sources of irrigation increased from 55.23 million hectares in 2000-01 to 63.25 million hectares in 2009-10, indicating 15% increase over the period.
- Net area under irrigation by Government canals increased from 15.81 million hectares in 2000-01 to 16.51 million hectares in 2009-10.
- Net area under irrigation by tube wells and other wells enhanced from 33.83 million hectares in 2000-01 to 39.04 million hectares in 2009-10.
- Net area under irrigation by tanks declined from 2.46 million hectares in 2000-01 to 1.64 million hectares in 2009-10.
- Net area under irrigation by other sources enhanced from 2.91 million hectares in 2000-01 to 5.88 million hectares in 2009-10.
- The total gross irrigated area enhanced from 76.19 million hectares in 2000-01 to 79.95 million hectares in 2009-10.
- The gross irrigated area under food grains increased from 53.61 million hectares in 2000-01 to 58.64 million hectares in 2009-10, the increase is due to increase of 4 million hectares in gross irrigated area under wheat during the period.

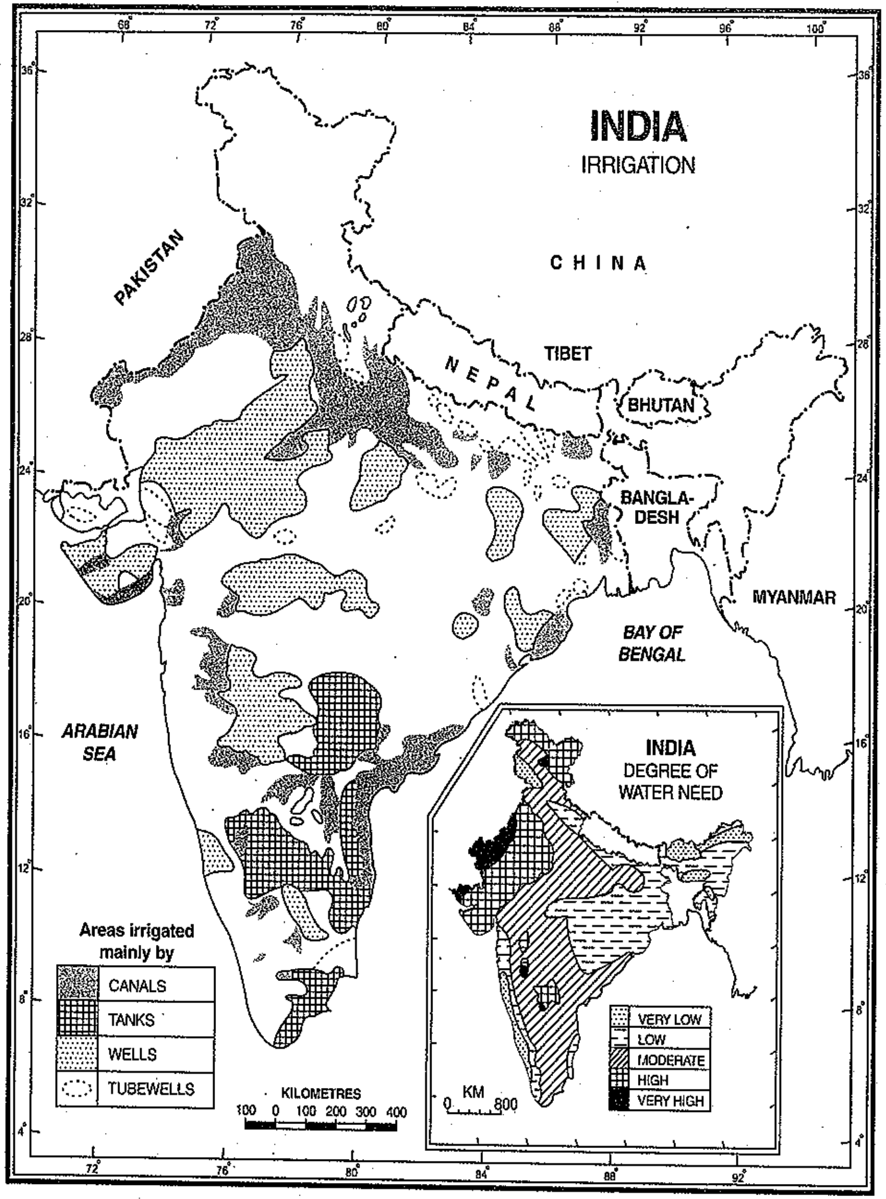

FIG. 16.1. India : Irrigation

TANK IRRIGATION

A tank consists of water storage which has been developed by constructing a small bund of earth or stones built across a stream. The water impounded by the bund is used for irrigation and for other purposes. Some tanks are built partly as dugouts and partly by enclosing bunds. Tanks are of varying size but most of the tanks are of small size and are built by individual farmers or groups of farmers. There are

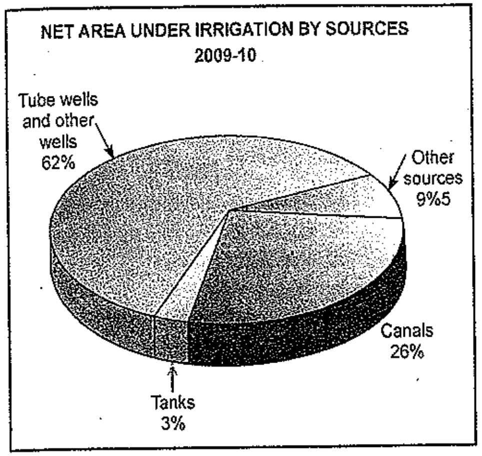

FIG. 16.2. Net areas irrigated in India by source
(Based on Statistical Year Book India, 2013, p. 12.3.

about 5 lakh big and 50 lakh small tanks irrigating nearly 1.64 million hectares of agricultural land. The ratio of tank irrigated land to the total irrigated area of the country has reduced from 14 per cent in the 1960-61 to about 3.0 per cent in 2009-10, primarily due to increase in well and tubewell irrigation and partly due to fall in the tank irrigation.

Tank irrigation is popular in the peninsular plateau area where Andhra Pradesh, Telangana and Tamil Nadu are the leading states. Andhra Pradesh and Telangana have 727 thousand hectares irrigated by tanks. These two states have about 28.8 per cent of tank irrigated area of India. About 16 per cent of the total irrigated area of the state is irrigated by tanks. The drainage areas of the Godavari and its tributaries have large number of tanks. Nellore and Warangal are the main districts of tank irrigation. Tamil Nadu has an area of 589 thousand hectares under tank irrigation. This is over 23 per cent of tank irrigated area of India and about one-fifth of the total irrigated area of the state. There are about 24,000 tanks in Tamil Nadu. Tanks comprise an important source of irrigation in the Karnataka Plateau, eastern Madhya Pradesh, Chhattisgarh, eastern Maharashtra, interior Odisha and Kerala. Outside the Peninsular plateau, West Bengal, Bihar, Bundelkhand area of Uttar Pradesh, Rajasthan and Gujarat have tank irrigation (Fig. 16.3). The tank irrigation is practised mainly in peninsular India due to the following reasons.

1. The undulating relief and hard rocks make it difficult to dig canals and wells.
2. There is little percolation of rain water due to hard rock structure and ground water is not available in large quantity.
3. Most of the rivers of this region are seasonal and dry up in summer season. Therefore, they cannot supply water to canals throughout the year.
4. There are several streams which become torrential during rainy season. The only way to make best use of this water is to impound it by constructing bunds and building tanks. Otherwise this water would go waste to the sea.
5. The scattered nature of population and agricultural fields also favours tank irrigation.

Merits of Tank Irrigation

Most of the tanks are natural and do not involve heavy cost for their construction. Even an individual farmer can have his own tank. Tanks are generally constructed on rocky bed and have longer life span. In many tanks, fishing is also carried on. This supplements both the food resources and income of the farmer.

Demerits of Tank Irrigation

Many tanks dry up during the dry season and fail to provide irrigation when it is needed the most. Silting of the tank bed is a serious problem and it requires desilting of the tank at regular intervals. Much water is evaporated from the large expanse of shallow water and is thus not available for irrigation. Tanks cover large areas of cultivable land. In many areas, other sources of irrigation have been adopted and the dry beds of tanks have been reclaimed for agriculture. Moreover, lifting of water from tanks and carrying it to the fields is a strenuous and costly exercise which discourages the use of tanks as a source of irrigation.

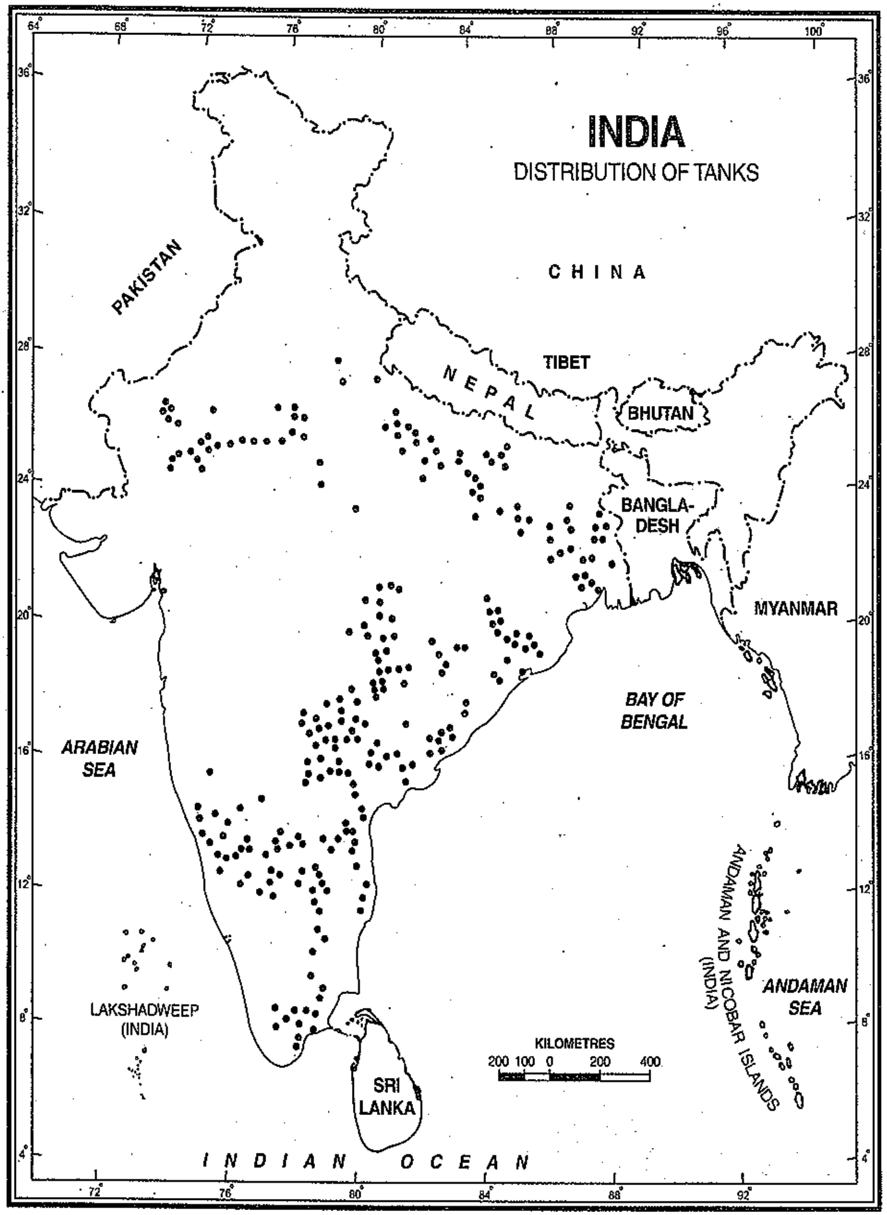

FIG. 16.3. India : Distribution of Tanks

WELLS AND TUBEWELLS

A well is a hole dug in the ground to obtain the subsoil water. An ordinary well is about 3-5 metres deep but deeper wells upto 15 metres and even more are also dug. This method of irrigation has been used in India from time immemorial. Various methods are used to lift the ground water from the well for irrigation, drinking, bathing and for other purposes.

Some of the widely used methods are the *persian wheel*, *reht*, *charas* or *mot*, and *dhinghly* (lever). Well irrigation is popular in areas where sufficient sweet ground water is available. These areas include a large part of the Great Northern Plain, the deltaic regions of the Mahanadi, the Godavari, the Krishna and the Cauvery, parts of the Narmada and the Tapi valleys and the weathered layers of the Deccan Trap and crystalline rocks and the sedimentary zones of the Peninsula. However, the greater part of the Penisnular India is not suitable for well irrigation due to rocky structure, uneven surface and lack of underground water. Large dry tracts of Rajasthan, the adjoining parts of Punjab, Haryana, and Gujarat and some parts of Uttar Pradesh have brackish ground water which is not fit for irrigation and human consumption and hence unsuitable for well irrigation.

There were about 5 million wells in 1950-51 and their number has now increased to about 12 million. Well irrigation accounts for about 62 per cent of the net irrigated area in the country against 26 per cent of canal and only 3 per cent of tank irrigation. It accounted 59.78 lakh hectares in 1950-51 which rose to about 390.4 lakh hectares in 2009-10 thereby registering more than six fold increase in well irrigation. Uttar Pradesh has the largest area lakh hectares under well irrigation and accounts for about 28.19 per cent of the well irrigated area of India. This is followed by Rajasthan (10.44%), Punjab (8.65%), Madhya Pradesh (7.97%), Gujarat (7.34%) Bihar (6.29%), Andhra Pradesh (5.87%), Maharashtra (5.75%), Haryana (4.41%), Tamil Nadu (4.35%), West Bengal (4.19%) and Karnataka (3.06%). In Gujarat, about 82.31 per cent of the net irrigated area is under well irrigation. The other states where well irrigation plays a significant role are Punjab (79.96%), Uttar Pradesh (73.22%), Rajasthan (70.78%), Maharashtra (64.62%), Madhya Pradesh (64.11%) and West Bengal (59.35%) (see Table 16.3). Uttar Pradesh, Rajasthan, Punjab, Madhya Pradesh, Gujarat, Bihar and Andhra Pradesh account for three-fourths of the total well irrigated area of India.

A *tubewell* is a deeper well (generally over 15 metres deep) from which water is lifted with the help of a pumping set operated by an electric motor or a diesel engine. Obviously, a tube well cannot be constructed everywhere and requires some geographical conditions favouring its installation. The main factors are :

(*i*) There should be sufficient quantity of ground water because a tube well can generally irrigate 2 hectares per day against 0.2 hectares per day irrigated by an ordinary well.

(*ii*) The water level should be nearly 15 metres. If the water table is more than 50 metres deep the cost of pumping out water from the tube well becomes uneconomic.

(*iii*) There should be regular supply of cheap electricity or diesel so that water from the tube well can be taken out at the hour of need.

(*iv*) The soil in the immediate neighbourhood of the tube-well should be fertile so that there is demand for irrigation and the cost involved in the construction and operation of the tube well can be recovered by the increased farm production.

The first tubewell of India was sunk in Uttar Pradesh in 1930. Till 1951 India had just 2,500 tube-wells. The central and the state governments are helping the farmers by distributing pumping sets, granting loans and giving subsidies. The number of electrical pumpsets/tubewells increased from 2 lakh in 1960 to over 4.5 million in 2009-10 while the dieselized pumpsets increased from 2.3 lakh to about 3.5 million during the same period. In several areas, the '*persian wheel*' earlier used for lifting water has been replaced by tubewells.

Merits of Well and Tubewell Irrigation

1. Well is the simplest and cheapest source of irrigation and the poor Indian farmer can easily afford it.

2. Well is an independent source of irrigation and can be used as and when the necessity arises. Canal irrigation, on the other hand, is controlled by other agencies and cannot be used at will.

3. Excessive irrigation by canal leads to the problem of *reh* which is not the case with well irrigation.

4. There is a limit to the extent of canal irrigation

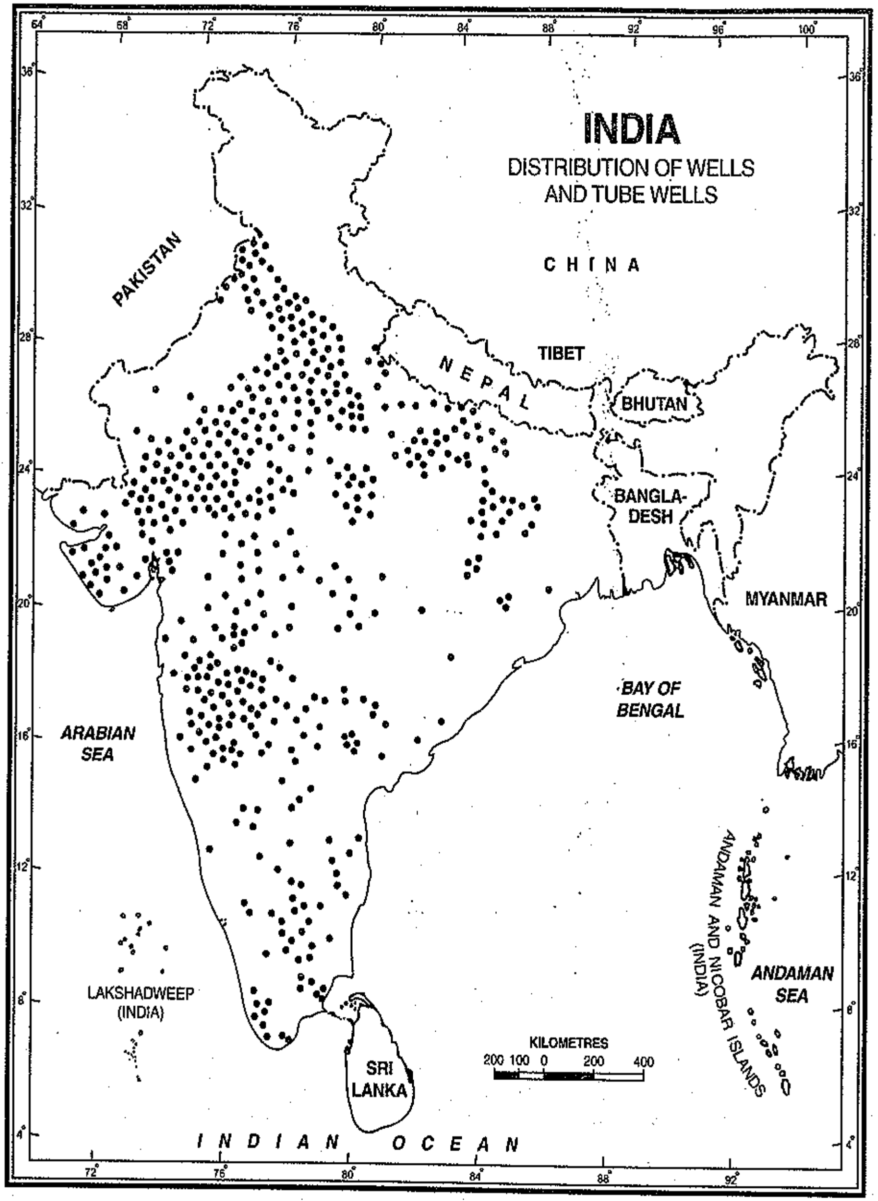

FIG. 16.4. India : Distribution of Wells and Tubewells

beyond the tail end of the canal while a well can be dug at any convenient place.

5. Several chemicals such as nitrate, chloride, sulphate, etc. are generally found mixed in well water. They add to the fertility of soil when they reach the agricultural field along with well water.

6. The farmer has to pay regularly for canal irrigation which is not the case with well irrigation.

Demerits of Well and Tubewell Irrigation

1. Only limited area can be irrigated. Normally, a well can irrigate 1 to 8 hectares of land.

2. The well may dry up and may be rendered useless for irrigation if excessive water is taken out of it.

3. In the event of a drought, the ground water level falls and enough water is not available in the well when it is needed the most.

4. Tubewells can draw a lot of groundwater from its neighbouring areas and make the ground dry and unfit for agriculture.

5. Well and tube well irrigation is not possible in areas of brackish groundwater.

CANALS

Canals used to be the most important source of irrigation upto 1960s, but in the 1970s they yielded first place to wells and tube wells and now constitute the second most important source of irrigation in India. The percentage of canal irrigation area to total irrigated area in the country has fallen from about 39.77 per cent in 1950-51 to 26 per cent in 2009-10.

Canals can be an effective source of irrigation in areas of low level relief, deep fertile soils, perennial source of water and extensive command area. Therefore, the main concentration of canal irrigation is in the northern plain of India, especially the areas comprising Uttar Pradesh, Haryana and Punjab. The digging of canals in rocky and uneven areas is difficult and uneconomic. Thus the canals are practically absent from the Peninsular plateau area. However, the coastal and the delta regions in South India do have some canals for irrigation.

Broadly speaking, canals in India are of two types, *viz*. (*i*) *Inundation canals*, which are taken out from the rivers without any regulating system like weirs etc. at their head. Such canals provide irrigation mainly in the rainy season when the river is in flood and there is excess water. When the rainy season is over, the flood in the river subsides, the level of water falls below the level of the canal head and the canal dries up. Some canals taken off from the Satluj in Punjab were of this type. Since irrigation from this type of canals is uncertain, they have been converted in perennial canals. (*ii*) *Perennial canals* are those which are taken off from perennial rivers by constructing a barrage across the river. Most of the canals in India today are perennial.

The net area under government canal irrigation is about 16.52 million hectares. The main canal irrigated areas are in the northern plains of India where Uttar Pradesh, Punjab, Haryana, Rajasthan and Bihar account for about 60 per cent of the canal irrigated area of the country. In south and central India, Andhra Pradesh, Maharashtra, Karnataka, Madhya Pradesh, Chhattisgarh, Odisha and Tamil Nadu are important states of canal irrigation.

Uttar Pradesh

Canals constitute an important source of irrigation in Uttar Pradesh. The state is drained by perennial rivers originating in the snow covered Himalayan ranges and is blessed with fertile soils. But the amount of rainfall, especially in western parts of the state, is not sufficient for sustained agricultural growth. Therefore, a large number of canals have been constructed to provide regular supply of sufficient water to the crops. Uttar Pradesh has about one-third of the total canal irrigated area of the country. Over one-fourth of the net irrigated area of the state is irrigated by canals. Following are the main canals.

1. Upper Ganga Canal. This canal takes off from the Ganga at Kankhal (Hardwar). The construction of this canal commenced in 1842 and it was completed in 1854. The main canal is 342 km long while the length of its distributaries is about 6,200 km. During the first 32 km of its course, between Haridwar and Roorkee, it passes through a broken country so that at some places it is taken over the rivers and at others below the rivers. It irrigates about 7 lakh hectares of land in the upper part of the Ganga-Yamuna Doab. Districts of Saharanpur, Meerut, Ghaziabad, Bulandshahar, Aligarh, Mathura, Etah, Kanpur, Mainpuri, Farrukhabad and Fatehpur get benefit from this canal. Its main branches are Devbandh, Anupshahar, Motta and Hathras. It joins with the Lower Ganga Canal at Mainpuri and the water in this canal is considerably increased. Further beyond, these two canals flow separately.

2. Lower Ganga Canal. This canal was taken from the Ganga near Narora (Bulandshahar) in 1878. The length of the canal including its distributaries is

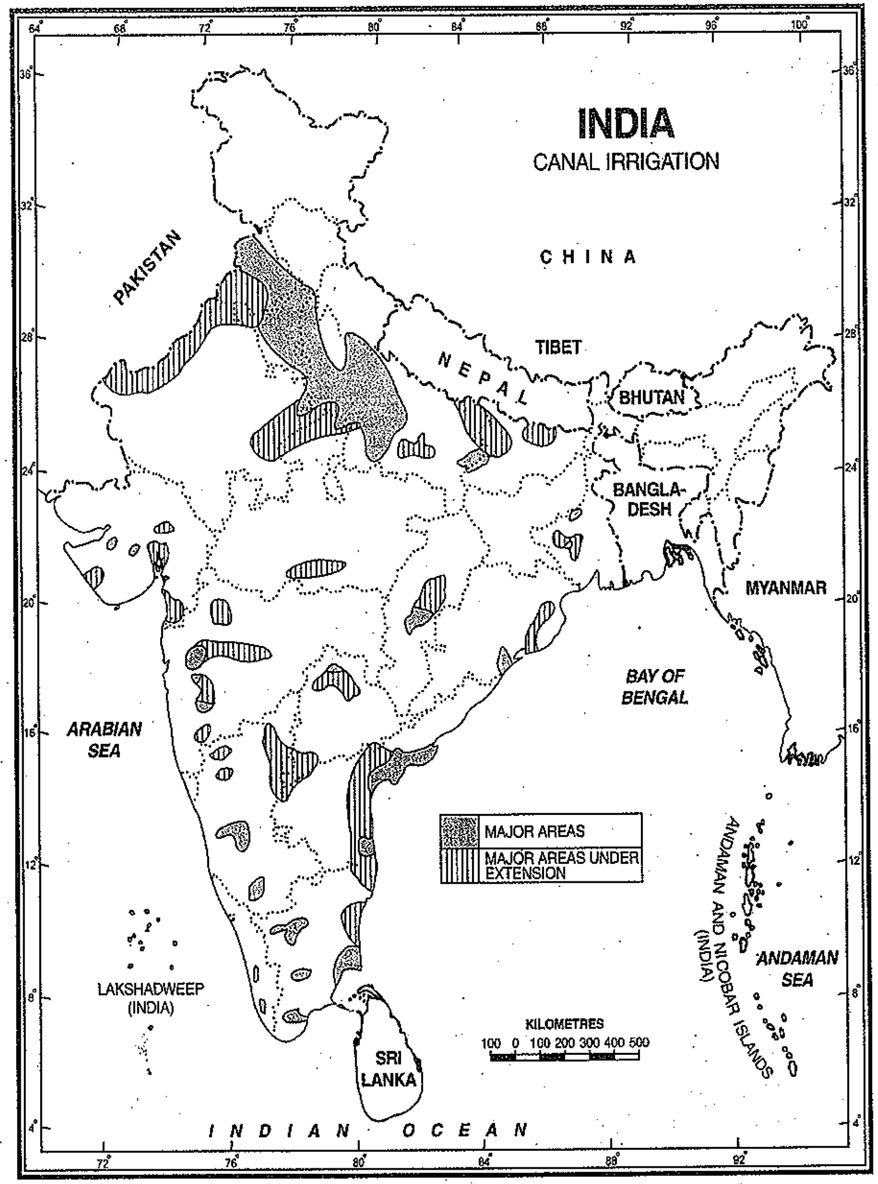

FIG. 16.5. India : Canal Irrigation

about 6000 km. Its main branches are Etawah, Kanpur and Fatehpur. It irrigates about 4.6 lakh hectares in the districts of Bulandshahar, Farrukhabad, Mainpuri, Aligarh, Etah, Etawah, Fatehpur, Kanpur and Allahabad.

3. Sharda Canal. As its name indicates, this canal is taken from the Sharda river at Banbasa near the Indo-Nepal border. The construction work on this canal was completed in 1928. The total length of the main canal and its distributaries is 13,624 km. It is

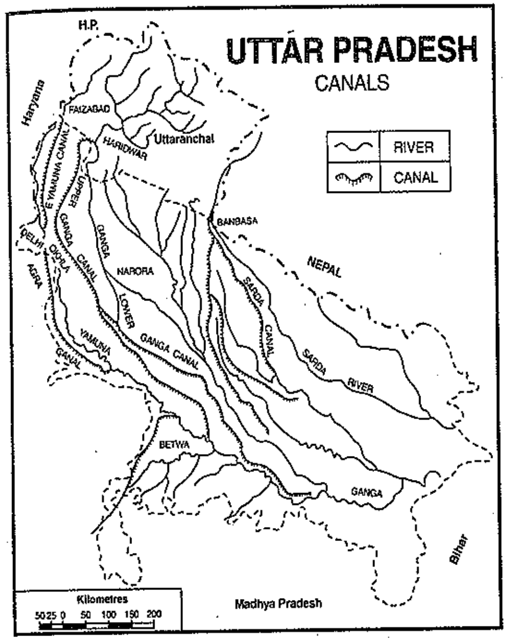

FIG. 16.6. Canals of Uttar Pradesh

thus one of the longest canal systems of the world. This canal system irrigates about eight lakh hectares of land mainly in Allahabad, Sultanpur, Pilibhit, Bareilly, Hardoi, Shahjahanpur, Sitapur, Lucknow, Barabanki, Rai Bareli, Unnao, Partapgarh and Kheri districts.

4. Eastern Yamuna Canal. It takes off from the river Yamuna at Faizabad. It was constructed in 1831. The main canal and its distributaries cover a distance of 1,450 km and irrigate about 2 lakh hectares of land in the districts of Saharanpur, Muzaffarnagar, Meerut and Ghaziabad. It again joins the Yamuna river at Delhi and irrigates a part of the union territory also.

5. Agra Canal. This canal is taken from the right bank of the Yamuna at Okhla (Delhi). It was built in 1874 and irrigates about 1.5 lakh hectares in Agra and Mathura in U.P., Faridabad and Palwal in Haryana, Bharatpur in Rajasthan and also parts of union territory of Delhi.

6. Betwa Canal. Built in the Third Five Year Plan, this canal takes off from the Betwa river about 56 km south-west of Jhansi. It irrigates about 1.2 lakh hectares in Jhansi, Jalaun and Hamirpur districts.

Apart from the above mentioned major canals, some other canals such as Ken, Chambal, Dhasan and Son canal also irrigate some areas in the southern part of Uttar Pradesh.

Punjab

In early days, canal irrigation accounted for about 39.14 per cent of the total irrigated area in Punjab but the share of canal irrigation fell down to less than 19 per cent in 2009-10. Following are some of the important canals of Punjab.

1. Upper Bari Doab Canal. This canal is taken from the Ravi river at Madhopur near Pathankot. Construction of this canal started in 1849 and completed in 1859. It irrigates about 3 lakh hectares in Gurdaspur and Amritsar districts.

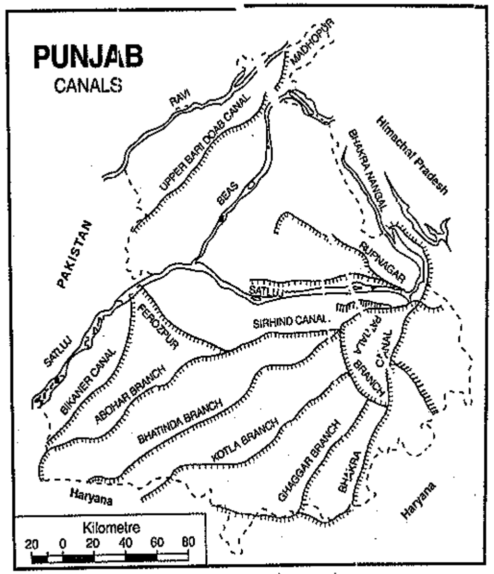

FIG. 16.7. Punjab : Canals

2. Sirhind Canal. This canal was taken from the Satluj river at Rupnagar (Ropar) in the year 1886-87. The total length of the canal along with its distributaries is 6,115 km. Its main branches are the Patiala, Abohar, Bhatinda, Kotla and Ghaggar. It irrigates about 7 lakh hectares in Patiala, Sangrur, Bhatinda, Ludhiana and Ferozepur districts. The Kotla and the Ghaggar branches provide irrigation to Hissar, Sirsa and Fatehabad districts of Haryana also.

In order to augment the supply of water, the *Sirhind Feeder Canal* was completed in 1960. It takes off from the Ferozepur Feeder at its 18th km at Malanwala. It is 142 km long and supplies water to Abohar branch of the Sirhind Canal. This water is drawn from the Satluj and Beas rivers which used to go unused to Pakistan. It also provides irrigation to Ferozepur, Faridkot and Muktsar districts in Punjab and to some parts of Rajasthan.

3. Bhakra Canal. It draws water from the Bhakra dam built across the Satluj river. It was completed in 1954. It irrigates a vast area of about 15 lakh hectares in Punjab, Haryana and Rajasthan. In Punjab, Ludhiana, Patiala, Sangrur, Jalandhar, and Ferozepur districts are benefited by this canal.

4. Bist Doab Canal. It is a part of the Bhakra-Nangal Project. The total length of this canal along with its distributaries is 1,090 km. It irrigates about 4 lakh hectares in Jalandhar and Hoshiarpur districts.

Bikaner and Beas are other projects which provide irrigation to parts of Punjab and the neighbouring states of Haryana and Rajasthan.

Haryana

Haryana depends upon canal irrigation for its agricultural prosperity to a great extent. About 49.89 per cent of the irrigated area in Haryana is irrigated by canals. Following are the main canals.

1. The Western Yamuna Canal. It takes off from the right bank of the Yamuna at Tajewala. It was built by Feroze Shah Tughlak. The total length of the canal along with its distributaries is 3,200 km and it irrigates about 4 lakh hectares in Ambala, Kurukshetra, Karnal, Panipat, Rohtak, Hissar, Sirsa, Fatehabad and Jind districts. Its important branches are, the Delhi, the Hansi and the Sirsa branch.

2. Bhakra Canal. After irrigating Punjab areas, the Bhakra canal enters Haryana near Tohana and irrigates large parts of Hisar, Fatehabad and Sirsa districts. Its main branches are the Fatehabad, the Ratia, the Rori, the Barwala and the Tohana branch.

3. Jui Canal. This is a lift irrigation scheme designed to irrigate the semi-desert region of Bhiwani and adjoining areas. This 169 km long canal irrigates about 32 thousand hectares.

4. Gurgaon Canal. It takes off from the Yamuna at Okhla in Delhi. Started in 1970, this canal irrigates 1.2 lakh hectares in Gurgaon and Faridabad districts.

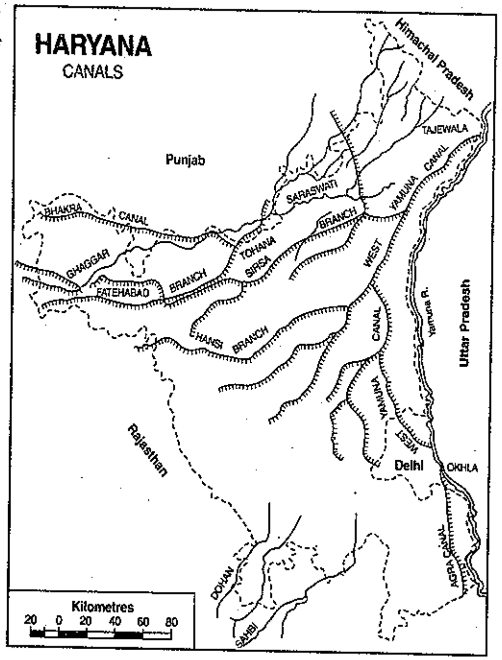

FIG. 16.8. Haryana : Canals

Andhra Pradesh

With 10.31% of the total canal irrigated area of India, Andhra Pradesh is next only to Uttar Pradesh and tops in South India in so far as area under canal irrigation is concerned. Canal irrigation accounts for about 36.42 per cent of the net irrigated area of the state. The major canals of Andhra Pradesh are taken off from the Krishna, the Godavari and the Tungabhadra rivers and the major canal irrigated areas are in the deltas and the coastal regions.

The Godavari delta project comprises of two weirs — the Dowlaiswaram and the Ralli, which were completed in 1846. From these, right bank canal and the delta canal have been taken to irrigate about 4.5 lakh hectares. The *Krishna delta project* comprise Vijayawada anicut. Sunkesula anicut across the Krishna and the Tungabhadra irrigates about 4.5 lakh hectares. The *Kurnool-Cuddapah* canal was taken off from the Tungabhadra in 1816. It irrigates about 1.2 lakh hectares in Kurnool and Cuddappah districts.

The *Nagarjunasagar Project* consists of a dam across the Krishna River in Nalgonda district from where two canals have been taken off. The right bank canal is 204 km long and irrigates 6.7 lakh hectares in Guntur, Nalgonda (in Telangana), Kurnool and Krishna districts. The left bank canal is 171 km long and irrigates 3.56 lakh hectares in Khammam (in Telangana), Krishna and West Godavari districts.

Bihar

Rainfall in several parts of Bihar is inadequate, unreliable and uncertain leading to severe and frequent droughts. This has made canal irrigation an important part of agricultural practice in Bihar. Canal irrigation accounts for over 31 per cent of the total area of the state.

1. Sone Canals. The Eastern Sone Canal was taken from the Sone river at Varun in 1857. This 130 km long canal irrigates 2.5 lakh hectares in Patna and Gaya districts. The Western Sone Canal has been taken from this river at Dehri. It provides irrigation to Shahabad district.

2. Kosi Canals. Two canals known as the Eastern and the Western Kosi Canal have been taken from the eastern and the western banks of the river respectively by constructing a multipurpose dam near the Indo-Nepal border. These two canals have the irrigation potential of 4.5 and 3.5 lakh hectares respectively. Purnea, Muzaffarpur, Darbhanga, Champaran and Saran districts are benefited by this project. Besides, 4 lakh hectares are irrigated in Nepal.

3. Gandak Canals. A 743 metre long dam has been built across the Gandak at Balmiki Nagar from where two canals have been taken off. The eastern canal is called Tirhut. It is 250 km long and irrigates about 7 lakh hectares in Champaran, Darbhanga, and Muzaffarpur districts. The western canal is known as Saran Canal and irrigates 7.6 lakh hectares of Saran district of Bihar and Deoria and Gorakhpur districts of Uttar Pradesh. Another *Triveni Canal* has been taken from Triveni to irrigate about one lakh hectares of Champaran district.

West Bengal

Although most parts of West Bengal receive sufficient rainfall and do not require irrigation, still some parts of the state do feel the necessity of irrigation. More than one third of the net irrigated area is irrigated by canals. The *Mayurakshi* project was completed in 1951 at Tilpara. Two canals have been taken from this project to irrigate large areas in Bir Bhum, Murshidabad and Bardhaman districts. The main canal from the Kaugsabati completed in 1965 irrigates 1.2 lakh hectares in Bankura and Medinipur districts. The canals from the Damodar river built by Damdar Valley Corporation irrigate over five lakh hectares in West Bengal. The 520 km long *Medinipur Canal* has been taken off from the *Kosi* at Medinipur and irrigates about ten thousand hectares.

Rajasthan

Most of Rajasthan is a desert area and largely depends upon irrigation for successful growth of crops. Canals form an important source of irrigation and account for about 27.6 per cent of the net irrigated area of the state.

1. Indira Gandhi Canal. (See Chapter 14).

2. Chambal Project. This is a joint venture of Rajasthan and Madhya Pradesh. Under this project, *Gandhi Sagar Dam* has been constructed. Canals taken off from this dam irrigate about 5.15 lakh hectares in Rajasthan and Madhya Pradesh. In the second stage, *Rana Partap Dam* has been constructed which provides irrigation to 1.2 lakh hectares. In the third stage *Jawahar Sagar Dam* has been constructed.

3. The Gang or Bikaner Canal. It was taken off from the river Satluj at Husainwala in 1928. This canal is *a blood transfusion from the living Punjab into the moribund marusthal*. It provides irrigation to about 3.4 lakh hectares in Bikaner division. The total length of this canal system is 1,280 km.

The other canal irrigation projects of Rajasthan include Jawai project on the Jawai river, Parbati project near Dhaulpur, Gudha project in Bundi District, Ghaggar canal, Pichuna Canal, Banas Canal, Bharatpur Canal and Urmila Canal. The Bhakra Canal also irrigates about 2.3 lakh hectares in Rajasthan.

Madhya Pradesh

The unevern surface, rocky structure and limited fertile soil have not encouraged the construction of canals and canals irrigation is not much important keeping in view the size of this state. However, a few canal systems have come up. Consequently 19.49 per cent of the net irrigated area is irrigated by canals in Madhya Pradesh is under canal irrigation. Most of the canal irrigated area is in Gwalior, Bhind and Morena districts. The *Chambal project* provides irrigation to about 2.83 lakh hectares in these districts. The *Weinganga* canal takes off from the Weinganga river and irrigates 4,000 hectares of land in Balaghat and Seoni districts. Besides it provides irrigation to Bhandara district of Maharashtra. The *Barna* project involves the construction of a barrage across the Barna river (a tributary of the Narmada). The canal taken out from this barrage irrigates about 64,400 hectares of land in Raisen district. The *Tawa* project canals originate from the barrage constructed across the Tawa river, and irrigate about 3 lakh hectares of land in Hoshangabad district.

Chhattisgarh

The geographical conditions of Chhattisgarh are more or less similar to those prevailing in Madhya Pradesh which are not favourable for canal irrigation. Even then this state has some areas under canal irrigation. The *Mahanadi canal* takes off from Mahanadi river at Rudri in Raipur district. A subsidiary reservoir has been built at Maramsilli. The length of the main canal and distributaries is 215 km and 1,175 km respectively. It irrigates about 3 lakh hectares. The *Tandula canal* takes off from the confluence of the Tandula and Sukha rivers by building two separate earthen dams. It irrigates about 1.1 lakh hectares in Raipur and Durg districts.

Odisha

Canals irrigate about 878 thousand hectares of land which is nearly 25% of the net irrigated area of the state. Canals taken off from the *Hirakud dam* on the *Mahanadi*, form a major irrigation network and provide irrigation to about 2.4 lakh hectares in Bolangir and Sambalpur districts. The 3,650 km long canal system in the Mahanadi delta region provides irrigation to about 4 lakh hectares in Cuttack and Puri districts. Taldanda Canal irrigates 62 thousand hectares in Mahanadi catchment area.

Karnataka

Over 36.5 per cent of the net irrigated area in Karnataka is irrigated by canals. The *Ghatprabha* valley scheme developed on the Ghatprabha river is the most important irrigation project and irrigates about 3.2 lakh hectares in Belgaum and Bijapur districts. Canals of the *Tungbhadra project* irrigate about 2.7 lakh hectares in Bellary and Raichur districts. The canals of *Malprabha* project irrigate about one lakh hectares in Belgaum, Dharwar and Bijapur districts and those of *Bhadra Project* also irrigate one lakh hectares in Shimoga district. The *Visveswaraya Canal* taken off from the *Krishnaraja Sagar Dam* on the Cauvery irrigates about 50 thousand hectares in Mysore and Mandya districts.

Tamil Nadu

Tamil Nadu has about 29 per cent of its net irrigated area under canal irrigation. The most important canal system lies in the Cauvery delta where 6,400 km long canals irrigate about 4 lakh hectares in Thanjavur and Tiruchchirapalli districts. The *Mettur Canal system* of the Mettur dam on the Cauvery river irrigates about 1.2 lakh hectares in Salem and Tiruchchirapalli districts. The *Lower Bhawani Project* canal system irrigates about 79 thousand hectares in Coimbatore district. *Parambikulam Aliyar and Manimuthar* are other projects.

Maharashtra

Over 35 per cent of the net irrigated area in Maharashtra is irrigated by canals. Over 3,000 km long canals irrigate over 4 lakh hectares. The right bank and the left bank canals of the *Mutha Project* across Mutha river (a tributary of the Bhima river) at Khadakvasla irrigate about 45 thousand hectares in Pune district besides providing potable water to Pune and Kirkee. The canals of the Nira project irrigate over 66 thousand hectares in Pune, Satara and Solapur districts. Two canals taken out of the Godavari at *Darana dam* irrigate about 27 thousand hectares in Nashik and Ahmednagar districts. Canals taken out from *Gangapur dam* at Godavari irrigate 33 thousand hectares in Nashik district. The *Pravara* canals take

off from *Bhandardara masonary* dam at Pravara river. Both the left bank and the right bank canals irrigate about 34 thousand hectares in Ahmednagar. The Tapi canal system is a joint venture of Maharashtra and Gujarat and irrigates about 3 lakh hectares. The other irrigation canals are those of Mula, Vir, Purna, Girna, Jayakawadi, Warna, etc. Some other projects are at different stages of their completion.

Gujarat

Mahi project stage I and II is designed to irrigate over 2 lakh hectares in Kheda and Panchmahals districts. Canals of *Ukai* project on the *Tapi* river irrigate over one lakh hectares. The other important irrigation projects of Gujarat are *Rudramala*, *Ozat*, *Dantiwada*, *Panam* and *Kaprapara*.

Merits of Canal Irrigation

1. Most of the canals provide perennial irrigation. This saves the crops from drought conditions and helps in increasing the farm production.

2. Canals carry a lot of sediment brought down by the rivers. This sediment is deposited in the agricultural fields which adds to the fertility of soil.

3. Some of the canals are parts of multipurpose projects and, therefore, provide cheap source of irrigation.

4. Although the initial cost involved in canal irrigation is much higher, it is quite cheap in the long run.

Demerits of Canal Irrigation

1. The canal water soaks into the ground and leads to the problem of *water-logging* along the canal route.

2. Excessive flow of water in the fields raises the ground water level. Capillary action brings alkaline salts to the surface and makes large areas unfit for agriculture. Vast areas in Punjab, Haryana and Uttar Pradesh suffer from the problem of '*reh*' caused by canal irrigation. Similarly about 36,000 hectares have been rendered useless in Nira Valley of Maharasthra due to high concentration of salts in the soil resulting from canal irrigation.

3. The marshy areas near the canals act as breeding grounds of mosquitoes which result in widespread malaria.

4. Many canals overflow during rainy season and flood the surrounding areas.

5. Canal irrigation is suitable in plain areas only.

INTENSITY OF IRRIGATION

Intensity of irrigation is defined as *the percentage of net irrigated area to the net sown area*. Map in Fig. 16.9 shows that the regional variations in the intensity of irrigation are great and at once impressive. These variations are due to varied geographical conditions in different parts of the country. Rugged mountains, sandy deserts and rocky terrains without aquifers have very poor facilities of irrigation. On the other hand, fertile alluvial plains with perennial rivers and potable groundwater as well as areas of less than 125 cm of annual rainfall are by far, the areas of high percentage of irrigation. The highest intensity of irrigation exists in the Kashmir Valley, large parts of Punjab and Haryana, the Ganga-Yamuna Doab of Uttar Pradesh, Western part of the south Bihar Plain, Birbhum (West Bengal), Lakhimpur (Assam), the Godavari Krishna Deltas and Chengalpattu district (Tamil Nadu). The intensity of irrigation in these areas is invariably above 60 per cent and in some parts of Punjab it exceeds 75 per cent. Dry areas of Ladakh district in Jammu and Kashmir and Lahul and Spiti district in Himachal Pradesh cannot raise crops without irrigation. Although exact data are not available, these areas are believed to have 100 per cent intensity of irrigation. Large parts of the northern plain and east coastal plain have average intensity varying from 30-60 per cent. Parts of Brahmaputra Plain, the Chambal Valley and those of the Peninsular plateau have low intensity of irrigation varying from 15 to 30 per cent. The areas of low intensity are those which either do not need irrigation by virtue of high and dependable rainfall or they have not been able to develop irrigation facilities due to unfavourable geographical conditions such as rugged topography, hard rocks, infertile soils, lack of surface and ground water, etc. In this category are included large parts of Rajasthan to the west of the Aravali Range, parts of Bihar plain, central part of Peninsular plateau, the Maharasthra and Kerala coasts, Manipur, Mizoram and Tripura. Andaman and Nicobar Islands have zero per cent intensity of irrigation due to adequate rainfall throughout the year.

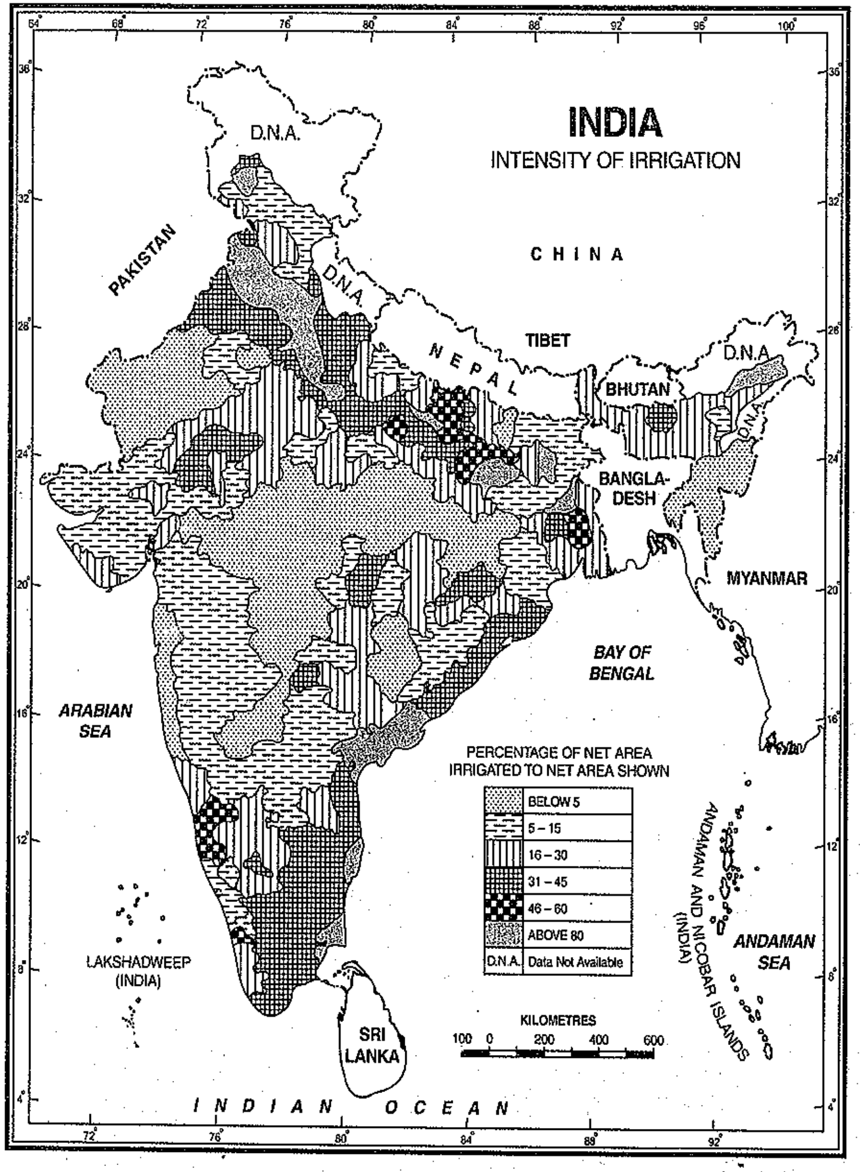

FIG. 16.9. Intensity of Irrigation

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CHAPTER 17

Multipurpose Projects

A multipurpose project is that which simultaneously serves several purposes. A dam built across a river often serves more than one purpose at a time and is termed as a multipurpose project. Flood control, irrigation, hydroelectric generation, navigation, fishing and tourism are some of the chief aims of a multipurpose project. The development of multi-purpose projects in India since the beginning of planning era in 1951 has been the salient feature of the economic growth of the country. Some of the important multipurpose projects are shown in Fig. 17.1.

1. BHAKRA NANGAL PROJECT

It is the largest and the most important multipurpose project named after the two dams built at Bhakra and Nangal on the Satluj river. It is a joint venture of the Punjab, Haryana and Rajasthan states designed to harness the precious water of the Satluj for the benefit of the concerned states. The project comprises of (*i*) Two dams at Bhakra and Nangal, (*ii*) Nangal Hydel Channel, (*iii*) Power houses with a combined installed capacity of 1,204 megawatt (M.W.) (*iv*) Electric transmission lines and (*v*) Bhakra canal system for irrigation.

The Bhakra Dam is one of the highest straight gravity dams in the world. It has been constructed on the Satluj river at the site of Bhakra gorge near Rupnagar (Ropar). The dam is 226 metres high and 518 metres long with its maximum width at the base as 362 metres. The dam has created a huge reservoir of water which is 88 km long and 8 km wide with a storage capacity of 986.8 crore cubic metres. This reservoir is named as Gobindsagar Lake after Guru Gobind Singh, the tenth guru of the Sikh community.

The Nangal Dam has been constructed at Nangal about 13 km downstream of the Bhakra dam. This 29 metre high, 305 metre long and 121 metre wide dam is an auxiliary dam which serves as a balancing reservoir for taking up daily fluctuations from the Bhakra Dam.

The Nangal Hydel Channel is 64.4 km long, 42.65 m wide and 6.28 m deep canal. It has been cemented throughout its length to avoid seepage. It is one of the longest cemented canals of the world. It takes off from the left bank of the river and flows through rugged topography of steep slope. There is a fall of 70 metres in elevation within a distance of 64 km. Its main function is to turn the turbines of power

houses located below the Nangal Dam but it also supplies water to the Bhakra irrigation canals.

Power houses have been built to generate hydroelectricity from water of the Satluj river. One power house has been built at Ganguwal about 19 km downstream from Nangal. Another power house has been constructed at a distance of 29 km from the Nangal dam. This is known as the Kotla power house.

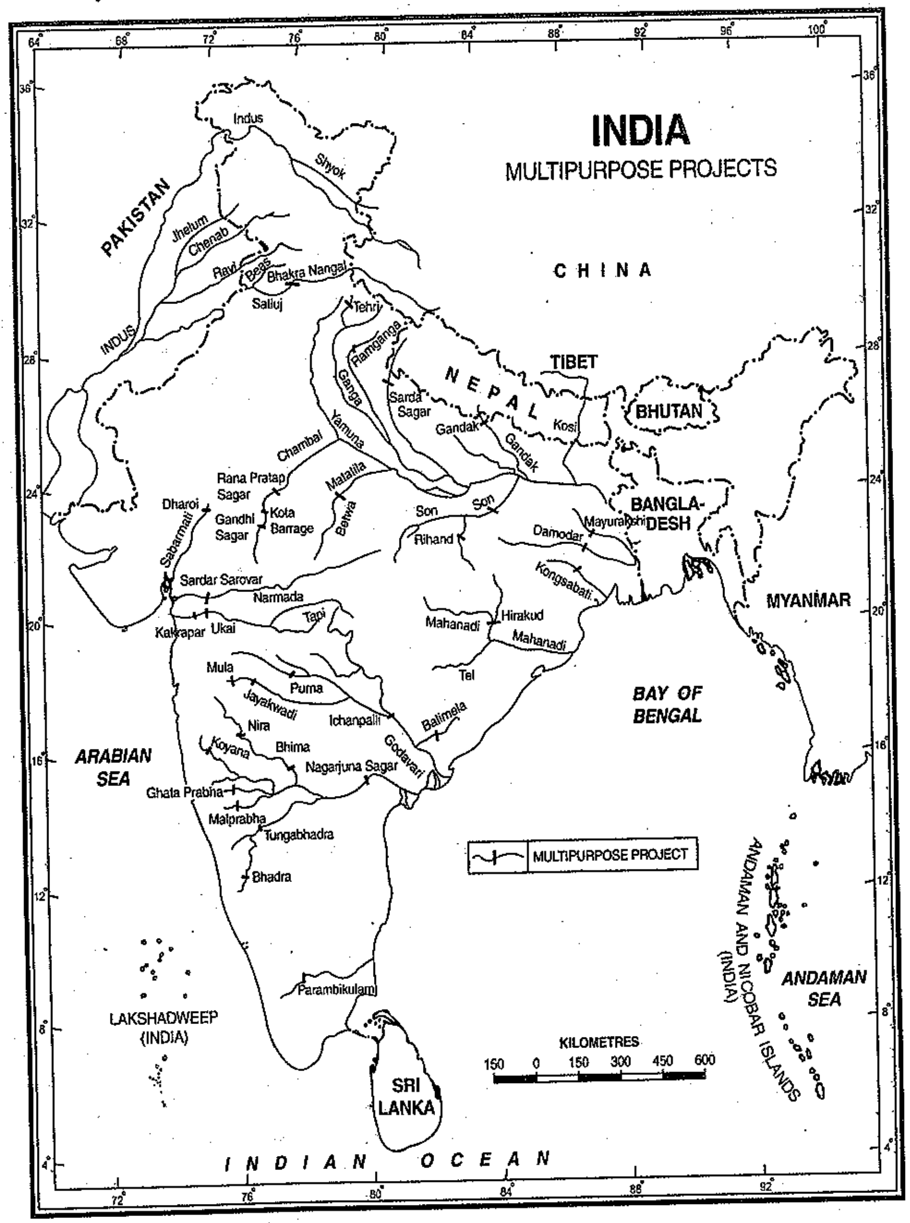

FIG. 17.1. India : Multipurpose Projects

The Ganguwal and the Kotla power houses have 2 units of 24 MW each and one unit of 29 MW. The third power house is at Rupnagar. Two power houses have been constructed at Bhakra dam, one of which is on the left and the other is on the right bank of the river. The installed capacity of these two power houses is 450 MW and 600 MW respectively.

The main Bhakra canal is 174 km long. The length of the canal system and that of the distributaries is 1,104 km and 3,360 km respectively. This canal system commands a gross area of about 27 lakh hectares and provides irrigation to about 15 lakh hectares. Of this 37.7 per cent is in Punjab, 46.7 per cent in Haryana and the remaining 15.6 per cent is in Rajasthan.

Transmission Lines have been laid to carry hydroelectricity to the consuming centres. A total of 3,680 km long transmission lines are used to supply power to Rupnagar, Ludhiana, Patiala, Rajpura, Nabha, Moga, Ferozepur, Fazilka, Faridkot, Muktsar, Jalandhar, Hoshiarpur, Kapurthala and Pathankot in Punjab; Ambala, Panipat, Hisar, Bhiwani, Rewari, Rohtak, Panchkula, Kalka, Gurgaon, Faridabad and Palwal in Haryana; Delhi; Kasauli, Kangra and Shimla in Himachal Pradesh and Rajgarh and Rattangarh in Rajasthan.

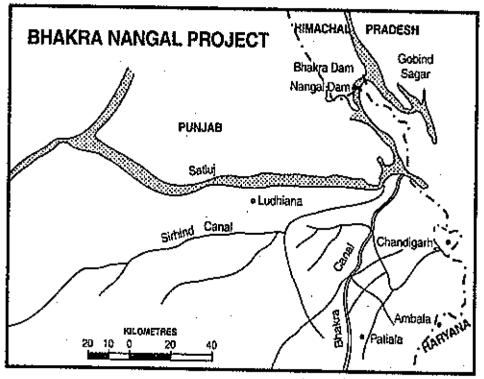

FIG. 17.2. Bhakra Nangal Project

"Bhakra Nangal Project is something tremendous, something stupendous, something which shakes you up when you see it. Bhakra today is the symbol of India's progress." —Nehru

Some Interesting facts about Bhakra-Nangal Project

1. About 14 million cubic metres of concrete and other building materials have been used for the completion of this project. This material is more than double the material used to build the *grand pyramids* of Egypt.

2. The number of tiles used in the main Bhakra canal is so large that if they are arranged in a straight line, the length of the line so formed will be seven times the length of the equator.

3. Seventy million man-days have been used to construct the canals of the Bhakra-Nangal project.

4. About 95.2 million cubic metres of earth has been excavated for constructing the canals of this project. This amount of soil is enough to construct a 6 metre wide road at 1 metre elevation from New Delhi to New York.

5. This project has helped in obtaining additional 1.3 million tonnes of foodgrains a year, 0.8 million tonnes of cotton, 0.5 million tonnes of sugarcane and 0.1 million tonnes of oilseeds. No other river valley project in the world has so much potential as this project.

However, Bhakra Nangal project like all other river valley projects, suffers from the problem of silting. Water coming from the higher reaches deposits its silt at the bed of the reservoir, thereby reducing its capacity to store water. The capacity of the reservoir was 6.03 million acre feet in 1963 which was reduced to 5.5 million acre feet in 1988, thereby causing a reduction of over half a million acre feet in a short span of only 25 years.

2. THE DAMODAR VALLEY PROJECT

(See Chapter 14)

3. THE HIRAKUD DAM PROJECT

It is an ambitious project of Odisha under the auspices of which a 61 metre high and 4,801 metre long dam has been built on the river Mahanadi at Hirakud about 14 km upstream off the city of Sambalpur. This is one of the longest dams in the world with a gross storage capacity of 8,100 million cubic metres over an area of 630 sq km. Two other dams have been constructed on

the Mahanadi—one at Tikrapara and the other at Naraj, a few kilometres west of Cuttack. These three dams provide irrigation to 1 million hectares of land in Sambalpur, Bolangir, Puri and Cuttack districts, generate 3.5 lakh kW of electricity and also offer navigation facilities. The whole of the Mahanadi valley particularly Sambalpur district, Sonapur and the delta region are benefited by this project. The areas served by the Hirakud project are very rich in minerals like iron ore, bauxite, manganese, graphite, chromite, mica and several other useful minerals which require large supply of hydroelectricity for their exploitation. Hirakud project provides the required power to these areas and helps their economic growth. Besides, this project supplies power to a large number of industries and urban centres.

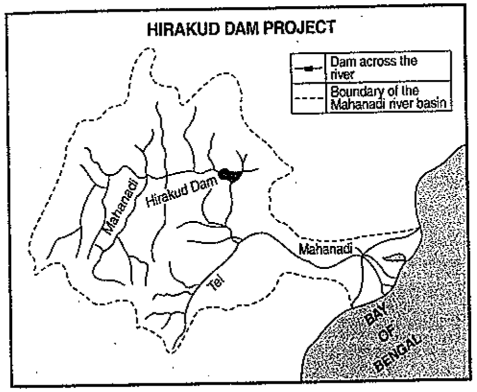

FIG. 17.3. Hirakud Dam Project

4. THE KOSI PROJECT

The Kosi river had earned the dubious name of *sorrow of Bihar* due to its devastating floods and frequent changes in its course. In order to tame the river and save precious lives and property from its annual fury, an agreement was signed with Nepal in 1954 (revised in 1961) and work on the project was started in 1955. Thus it is an international project. The entire plan has been executed by India but the benefits are being shared both by India and Nepal. The chief objectives of this project are irrigation, flood control, power generation, land reclamation, fishing and navigation.

The entire work on this project comprises three units *viz.*, a barrage near Hanumannagar in Nepal, flood embankments on both sides of the river and construction of irrigation canals.

The 1149 metre long and 72 metre high concrete barrage at Hanumannagar in Nepal was constructed in 1965. About 270 km long embankments on either side of the river were completed much earlier in 1959. The eastern and the western flood embankments were later extended by 25.76 km and 4.0 km respectively. This extension has provided protection to an area of 15,190 hectares of land in the lower reaches of the river from recurring submergence by floods.

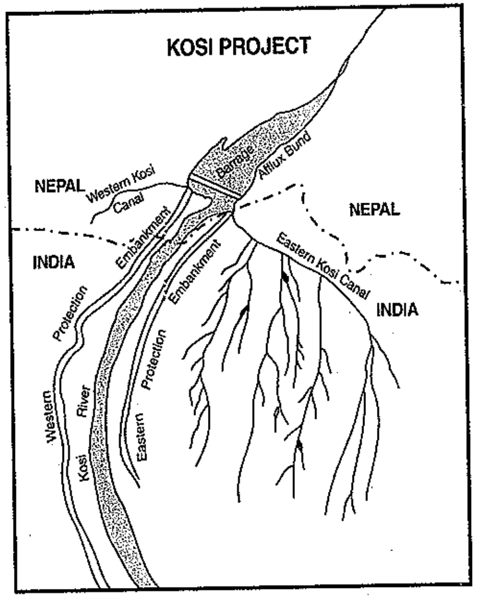

FIG. 17.4. Kosi Project

The *Eastern Kosi* canal is 43.5 km long and provides perennial irrigation to 5.19 lakh hectares in Purnea and Saharsa districts of Bihar. This canal has been extended to irrigate 1.6 lakh hectares of additional land in Saharsa and Munger districts. The 113 km *Western Kosi* Canal takes off from the right bank of the *Kosi barrage* and irrigates about 3.25 lakh hectares in Darbhanga district of Bihar and 12,120 hectares in Satpari district of Nepal. The length of the Rajpur Canal is 9.6 km only but it irrigates 1.6 lakh hectares in Saharsa and Munger districts. It takes off from the Eastern Kosi main canal. The power house at Eastern Kosi canal has an installed capacity of 20 M.W. Electricity generated by this power house is shared on 50 per cent basis by India and Nepal. There is a plan to connect the power house of Kosi to the power houses of the Damodar Valley Project and set up a grid to supply electricity to larger areas.

5. THE RIHAND VALLEY PROJECT

This is by far the most important multipurpose project of Uttar Pradesh. It consists of 934 m long and 92 m high straight gravity concrete dam across the Rihand river (a tributary of the Son) near Pipri in Mirzapur district. The reservoir created by this dam has been named as Gobind Ballabh Pant Sagar. It spreads over an area of 466 sq km and is the largest man made reservoir in India. It has the capacity to hold 11.4 lakh hectare metres of water. Another dam about 25 km north of the Rihand Dam has been constructed at Obra. The power house near the Rihand dam has 6 units each with a 5 MW capacity. Besides, power house at Obra also has 6 units, each having a capacity of 50 M.W. This power is supplied to the eastern parts of Uttar Pradesh, western parts of Bihar and northern parts of Madhya Pradesh. The Son river valley, within a radius of 200 km from Pipri, is blessed with vast deposits of coal, iron ore, limestone, mica, bauxite, feldspar, etc. The hydroelectric power generated by the Rihand Valley Project goes a long way to help in exploiting these mineral resources and usher into a new era of economic prosperity.

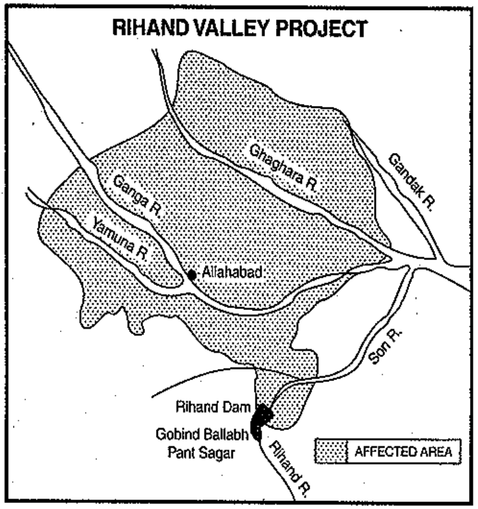

FIG. 17.5. The Rihand Valley Project

About 5,000 wells in Uttar Pradesh have been energised. Another 2.25 lakh hectares of land has been provided with tube-well irrigation in Bihar.

Flood control in Son valley, fishing in Gobind Ballabh Pant Sagar, tourism, prevention and control of soil erosion in Baghelkhand region are some of the other benefits from this project.

6. THE CHAMBAL VALLEY PROJECT

This is a joint venture of Rajasthan and Madhya Pradesh initiated in 1954 on the Chambal river (the main tributary of the Yamuna). The project aims at harnessing the Chambal river for irrigation, power generation and for prevention and control of soil erosion in the valley. The project has been executed in three successive stages.

The first stage consists of construction of the 64 m high and 514 m long Gandhisagar dam about 8 km downstream of the Chaurasigarh fort in Bhanupura tehsil at the border of M.P. and Rajasthan. Constructed in 1960, the dam has created the Gandhisagar reservoir which spreads over an area of 688 sq km. It has a capacity to hold 692 crore cubic metres of water which provides irrigation to 4.44 lakh hectares. Five units of 23,000 K.W. capacity each have been set up at the dam site.

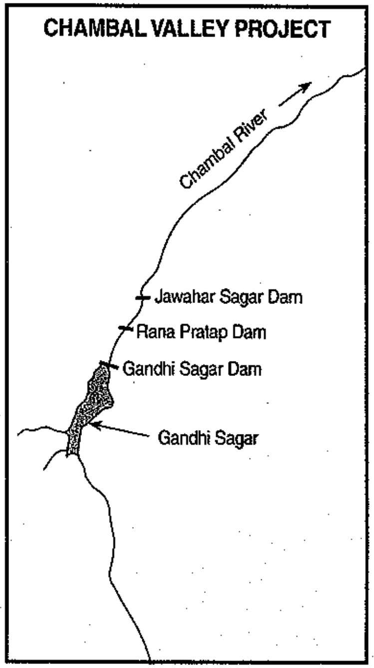

FIG. 17.6. The Chambal Valley Project

The second stage includes the construction of the 54 m high and 1,143 m long *Rana Pratap masonry dam* at Rawatbhata about 56 km downstream of the Gandhisagar dam. It has a gross storage capacity of 290 crore cubic metres spreading over an area of 198 sq km. It provides irrigation to 1.2 lakh hectares of land. The Rana Pratap power station is located on the left bank just at the toe of the dam. Four generating units of 43,000 kW. each are installed here.

The third stage consists of the construction of a 45 m high and 548 m long gravity dam, known as the *Jawahar Sagar dam or Kota dam*, about 29 km upstream of Kota city. It was completed in 1971-72. The reservoir created by this dam has a potential of 68 million cubic metres. Three generating units of 33,000 K.W. each have been installed here.

Kota barrage was constructed in 1960, at a distance of less than 1 km from Kota. This is 36 m high and 600 m long earthen barrage. Irrigation canals taken from both sides of the barrage irrigate 4.4 lakh hectares in Rajasthan and M.P.

The areas benefited by this project include Kota, Bundi, Bharatpur, Jaipur, Sawai Madhopur, Tonk, Ajmer, Pali, Bhilwara, Sirohi and Udaipur districts of Rajasthan and Mandsaur, Indore, Ujjain, Gwalior and Ratlam districts of M.P.

7. TUNGBHADRA MULTIPURPOSE PROJECT

It is a joint undertaking of Andhra Pradesh and Karnataka. The project comprises a 2,441 metre long and 50 metre high straight gravity masonry dam across the Tungabhadra (a tributary of the Krishna River) at Mallapur in Bellary district of Karnataka, two irrigation canals and power houses on both sides of the dam.

The 349 km long *Right Bank Low Level* canal was completed in 1963. It irrigates 3.5 lakh hectares in Karnataka and Andhra Pradesh. Another 196 km long canal called the *Right Bank High Level Canal* has also been completed and irrigates 36 thousand hectares. The 227 km long *Left Bank Low Level Canal* was also completed in 1963. It irrigates 1.82 lakh hectares of land.

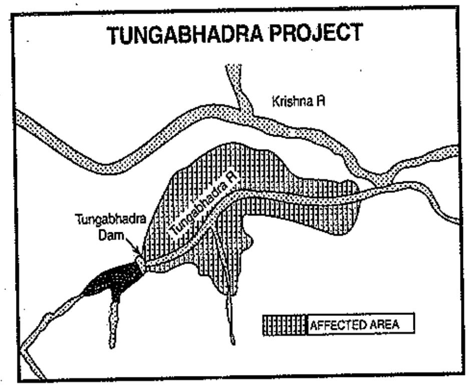

FIG. 17.7. Tungabhadra Project

Of the three power stations, two are situated at the foot of the dam (one on either side of the dam) and the third is at 15th km of the Right Bank Low Level Canal. All the three power stations have a potential of 126 M.W.

8. THE GANDAK PROJECT

This project is jointly executed by Bihar and Uttar Pradesh. Nepal also derives some benefit according to an agreement signed in 1959.

This project comprises a 747.37 metre long and 9.81 metre high barrage at Bhansoloten (Balmikinagar) in Bihar near the Nepal border below the Tribeni Canal Head Regulator (half of the barrage length is in Nepal), 4 canals, (2 each in India and Nepal) and a power house. The Project was completed in 1966-67. The 66 km long Main Western Canal irrigates 4.84 lakh hectares in Saran district of Bihar and about 1.88 lakh hectares in Gorakhpur and Deoria districts of Uttar Pradesh. A separate canal takes off from the western bank and irrigates about 16.4 thousand hectares in the Bhairwa area of Western Nepal. The Main Eastern Canal irrigates about 6.03 lakh hectares in Champaran, Muzaffarpur and Darbhanga districts of Bihar and 42 thousand hectares in Parasa, Bara and Rautuhat districts of Nepal. A power house with an installed capacity of 15 M.W. on the Main Western Canal has been commissioned and has been gifted to Nepal.

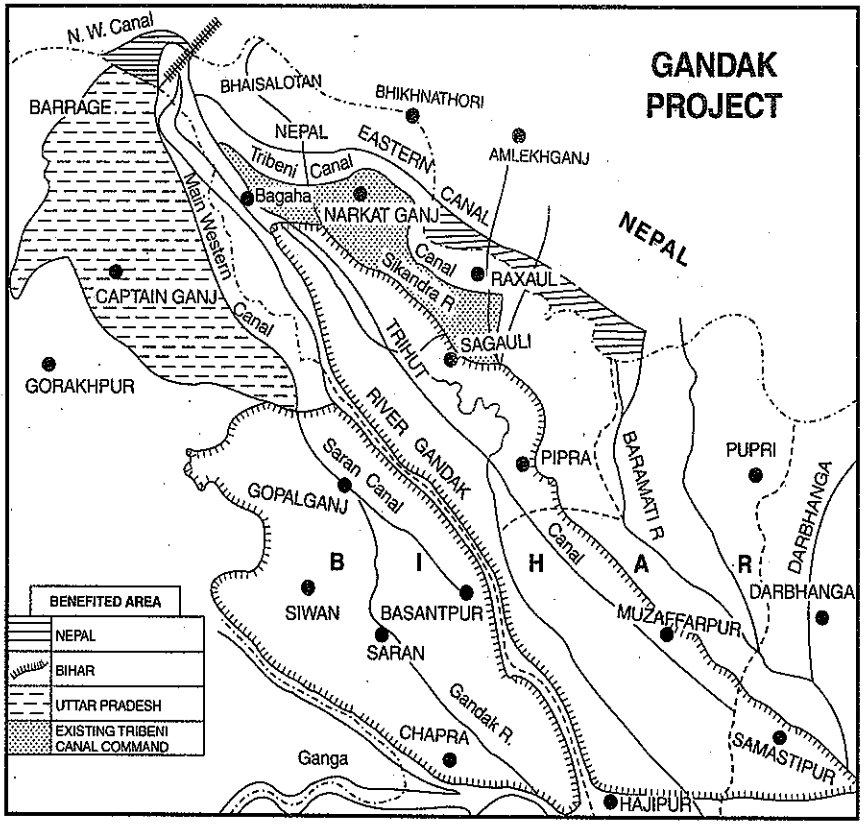

FIG. 17.8. The Gandak Project

9. THE NARMADA VALLEY PROJECT

Originating in the Amarkantak plateau of Madhya Pradesh, the Narmada is the fifth largest river of India and the largest among the west flowing rivers of the Peninsula. The volume of average annual flow of water is 40,700 million cubic metres, 90 per cent of which flows during the monsoon season. Only 5 per cent of this flow is utilized and 95 per cent flows unutilized to the Gulf of Khambhat. The Narmada Valley Project aims at harnessing this flow for the economic prosperity of the concerned areas. This is going to be one of the largest river valley projects of the world because the entire project includes the construction of 30 major, 135 medium and 3,000 minor dams on the river. Conceived in 1945-46 the project has been surrounded by controversies which have become very sharp after 1987 when the construction started and in the present day context this project is more controversial than any other river valley project of the world. There seems to be a tug of war between the environmentalists on one hand, and the protagonists of the project on the other. The environmetalists have predicted doom as, according to them, the project would lead to waterlogging, soil erosion, destruction of forests, cultivable land and wild life and also trigger health problems. They plead that the reservoirs created by two main dams *viz.* the *Sardar Sarovar dam and the Narmada Sagar Dam* will submerge 480 villages and displace 1.5 lakh persons and 8 lakh cattle heads. The Bargi Dam, a part of the giant *Narmada Sagar-Sardar Sarovar* scheme, has already dislocated about one lakh people in 162 villages in M.P. This dam was commissioned in 1968. Besides 50,000 hectares of reserve forests

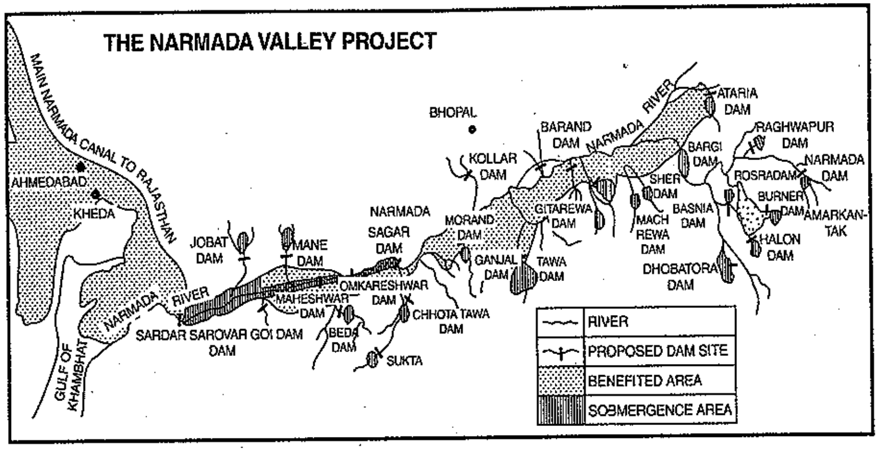

FIG. 17.9. The Narmada Valley Project

would also be destroyed. However, the document prepared by the *Ministry of Water Resources* in 1993 showed that a total of 245 villages in three states of Madhya Pradesh, Gujarat and Maharashtra would come under submergence of the river water. It would directly affect 38,044 families in the valley (31,080 in M.P., 4,500 in Gujarat and 2,464 in Maharashtra). The submergence would also render useless 11,279 hectares of cultivable land besides causing damage to forest spread over 10,719 hectares of land. There would also be immense loss of flora, fauna and marine life. There is also a pressing demand for the reduction of height of the *Sardar Sarovar Dam* from 455 ft to 436 ft. to save over 38,000 people from rehabilitation and 25,000 acres of land from getting submerged.

On the other hand, the protagonists of the project plead that this project would augur an impetus for a commendable economic development of the region. There is no denying the fact that the Narmada scheme is designed to benefit the people in not only Gujarat but also those in Madhya Pradesh and Maharashtra, with Rajasthan tagged as a marginal beneficiary to get more drinking water. The dams on the river are designed to produce about 3,000 M.W. of hydroelectricity. The canal system to be built in the integrated scheme is expected to provide irrigation facility to 17.92 lakh hectares of land in Gujarat, 1.40 lakh hectares in Madhya Pradesh and 73,000 hectares in Rajasthan. Although 87% of the Narmada flow is in M.P., 11.5% in Gujarat and 1.5% in Maharashtra, Gujarat is the main beneficiary state. This is the reason that the Narmada is called the *life line or Mother Narmada* in Gujarat. The increased irrigation potential is estimated to jack up the food grains production by 43 lakh tonnes a year. Further, Gujaratis claim a positive impact on the health scene. There would be substantial reduction in scabies and skin diseases in Saurashtra, Kuchchh and northern Gujarat due to the availability of potable water.

The Sardar Sarovar Project (SSP)

Construction of 1250 metres long and 121.92 metres tall dam completed upto Brim in December, 2006 in the Lower Narmada Valley in Gujarat (Fig. 17.10). It has create a reservoir having a potential of 77 lakh acre feet. It has provide irrigation to 18 lakh hectares in Gujarat which has helped in increasing the farm production by 82 lakh tonnes. About 10.6 lakh hectare metre water has been made available for domestic and industrial use to 131 cities and towns and to 8,720 villages. Two power stations produce 1,450 M.W. of hydroelectricity. An area of 4,650 hectares has been brought under forest to partly compensate for 10,713 hectares which has been submerged under the reservoir. It will provided employment to 4 lakh persons during the course of construction and to about 6 lakh persons after the completion due to increase in agriculture, animal husbandry, dairy, fertilizer industry and other allied occupations. The initial cost of the project was put at ₹ 5,793 crore which has now escalated to about ₹ 13,400 crore.

HIGHLIGHTS OF SARDAR SAROWAR PROJECT

- Generation of 1450 MW Hydro Power achieved.
- Beneficial to Gujarat, Rajasthan, Madhya Pradesh and Maharashtra.
- Irrigation facility in 18 lakh hectares in Gujarat and 2.50 lakh hectares in Rajasthan.
- Drinking water facility to 2 crores population of Gujarat and 15 lacs population of Rajasthan.
- Main Canal of 458 kms have been constructed and Branch Canals of 2,585 kms.
- 5,112 kms Distributory.
- 18,453 kms minor and 48,058 kms sub minor canals.
- Narmada Dam site is emerging as a favourite and pleasing Tourist Place, more than 12,00,000 Tourists visit the Narmada Dam site every year.
- Share of water after completion of the project will be by Madhya Pradesh (65.18%), Gujarat (32.14%), Rajasthan (1.79%) and Maharashtra (0.89%).
- States' share of 1,450 MW hydro power will be Madhya Pradesh (57%), Maharashtra (27%) and Gujarat (16%).

The Narmada Sagar Dam Project

The foundation stone of the Narmada Sagar Dam on the Narmada in Madhya Pradesh was laid on 3rd October, 1984. When completed, it will completely submerge 89 villages and 91 thousand hectares of land in East Nimar (Khandwa), Dewas and Hoshangabad districts. Besides, 105 villages will be partially submerged (**Fig. 17.9**). About 900 sq km of black soil fertile land and 40,000 hectares of forest land would also be submerged in water. On the positive side this project will usher into a new era in the form of added irrigation, water power generation, potable water and water for industrial purposes, fishing, tourism, etc.

On June 12, 2014, the Narmada Control Authority (NCA) permitted the Gujarat government to raise the height of the Narmada dam by about 17 metres from 121.92 metres to 138.68 metres which will also be the height of the reservoir in closed gates condition. With this increase in height the storage capacity of the reservoir will go up from the existing 1.27 million acre feet to 4.75 million acre feet.

10. THE NAGARJUNASAGAR PROJECT

Started in 1955-56, the Nagarjuna Sagar Project involves the construction of a 124.7 metre high and 1450 metre long concrete dam on the Krishna river in Nalgonda district of Telangana about 114 km to the south-east of Hyderabad. The reservoir behind the dam spreads over an area of 118 sq km with a storage capacity of 1,156 crore cubic metre of water. Two canals have been taken, one each from either side of the dam. The 349 km long *Jawahar canal* on the right side of the dam has a capacity to irrigate about 4 lakh hectares in Guntur, Prakasam (Ongole) and Nellore districts. The 357 km long *Lal Bahadur canal* irrigates about 3 lakh hectares in Khammam, West Godavari and Krishna districts. A power house with two units of 50 M.W. each was set up at the toe of the dam in 1970. It supplies electricity to Nalgonda, Mahaboobnagar and Hyderabad districts for various purposes.

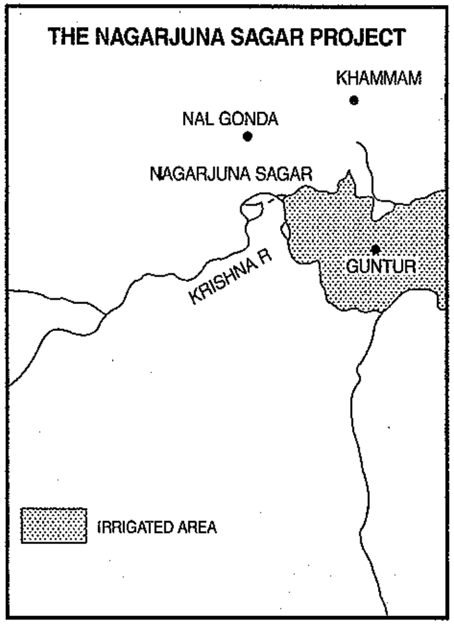

FIG. 17.10. Nagarjunasagar Dam Project

11. TEHRI DAM

This dam in Tehri Garhwal was conceived in 1949. Situated at the confluence of the Bhagirathi and the Bhilganga rivers in Garhwal district of Uttarakhand, this 2160.5 m long Tehri dam, said to be the highest in Asia, was commissioned in 1972, but work on it began only in 1978. Ever since, environmental and safety aspects threatened the project. This rock-fill dam, generates 3,500 MW of electricity, irrigates 270,000 ha of arid land between the Ganga and Yamuna. A gigantic reservoir has been created over an area of 4,200 ha which feeds an underground power house with a racing torrent generating enough electricity. The initial project cost of ₹ 192 crore (in 1978), reached ₹ 6,000 crore in 1998.

MAJOR EVENTS CONCERNING TEHRI DAM

1949 Tehri dam on the Bhagirathi river conceived.

1961 Survey started for site selection.

1978 Construction starts for 600 M.W. power project.

1979 Installed capacity raised to 1,000 M.W.. Antidam protests starts and work on the project suspended for seven years.

1986 Union Cabinet approves Tehri as a joint project of Centre and Uttar Pradesh government. Assistance from erstwhile USSR sought. Writ petition filed in the Supreme Court against the project on ground's safety and environmental impact. Installed capacity raised to 2400 MW.

1988 Tehri Hydro Development Corporation formed.

1990 Experts conclude that Tehri dam is safe even in the event of a severe earthquake of 8 magnitude on the Richter scale.

1991 Foundation sheet of the dam raised to 15 metres above the river bed. Earthquake of 6.6 magnitude on Richter Scale rocks Uttarkashi on 20th October. No damage occurred to the dam.

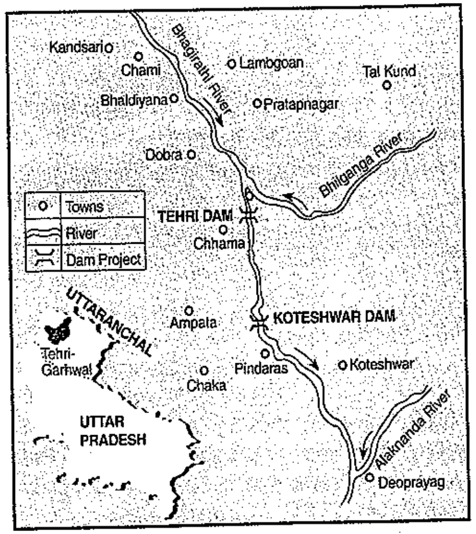

FIG. 17.11. Tehri Dam

The 2,400-MW dam has submerged town of Tehri, which was well known as a seat of Garhwali culture, and 23 villages in its vicinity. About 72 other villages along the river have also been partly submerged. People from 21 villages have already been displaced for constructing the New Tehri township, thus displacing about 70,000 people from their ancestral lands. The dam would also flood 1,000 ha of cultivated land, 1,000 ha of forest land and 2,000 ha of pasture land.

12. THE BEAS PROJECT

A joint venture of Punjab, Haryana and Rajasthan, the project consists of (*i*) Beas-Satluj link and (*ii*) Pong dam on the Beas. The Beas-Satluj link involves the construction of a 61 metre high diversion dam at Pandoh in Himachal Pradesh, about 27 km long water conductor system comprising two tunnels 12-13 km long each and an open hydel channel and a power plant at Dehar with an installed capacity of four units of 165 M.W. each. It has the capacity to provide irrigation to about 5.25 lakh hectares in Punjab and Haryana.

The second unit includes a 116 metre high dam at Pong in the Dhaoladhar range near Pong village. It is mainly an irrigation scheme which is intended to ensure extension of perennial irrigation to about 21 lakh hectares in Punjab, Haryana and Rajasthan. It also provides for a power plant of 240 M.W. capacity with provision of 2 future units of 60 M.W. each. The total installed capacity of the Beas complex is 1020 M.W. including one unit of 120 M.W. at Bhakra right bank power house.

Apart from the above major multipurpose projects, there are several other projects including the Mahi project, Mayurakshi, Rampadsagar, Ramganga, Machkund, and many more which have been taken up to boost the economy of the country.

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CHAPTER 18

Biotic and Marine Resources

INTRODUCTION

Biotic resources consist of living creatures which include plants, animals (both wild and domestic), birds, animals living in water, and above all man himself. Considering the space constraint we will confine our attention to the description of domestic animals, poultry birds and animals living in water only (like fish, aquaculture).

LIVESTOCK

Livestock includes domestic animals such as cattle, buffaloes, sheep, goats, horses, ponies, donkeys, camels, pigs, etc. India's animal wealth is both large and varied. In most parts of India, killing of animals is taboo from religious point of view, as a result of which animals of various descriptions have outgrown in number.

In 2007, India had 199.1 million cattle, 105.3 million buffaloes, 71.6 million sheep, 140.6 million goats, and 148.7 million poultry birds. Thus India far exceeds any other country of the world insofar as the number of animals is concerned. India boasts of about half of the buffaloes, one fifth of the cattle and one sixth of the total goat population of the world. But this quantitative supremacy in no way speaks of the quality of our animals. Our animals are of poor quality in terms of stamina for draught and milk yield. Several factors are responsible for this sad state of affairs. Livestock rearing is a highly neglected industry in India and is always treated as an occupation subsidiary to crop production. Indian agricultural scene is primarily dominated by subsistence agriculture and commercial grazing is conspicuous by its absence. Every farmer has a few animals which are fed on straw and other farm-by-products. Only 3 per cent of our total area is termed as grassland which is too small to feed such a vast population of livestock. Animal husbandry accounts for nearly one-fourth of the total income from the agriculture sector and its contribution to the national income does not exceed 5 per cent. In the year 2008, livestock and fisheries sector contributed about 4.07

per cent the total GDP and nearly 29.7 per cent to the value of output from total agricultural and allied activities.

However animal husbandry sector provides large scale self-employment opportunities to the rural people and plays an important role in supplementing family income and generating gainful employment, particularly among the landless labourers, small and marginal farmers and women. It also provides cheap nutritional food to millions of Indians by producing meat, milk, eggs, etc. Livestock is a great source of raw material byproducts such as hides and skins, bones, blood, fat, etc. Livestock is the best insurance against the vagaries of nature like drought, famine and other natural calamities.

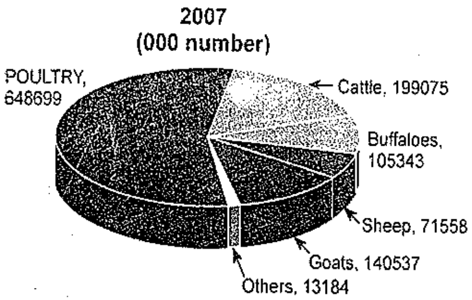

FIG. 18.1. India : Composition of Livestock

CATTLE

India has the largest number of cattle in the world. In 2007, India had 1,99,075 thousand cattle which account for about one fifth of the world's total number of cattle and about 37.6 per cent of the total livestock population of India. Thus the number of cattle possessed by India is simply amazing. Further the cattle have registered an increase of 28 per cent from 155.3 million in 1951 to 199.08 million in 2007. Uttar Pradesh has the highest number of 20 million cattle in India. Next in descending order are, Madhya Pradesh, Maharashtra, West Bengal, Bihar, Odisha, Rajasthan, Karnataka, Jharkhand and Andhra Pradesh. The other states with considerable number of cattle are Assam, Chhattisgarh, Gujarat and Tamil Nadu (**Fig. 18.2**).

The number of adult male cattle increased from 51.76 million in 2003 to 56.01 million in 2007. Out of total male cattle available in 2007, 4.68 per cent were used for breeding only, 79.66 per cent were used for 'agriculture and breeding', 9.08 per cent used for bullock cart and breeding and 6.58 per cent for other purposes. According to 2007 figures about 25 per cent of the adult male cattle were concentrated in two states of Madhya Pradesh and Maharashtra. Rajasthan and Bihar had 5 per cent and 3.7 per cent respectively of the total adult male cattle of India.

It has already been mentioned that Indian cattle are, by and large, of poor quality. The average yield of milk per cow is just one litre per day whereas this yield is 30-40 litres in some of the advanced countries like New Zealand, Denmark and Holland. This is the reason that Indian cow is often called *tea-cup-cow*.

Although majority of Indian cattle are of poor quality, there are 14 well defined excellent breeds of milch cattle and 12 well known draught and disease resisting breeds of cattle. Most of the good milch, draught or dual purpose breeds are found in dry northern, north-western and southern parts of the country. The humid regions generally do not support good breeds of cattle.

Milch Breeds. *Gir, Sindhi, Red Sindhi, Sahiwal, Tharparkar* and *Deoni* are some of the outstanding breeds of milch cattle. The ***Gir*** is a native of Saurashtra and is now found in several parts of Gujarat and adjoining Rajasthan. ***The Sindhi*** breed is mainly raised in Gujarat, Rajasthan and Maharashtra although it can be raised in several other parts of the country due to its disease resistant quality. The ***Red Sindhi*** breed has a distinct red colour and hails from Sind in Pakistan. The ***Sahiwal*** breed has its origin in the Montogomery district of Pakistan and is widely raised in Punjab, Haryana, Rajasthan, Uttar Pradesh and Delhi. ***The Deoni*** breed is widely raised in Telangana and Andhra Pradesh.

Draught Breeds. Among the important draught breeds are included the *Nagori, Bauchaur, Kenkatha, Malvi, Kherigarh, Hallikar, Khillari, Amritmahal, Kangayam, Ponwar, Bargur,* and *Siri*. The ***Nagori*** breed is a native of Jodhpur and is found in large parts of Rajasthan, Haryana, U.P. and M.P. ***The Bauchaur*** breed is mainly found in Bihar. The ***Malvi*** is largely concentrated in the dry western parts of Madhya Pradesh. ***The Kenkatha or Kenwariya*** breed hails from Banda district of Uttar Pradesh and neighbouring areas of Madhya Pradesh. Kheri district of Uttar Pradesh is the habitat of the *Kherigarh* breed. The ***Halikar*** and ***Amritmahal*** breeds are indigenous to Tumkur, Hassan and Mysore districts of Karnataka but are spread all over the Peninsular India. Solapur and Satara districts comprise the home of the ***Khillari*** breed. The ***Bargur*** and the ***Kangayam*** breeds are the natives of Coimbatore district of Tamil Nadu. The ***Siri*** breed flourishes well in the hilly areas of Darjeeling and Sikkim.

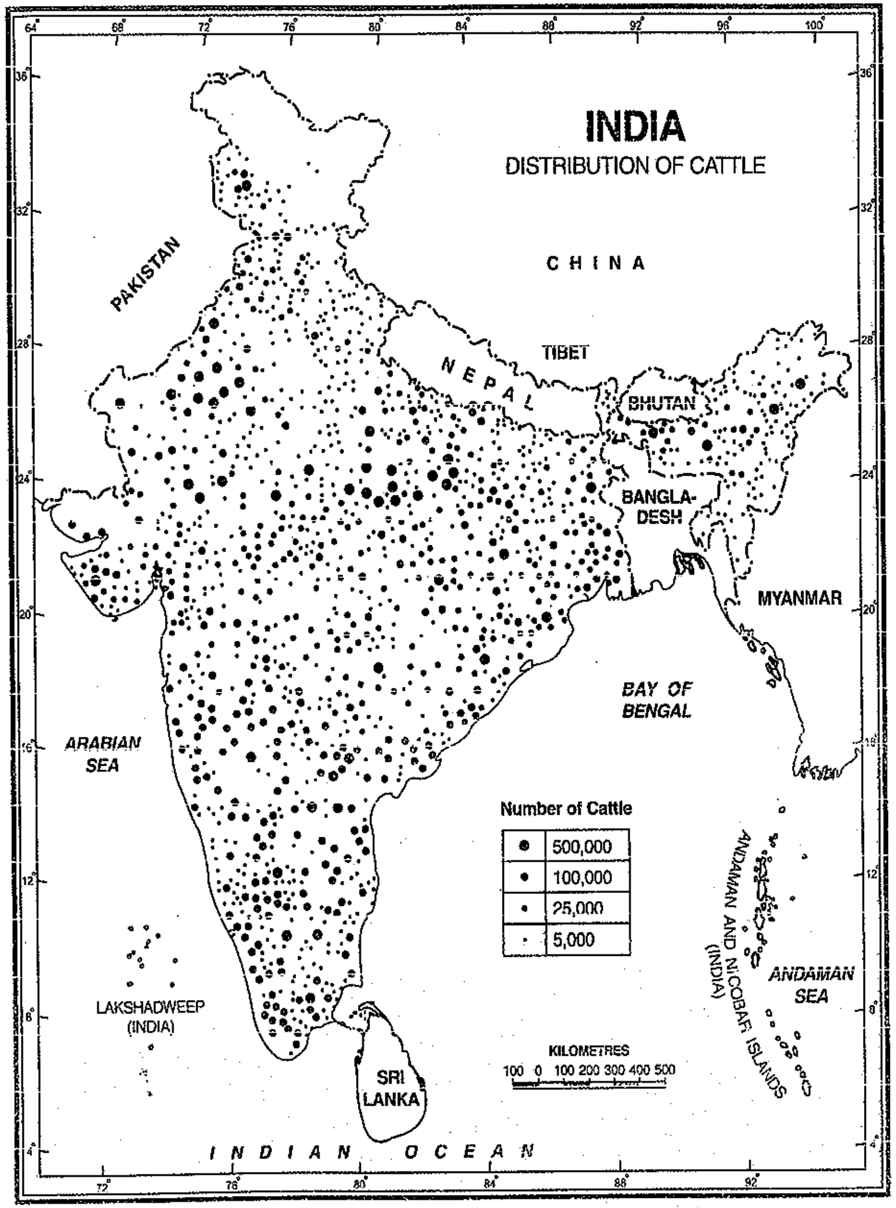

FIG. 18.2. India : Distribution of Cattle

Dual Purpose Breeds. Cattle of these breeds are used both for milk and for draught purposes. The cows are fairly good yielders of milk while bullocks are good for draught. *Tharparkar*, *Haryana*, *Mewati*, *Kankrej*, *Rath*, *Nimari*, *Dangi*, *Gaolao*, *Krishna Valley* and *Ongole* are important breeds of this category. ***The Tharparkar*** breed hails from the Sind province of Pakistan and is found in large parts of Gujarat and Rajasthan. As its name indicates, the ***Haryana breed*** is the much prized cattle of Haryana and is also found in the neighbouring parts of Delhi and Western Uttar Pradesh. ***The Mewati*** breed is found in Mathura district of Uttar Pradesh and Bharatpur and Alwar districts of Rajasthan. ***The Kankrej*** breed is indigenous to Gujarat plains. ***The Rath*** breed is a mixture of *Haryana*, *Nagori* and *Mewati* breeds and is found in the areas dominated by these breeds. The ***Nimari*** breed is largely found in the Narmada Valley in East and West Nimar districts of Madhya Pradesh. The ***Dangi*** breed is normally found in Kolaba, Thane, Nashik and Ahmednagar districts of Maharashtra. The ***Gaolao*** breed belongs to Chhindwara district of Madhya Pradesh and Wardha and Nagpur districts of Maharashtra. The ***Krishna valley*** breed is popular in upper Krishna Valley in Maharashtra and Karnataka. The ***Ongole*** breed hails from Nellore and Guntur districts of Andhra Pradesh.

Exotic Breeds. Some of the high milk yielding exotic breeds have been developed in India, especially in 20 military forms in hilly areas. Some foreign breeds have been crossed with Indian breeds and new breed called ***cross breed*** has been developed. The maximum yield of milk per lactation at the military farms is about 6,000 kgs while the average yield is 2,600 kg. Some of the important exotic breeds are Jersey, Holstein-Friesian, Swiss-Brown, Gurnsey, German Feleckvich, and Ayreshire.

BUFFALOES

India's buffaloes population was 105.3 million in 2007. This is about half the buffaloes population of the world and about 20 per cent of the total livestock of India. Buffaloes thrive best in areas of warm and humid climate. Buffaloes are reared mainly for milk but some buffaloes are used as draught animals in certain parts of the country. Uttar Pradesh has the largest number of over 27.4 million buffaloes which is over 26 per cent of the total buffaloes of India. The other major states with considerable buffaloes are Rajasthan (9.8 million), Andhra Pradesh (9.6 million), Madhya Pradesh (6.6 million), Gujarat (6.3 million), Punjab (6.2 million), Maharashtra (6.1 million), Bihar (5.9 million), Haryana (4.8 million) and Karnataka (4.4 million). The density of buffaloes is higher in the alluvial plains of North India where large quantity of fodder is available.

Buffaloes are the main source of milk in India and provide 46 per cent of total milk of India. Rest of the milk is obtained from other animals like cattle sheep, goats, camels, etc.

In addition to the fact that India has more buffaloes than any other country of the world; the Indian buffalo-breeds are some of the world's best. *The Murrah*, *Bhadawari*, *Jaffarabadi*, *Surti*, *Mehsana*, *Nagpuri* and *Nili Ravi* are among the important breeds. The **Murrah** breed is indigenous to Rohtak, Hisar and Gurgaon districts of Haryana and to the neighbouring areas of Delhi. Buffaloes of this breed yield 1,400 to 2,270 kg of milk per lactation with 7 per cent fat content against only 4.5 per cent in cow's milk. The Murrah male buffaloes are good draught animals. The **Bhadawari** breed belongs to Agra and Etawah districts of Uttar Pradesh and the neighbouring parts of Madhya Pradesh and Rajasthan. The **Jaffarabadi** breed hails from the Gir forest of Gujarat. The buffaloes of this breed are quite massive and yield about 2,500 kg of milk per lactation. The **Surti** breed comes from the Gujarat plains and gives about 1,655 kg of milk per lactation. The **Nagpuri** originates from Nagpur. The **Nili Ravi** breed belongs to Ferozepur district of Punjab and yields about 1,600 kg of milk in one lactation.

The number of adult male buffaloes increased from 5.21 million in 2003 to 6.44 million in 2007. Out of total male baffaloes available in 2007, 13.46 per cent were used for breeding only 58.22 were used for 'agriculture and breeding', 18.37 per cent used for bullock cart and breeding and only 9.95 per cent were used for other purposes.

Cattle and Buffalo Development Programmes

The important schemes initiated by the government for the development of cattle and buffaloes are Key Village Blocks (KVBs) and Intensive Cattle

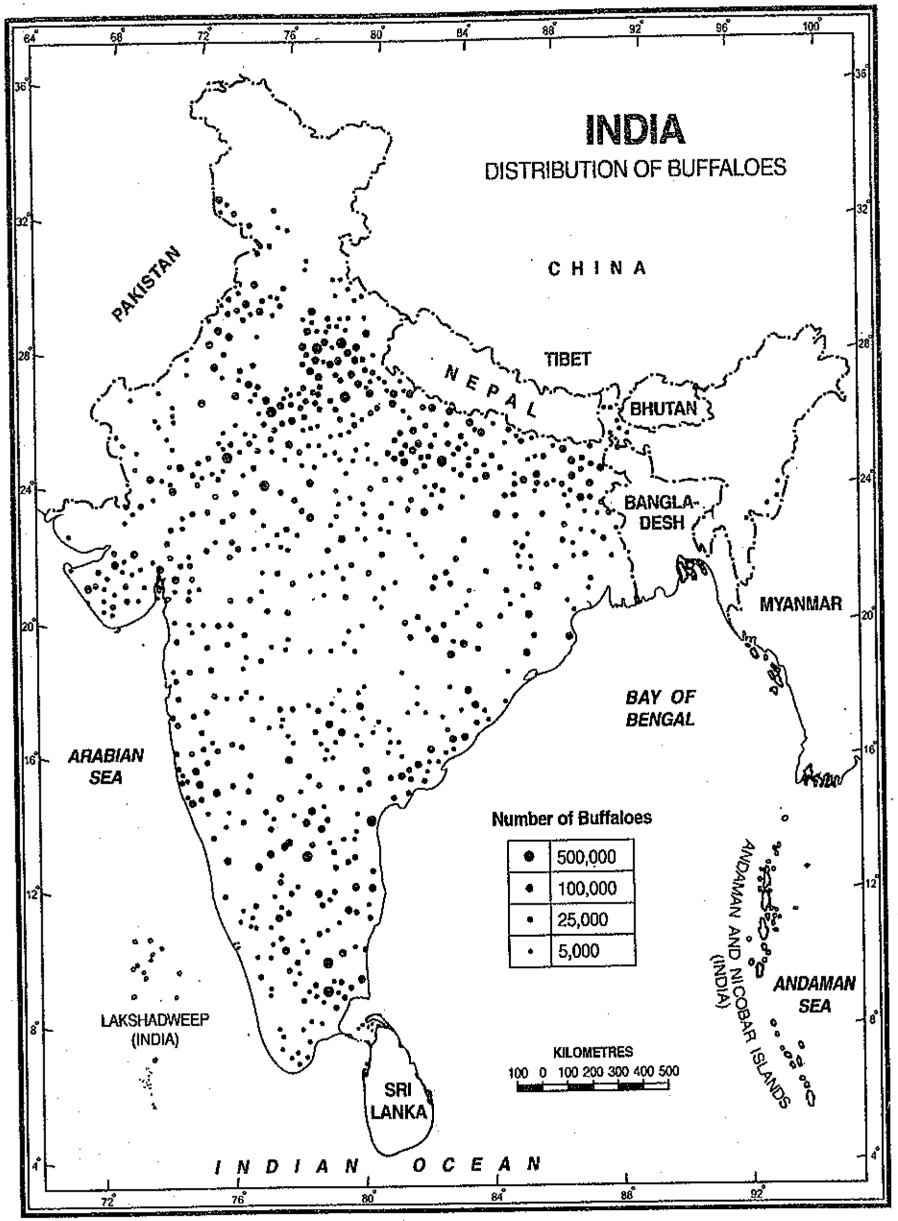

FIG. 18.3. India : Distribution of Buffaloes

Development Projects (ICDPs). A major programme for genetic improvement called National Project for Cattle and Buffalo Breeding (NPCBB) was launched in October, 2000. Seven central cattle breeding farms at *Suratgarh* (Rajasthan), *Dhamrod* (Gujarat), *Alamadhi* (Tamil Nadu), *Chiplima* and *Suncheda* (Odisha), *Andeshnagar* (U.P.) and *Hessarghatta* (Karnataka) are engaged in scientific cattle breeding programme and progeny testing of selected breeds of indigenous as well as exotic cattle and buffaloes. The embryo transfer technique is the latest technology for developing cattle and buffaloes and for increasing their productivity. Availability of good feed and fodder in sufficient quantity is the pre-requisite for proper development and growth of livestock. Seven regional stations in different agro-climatic zones have been set up to provide the latest fodder production technology. These are *Hisar* (Haryana), *Kalyani* (West Bengal), *Gandhinagar* (Gujarat), *Alamadi* (Tamil Nadu), *Hyderabad* (Telangana), *Suratgarh* (Rajasthan) and *Shehoma* (J&K). Central Frozen Semen Production and Training Institute located at Hessergatta in Karnataka is producing frozen semen of indigenous, exotic and crossbreed cattle and Murrah buffalo bulls for use in Artificial Insemination (A.I.) : Central Herd Registration Scheme (CHRS) is meant for registration of elite cow and buffalo, breeds of national importance and provides incentives for rearing of elite cows and male calves. It plays a significant role in sourcing indigenous germplasm required for the National Project for Cattle and Buffalo Breeding. Four CHRS units have been established at Rohtak (Haryana), Ahmedabad (Gujarat), Ajmer (Rajasthan) and Ongole (Andhra Pradesh).

Livestock Health

The governments of states and union territories have made provisions for better health facilities to the livestock by setting up Polyclinics/Veterinary Hospitals/Dispensaries/First Aid including Mobile Veterinary Dispensaries so that morbidity and mortality rate among the animals is minimised. One Central and five Regional Disease Diagnostic Laboratories are also functioning. For controlling major livestock and poultry diseases by way of prophylactic vaccination, the required quantity of vaccines are produced in the country at 27 veterinary vaccine units production units (20 in public sector and 7 in private sector).

Livestock Health and Disease Control

Centrally sponsored scheme 'Livestock Health and Disease Control' has been launched to help the state governments in controlling diseases among animals. Following are its major components :

(*a*) Assistance to States for Control of Animal Diseases (ASCAD)

(*b*) Professional Efficiency Development (PED)

(*c*) National Project on Rinderpest Eradication (NPRE)

(*d*) Foot and Mouth Disease Control Programme (FMD-CP)

(*e*) National Animal Disease Reporting System (NADRS)

(*f*) National Control Programme on Peste des petits ruminants (NCPPPR)

(*g*) National Control Programme on Brucellosis (NCPB)

(*h*) Establishment and strengthening of Veterinary Hospitals and Dispensaries (ESVHD)

Livestock Insurance

Centrally Sponsored Scheme (CSS) for providing assured protection to farmers and cattle rearers against eventual loss of animals due to death was launched on a pilot basis during 2005-06 and 2006-07 in 100 selected districts. A full fledged scheme on Livestock Insurance was implemented in 2008-09. The scheme benefits farmers (large, small, marginal) and cattle rearers having indigenous/crossbred milch cattle and buffaloes.

SHEEP

With 71.6 million sheep (2007), India stands sixth in sheep population in the world after Australia, Russia, China, Argentina and New Zealand. More than 4 per cent of the world's sheep are reared in India. *Most of the sheep are raised in regions which are too dry, too stony or too mountainous to be too good for agriculture or for cattle rearing*. Most of the Indian sheep are of poor quality yielding inferior wool in less quantity. Their yield of mutton is also very low. However, some of the good breeds are found in the northern temperate region. By virtue of their sheer number, sheep occupy an important place in our economy because they provide us with wool, mutton and skins. About five million households are engaged in the rearing of sheep and other allied activities. The largest number of 18.6 million sheep are found in Rajasthan which account for over one-fourth of the total sheep population of India. This is followed by

Andhra Pradesh including Telangana, Karnataka, Tamil Nadu, Maharashtra, Jammu and Kashmir, Uttarakhand, Himachal Pradesh, Gujarat, Bihar and Uttar Pradesh. The distribution of sheep may be properly studied by dividing the sheep areas into following regions :

1. The Temperate Himalayan Region. It comprises of Jammu and Kashmir, Himachal Pradesh and Uttarakhand. The entire region has temperate climate which is quite suitable for good quality sheep. Excellent pastures exist on the hill slopes. India's best quality sheep are reared in the Kulu, Kangra and Chamba districts of Himachal Pradesh and Kashmir Valley at altitudes varying from 2,000 to 3,000 metres. The shephards practise *seasonal transhumance*, going up in summer and moving down in winter. There are about 55 lakh sheep producing over 5,000 tonnes of superior qaulity wool in this region.

2. The Dry North-Western Region. This region includes Rajasthan and neighbouring parts of Punjab, Haryana, western Uttar Pradesh, Gujarat and Madhya Pradesh. There are more than 13 million sheep contributing to about half of the total wool production of India. However, the wool is of comparatively inferior quality and the yield of wool per sheep is lower than that of the Himalayan region.

3. The Semi-arid Southern Region. This region comprising Maharashtra, Karnataka, Andhra Pradesh, Telangana, Tamil Nadu and parts of Madhya Pradesh supports about 23.5 million sheep which is about one-third of the total number of sheep found in India. In spite of the largest number of sheep, this region produces only 11,000 tonnes of inferior quality rough wool. About 50 per cent of the sheep of this region are raised for mutton and produce no wool.

4. The Humid Eastern Region. This region, comprising Bihar, West Bengal, Assam and Odisha, has humid climate which is not favourable for sheep rearing. There are about 30 lakh sheep which are mainly reared for producing mutton. The per sheep wool and the total production of wool are lower than that of any other region.

Development of Sheep

Development of sheep is necessary to meet the growing demand for wool and mutton in the country and for a possible export of these commodities. This can be done by scientific breeding of the sheep. The breeding policy envisages selective breeding of important carpet wool breed and cross-breeding involving suitable exotic breeds with coarse carpet type. India is importing large number of exotic fine wool breed sheep in a phased manner. So far nearly 10 thousand fine wool sheep have been imported from the USA, Australia and Russia for increasing the production of quality wool. A central Sheep Breeding Farm with exotic breeds of sheep has been established at Hisar in Haryana. At present, it is having a breeding programme with pure exotic breed as well as cross breeding for production of superior rams. It has distributed over 12,000 exotic/cross breed rams to different states. During 2010-11 the form supplied 698 rams and 65 bucks.

GOATS

Goat is called the *poor man's cow* because it can be cheaply reared on meagre grass of poor quality. It is the major supplier of mutton along with milk, hair and skins. The number of goats increased sharply from 47.16 million in 1951 to 140.5 million in 2007. Goats are found in larger number as compared to sheep and are next only to cattle. About one-sixth of the world's goats are reared in India. Although goats are found in almost all parts of the country, their major concentration is in Bihar, Rajasthan, West Bengal, Uttar Pradesh, and Maharashtra. These states account for more than half the goats of India.

About 90 per cent of goats in the country are *desi* or non-descript, mostly found in the Deccan Plateau. But there are some outstanding breeds which are found in some specific areas. The Himalaya or *Angora* goat which is also known as the *Chamba*, *Gaddi*, *Chegu* or Kashmiri breed is reared in Kashmir and Himachal Pradesh. It produces soft warm hair. The *Pashmina* reared in Kashmir and Kulu valley is world renowned for its pashmina hair known as ***Mohair***. The yield of hair per goat varies from 21 to 56 grams per year. The *Jamunapuri* is the breed found between the rivers Yamuna and the Chambal. It is a dual purpose breed providing meat and milk. The *Barabari* breed of western Uttar Pradesh and Haryana can yield upto 2.5 kg of milk per day. Among the other breeds are the *Beetal* of Punjab, the *Marwari*, *Mehsana*, *Kathiawar*, and *Zalwadi* of Rajasthan, Gujarat and Madhya Pradesh and the *Barari*, *Surti* and *Deccani* of the Peninsular India. Several important foreign breeds such as *Alpine*, *Nubian*, *Saanen*, *Toggenberg* and *Angora* have been used for cross breeding with the local breeds.

PIGS

There are about 100 lakh pigs providing about 5 per cent of India's meat production in the form of pork. In a poor and thickly populated country like India, pig rearing is an important activity because pig provides rich meat at low cost. Pig farming plays an important role in improving the socio-economic status of sizeable section of weaker rural communities especially in north-eastern states where every rural family rears pigs for meat. Pig farms have been set up for improving the quality of pigs. At present, there are about 100 pig farm units in the country run by state governments maintaining about 29,000 pigs.

The Central Government has prepared a scheme to assist farmers/landless labourers/cooperatives and Tribals, particularly in the North-eastern States by rearing pigs under stall fed condition for quality pork production and organised pork marketing in rural and semi-urban areas. The main objectives of the scheme are :

(*a*) Encourage commercial rearing of pigs by adopting scientific methods and creation of infrastructure.

(*b*) Production and supply of improved germ plasm.

(*c*) Organising stakeholders to popularize scientific practices.

(*d*) Create supply chain for meat industry.

(*e*) Encourage the value addition for better income.

HORSES AND PONIES

There were 8.46 lakh horses and ponies in the country in 2007. They have lost much of their importance with the increasing use of automobiles for transport. But in remote hilly areas, horses and ponies are the only means of transport. About one-fourth of the total horses and ponies are found in Uttarakhand, Himachal Pradesh, Bihar, and Jammu and Kashmir. Some of the important indigenous breeds include *Marwari*, *Kathiawari*, *Manipuri*, *Bhutani*, *Spiti* and *Chummarti*. Some other breeds have been developed by cross-breeding the indigenous breeds with the Arabian and English breeds.

DONKEYS AND MULES

Donkeys and mules are used as beasts of burden, especially in those areas where modern modes of transportation cannot be used. Most of the donkeys are found in Rajasthan, Uttar Pradesh, Punjab, Gujarat and Tamil Nadu. Mules are derived from the cross-breeding of mares and donkeys. The largest concentration of mules is found in Uttar Pradesh and West Bengal.

CAMELS

Camel is an extremely useful animal for draught and transport purposes in the arid lands and is called ***ship of the desert***. There were about 140 lakh camels in the country in 2007, about two-thirds of which were concentrated in Rajasthan alone. The rest of the camels are found in the arid and semi-arid areas of Punjab, Haryana and Gujarat.

LIVESTOCK PRODUCTS

Livestock provide us with a large variety of products which are very useful in our everyday life. Animal products help in increasing the national income and in the upliftment of the rural masses. Livestock products play a significant role in the national economy of India. As mentioned earlier, the gross value of output from livestock sector (at current prices) is estimated to account for 25 per cent of the total value of output from agriculture sector. This excludes the contribution of animal draught power. Animal husbandry plays a significant role in rural economy by providing gainful employment particularly to small/marginal farmers and agricultural labourers and more so for people living in drought prone, hilly, tribal and other poorly developed areas, where crop production on its own may not sustain them fully. The major animal products include milk, meat, wool, hides and skins, dung, etc. Several industries mainly depend on the animal products. Over and above, animals render extremely useful service in different agricultural operations. Draught animals plough 100 million hectares of farmland forming 60 per cent of the cultivated area. They also

transport 25,000 million tonne kilometres of freight. Without animals, no cultivation would be possible, fields would remain unploughed, stores and bins stand empty and food and drink loose half their savour, for in a vegetarian country like India what can be worse than to have no milk, butter or *ghee*.

Milk

Milk is primarily obtained from buffaloes, cows and to some extent from goats and sheep. About two-thirds of buffaloes milk is produced in Uttar Pradesh, Punjab, Haryana, Andhra Pradesh, Telangana and Madhya Pradesh. Similarly, about two-thirds of cow milk is produced in Uttar Pradesh, Tamil Nadu, Madhya Pradesh, Maharashtra, Punjab, Kerala, Karnataka and Bihar.

White Revolution

The production of milk immediately after Independence was at a very low level and remained almost stagnant between 1947 and 1970 with animal growth rate of merely one per cent. As a result of concerted efforts by centre and state governments, the milk production increased rapidly. Milk production increased from a meager 17 million tonnes in 1951 to a staggering 132.43 million tonnes in 2012-13 thus registering a 7.8 times growth within a span of six decades. The per capita availability of milk also increased from 124 grams per day in 1951 to 290 grams per day in 2011-12 (**Table 18.1**). This phenomenal increase in milk production after 1970 has been named as ***White Revolution***, similar to Green Revolution in agriculture. India is now the world's largest producer of milk. The dairy sector is the largest contributor in the agricultural sector to the nation's GDP.

Operation Flood

The phenomenal increase in milk production (**Table 18.1**) has also been termed as ***Operation Flood***. It started with the establishment of the National Dairy Development Board (NDDB) in 1965. This board was set up to promote, plan and organise dairy development through cooperatives. These cooperatives were envisaged as democratic institutions, owned and managed by rural producers and were sensitive to the producers' demands. The dairy development programme through cooperative

TABLE 18.1. Phenomenal Increase in Milk Production in India (1950-51 to 2011-12)

Year	Milk Production (in million tones)	Per Capital availability of milk in gram per day
1950-51	17.0	124
1960-61	20.0	126
1970-71	22.0	128
1980-81	31.6	128
1990-91	53.9	176
2000-01	80.6	217
2005-06	97.1	241
2006-07	102.6	251
2007-08	107.9	260
2008-09	112.2	266
2009-10	116.4	273
2010-11	121.8	281
2011-12	127.9	290
2012-13	132.4	—

Source : (*i*) Economic Survey, 2004-05, p. 175
(*ii*) Economic Survey, 2011-12, p. 192
(*iii*) Economic Survey, 2012-13, p. 185.
(*iv*) Economic Survey 2013-14, p. 149.

societies was first established in the Anand District of Gujarat which was most successful. Consequently Anand model of dairy development was replicated in other parts of the country. The cooperative societies helped the milk produces by providing financial and technical assistance and in the sale of milk at remunerative prices.

The NDDB launched 'Operation Flood' in 1970 with commodity gifts from the European Economic Community. Those gifts included skimmed milk, milk powder and butter oil. The operational system of 'Operation Flood' consists of multi-tiered cooperative structure with Primary Village Cooperative Societies at the base. District Units at the district level, State Federations at the state level and the National Cooperative Dairy Federation of India as the apex body for milk cooperative societies. The cooperative societies have a well organised system of carrying milk from the producers to the consumers. After milk is being collected at the village collecting centre, milk is promptly transported to the dairy plant at the milk chilling centre. The timings of collecting milk are rigidly maintained by the village society, truck operators and milk is quickly transported to dairy plants. The chilling plants are managed by producers' cooperative unions which purchase milk directly from the producers, thus eliminating the middlemen. Before setting up of these societies, middlemen were indulging in maximum exploitation of the milk producers.

Today, 'Operation Flood' is considered to be the largest dairy development programme in the world.

Objectives

Following are the main objectives of 'Operation Flood':

1. Forming cooperative societies.
2. Procurement transportation and storage of milk at the chilling plants.
3. Production of milk products and management of their marketing.
4. Provision of cattle feed.
5. Facilities for superior breeds of cows and buffaloes, health services, veterinary treatment and artificial insemination.
6. Provision of extension services.

Phases of the White Revolution

The White Revolution is usually examined under the following three phases:

Phase-I (1970-81). The objective of this phase was to set up dairy cooperatives in 18 milk sheds in 10 states to provide milk to four metropolitan cities *i.e.*, Mumbai, Kolkata, Delhi and Chennai. The important step in this phase was the setting up of 4 Mother Dairies in Mumbai, Kolkata, Delhi and Chennai. By the end of this phase, there were 13,000 village dairy cooperatives covering 15 lakh farmer families.

Phase II (1981-85). This phase coincided with the Sixth Five Year Plan and was designed to be built on the foundation of Phase-I. Dairy development programme was extended to three states of Karnataka, Rajasthan and Madhya Pradesh. The programme aimed at organising in 144 more cities, proper provision for fodder to feed the milch animals, control on animal diseases, improving the breeds and providing facilities to the milkmen. A new vaccine called 'Raksha' was developed by the Research Institute at Hyderabad to control cattle diseases. By the end of Phase II, there were 136 milk sheds and 34,500 village dairy cooperatives with a membership exceeding 36 lakhs.

Phase III. Started in 1985, this phase aimed at setting up 170 milk centres to benefit 250 districts in 22 states. The emphasis was on consolidating the gains of earlier two phases by improving productivity and efficiency of the cooperative dairy sector and its institutional base for sustainable development. By September 1996, about 73,300 dairy cooperative societies had been organised in 170 milksheds and the membership rose to ten million milkmen.

Achievements of White Revolution

1. India has become the largest producer of milk in the world.
2. There has been significant increase in the total production of milk and per capita availability of milk in the country.
3. The increase in milk and milk products has reduced the import of these products substantially and helped in saving the precious foreign exchange. In fact, India is now in a position to export some of the milk products to a number of countries.
4. The small and marginal farmers and landless labourers have been especially benefited from the White Revolution. About two-thirds of the milk supplies under "Operation Flood" come from the small and marginal farmers and landless labourers.
5. 'Operation Flood' has helped in increasing the income levels of small and marginal farmers as well as of the landless labourers. About 9 million small farmers in 70,000 village are earning jointly an incremental income of about ₹ 2,500 crore annually.
6. Dairy industry and infrastructure have been expanded and modernised. A Milk Grid has been activated to offset regional and seasonal imbalance in milk production. A stable structure has now been developed to safeguard against political instability.
7. To ensure success of 'Operation Flood' programme, research centres have been set up at Anand, Mehsana, Palampur (Banaskantha) all in Gujarat. Besides, three regional centres are working at Siliguri, Jalandhar and Erode.
8. A centrally sponsored scheme for livestock insurance was initiated in 2006-07 and is being implemented in all the states with twin objectives of providing protection mechanism to farmers and cattle rearers against any eventual loss of their animals due to death and to demonstrate the benefit of the insurance of livestock and popularize it with ultimate goal of attaining qualitative improvement in livestock and its products. The scheme benefits farmers and cattle rearers with indigenous/cross-breed milk cattle and buffaloes in 300 selected districts. During 2006-07 and 2010-11, about 29.10 lakh animals were insured.
9. Genetic improvement of milch cattle has been made possible by cross-breeding and this process has become very common in India.

Problems

White Revolution has several achievements to its credit and has increased the milk production to a great extent and has infused new life in producers and consumers alike. In spite of all its achievements, it has to face some problems as described below:

1. Collection of milk from remote and inaccessible areas is difficult, expensive, time consuming and economically unviable. Under these circumstances, the producers do not get remunerative price for their milk but the consumers have to buy milk at much higher cost.
2. In most villages, the cattle are kept under unhygienic conditions which results in lesser quantity of lower quality milk.
3. The existing marketing facilities are inadequate. In most villages, milk is converted into *ghee* which is not much remunerative. Therefore, there is need to improve the marketing infrastructure.
4. Although India possesses some of the best breeds of cattle in the world, yet most of the breeds are inferior which yield low production. There is great scope for improving the cattle breeds.
5. The extension service programme is not effective and needs improvement.

Prospects

Keeping in view the number of milch cattle and increasing demand for milk and milk products, it can be safely said that dairy development in India has great future. There are immense possibilities of capturing the international market with reference to liberalisation and global trade. Several corporate sector firms are taking advantage of the existing situation of liberalisation and globalisation. Such a situation can be encashed by strengthening the infrastructure and by increasing the production. India is capable of exporting milk products after meeting her domestic requirements by increasing quantity and improving quality of its products. The government has constituted Technology Mission for dairy development and Anand Model Cooperatives are being promoted to cover about 60 per cent of the total area of the country.

Intensive Dairy Development Programme (IDDP) was launched in 1993-94 for helping Non-Operation Flood, hilly and backward areas. Following are the main objectives of the IDDP:

(*i*) development of milch cattle

(*ii*) increasing milk production by providing technical input services

(*iii*) procurement, processing and marketing of milk in a cost effective manner

(*iv*) ensure remunerative prices to the milk producers

(*v*) generate additional employment opportunities

(*vi*) improve social, nutritional and economic status of residents of comparatively more disadvantaged areas.

The scheme was modified in March 2005 and also extended to some districts of Operation Flood Programme.

A comprehensive new scheme National Programme on Bovine Breeding and Dairy Development was launched with the objective of enhancing milk production and productivity in a sustainable manner. The National Dairy Plan Phase-I was launched in March 2012 with the objective of improving productivity of milch animals, strengthening and expanding village-level infrastructure for milk procurement and providing producers greater access to market in dairy sector continues. The number of milk animals increased from 62 million in 2000 to 83.15 million in 2012.

Production of Milk at the State Level. Table 18.2 shows that Uttar Pradesh is the largest producer accounting for more than 17 per cent of the total milk production of India. This is followed by Rajasthan (10.53%) and Andhra Pradesh (including Telangana) which produces more than 7 per cent of India's milk.

TABLE 18.2. Production of Milk in thousand tonnes (2012-13)

State	Production	Percentage of all India production
1. Uttar Pradesh	23,330	17.62
2. Rajasthan	13,946	10.53
3. Andhra Pradesh (including Telangana)	12,762	9.64
4. Gujarat	10,315	7.79
5. Punjab	9,724	7.34
6. Madhya Pradesh	8,838	6.67
7. Maharashtra	8,734	6.59
8. Haryana	7,040	5.32
9. Tamil Nadu	7,005	5.29
10. Bihar	6,845	5.17
Others	23,892	17.04
All India	**1,32,431**	**100.00**

Source : Data computed from Agricultural Statistics at a glance, 2013, p. 324.

Although Gujarat has the distinction of being the birth place of the "White Revolution" in India, this state produces only 7.79% of India's milk and has to content with fourth position among the major milk producing states of the country. The other important milk producing states of India are Punjab, Madhya Pradesh, Maharashtra, Haryana, Tamil Nadu and Bihar.

Meat

The annual meat production in the country is 5.9 million tonne of which 54 per cent is obtained from goats and sheep, 26 per cent from cattle, buffalo, and 7 per cent from pigs. The remaining 13 per cent comes from poultry birds. As about two-thirds of the Indian population is vegetarian and a large number of non-vegetarian people do not eat all types of meat due to religious sentiments, the production of meat is not much in spite of the fact that India has a very large livestock population. The annual per capita consumption of meat in India is less than 2 kg which is too small compared to over 100 kg in Australia, Argentina and New Zealand.

There are about 3,600 recognised slaughter houses in the country in which over five crore animals are slaughtered annually. Besides there are 32,000 illegal slaughter houses. Asia's biggest modern slaughter house is operating in Deonar, Mumbai while another abattoir of the Goa meat complex is functioning at Usgaon. There are 21 export-oriented modern abattoirs and 57 meat processing plans registered with Agriculture and Processed Food Products Export Development Authority exporting raw meat (chilled and frozen) to about 63 countries. In 1990-91 the country had exported meat worth ₹ 140 crore. The figure rose to ₹ 27,247 crore in 2013-14.

Table 18.3 shows that Uttar Pradesh is the largest meat producing state of India and produces over 19 per cent of the total meat production of the country. This is followed by Andhra Pradesh (including Telangana), West Bengal, Maharashtra, Tamil Nadu and Kerala.

Hides & Skins

India produces about 2 crore pieces of cattle hides and about 65 lakh pieces of buffalo hides accounting for about 15 per cent of the world's hides. More than 50 per cent of Indian hides are produced in Uttar Pradesh, Madhya Pradesh, Gujarat, Maharashtra, Bihar, West Bengal, Telangana and Andhra Pradesh. India also produces about one crore pieces of goat skins and about two crore pieces of sheep skins every year. Indian skins are one of the best in the world and are much in demand in the international market. India exported leather and manufactures worth ₹ 34,517 crore in 2013-14.

TABLE 18.3. Distribution of meat production in India (2012-13)

State	Production ('000 tonnes)	Percentage of all India production
1. Uttar Pradesh	1,137	19.11
2. Andhra Pradesh (including Telangana)	906	15.23
3. West Bengal	648	10.89
4. Maharashtra	591	9.94
5. Tamil Nadu	462	7.77
6. Kerala	401	6.74
Others	1,803	30.32
All India	**5,948**	**100.00**

Source : Data computed from Agricultural Statistics at a glance 2013, p. 325.

Wool

There has been a modest increase in the production of wool from 41.2 million kgs in 1990-91 to about 42.99 million kg in 2010-11. This has been possible primarily due to proper sheep care and cross breeding of the high yielding fine quality exotic breeds with low yielding coarse indigenous breeds. However, the average yield of wool per sheep is still very low as compared to that obtained in Australia, New Zealand and in some other advanced countries. A Bikaneri sheep gives an average of 1 kg per clip while a fine Merino sheep gives 3 to 15 kg per clip. About 30 per cent of Indian wool is produced in Rajasthan. The other important producers are Karnataka (17.41%), Jammu and Kashmir (16.68%), Andhra Pradesh including Telangana (10.92%), Gujarat, Himachal Pradesh, Maharashtra and Uttar Pradesh.

TABLE 18.4. Distribution of Wool Production in India in thousand kgs (2012-13)

State	Production	Percentage of all India production
1. Rajasthan	14,007	30.41
2. Karnataka	8,020	17.41
3. Jammu & Kashmir	7,681	16.68
4. Andhra Pradesh (including Telangana)	5,031	10.92
5. Gujarat	2,664	5.78
6. Himachal Pradesh	1,649	3.58
7. Maharashtra	1,503	3.28
8. Uttar Pradesh	1,456	3.16
Others	4,044	8.78
All India	**46,055**	**100.00**

Source : Data computed from Agricultural Statistics at a Glance 2013, p. 325.

The current wool production in India is 46 million kg against a total requirement of about 80 million kg per annum. Therefore, India has to import a large quantity of wool, especially the superior quality wool. India also exports raw wool in small quantity to the USA and UK.

Sericulture

Sericulture includes cultivation of mulberry tree and rearing of silk worms. Most of silk in India is obtained from silk worm which feeds on the mulberry leaves. On an average 1 kg of silk needs about 150 kg of mulberry leaves. As per current figures, about 4.5 lakh hectares of area is under mulberry cultivation. Silk production is mainly confined to areas between 15° and 34° N latitudes. The climate of the areas encompassed within this latitudinal zone is congened to the growth of mulberry trees and includes six major states of Karnataka, Andhra Pradesh, Telangana, Tamil Nadu, West Bengal and Jammu and Kashmir. These six states collectively account for 97 per cent of the total area under mulberry cultivation and 95 per cent of raw silk production in the country. Of late, sericulture has gained ground in some non-traditional areas also.

Sericulture is a labour-intensive agro-based cottage and industry which provides gainful employment to about 7,.25 million people in rural and semi-urban areas in India. Of these, a sizeable number of workers belong to schedule castes/scheduled tribes and economically weaker sections of society. There is substantial involvement of women in this industry.

The major fields of employment cover silk worm seed producers, farmers-cum-rearers, twisters, hand spinners of silk waste and traders. Mulberry plantation also requires high input of human labour. One hectare of mulberry plantation generates employment for a minimum of 13 persons annually.

Two types of silk are produced in India, *viz*. mulberry and non-mulberry. The distinction arises from the rearing of silk worms either upon mulberry leaves or on leaves of other plants. India produced 23,060 metric tons of silk in 2012 which was 13% more than produced in 2010-11. Of this mulberry silk accounts for 80.73%. The main producers of mulberry silk are Karnataka, West Bengal, Jammu and Kashmir, Tamil Nadu, Telangana and Andhra Pradesh although some other states have made some progress under their development plans. Karnataka and Andhra Pradesh are the leading producers of mulberry silk which account for 43 and 32 per cent respectively of the total mulberry silk production of India.

Vanya (non-mulberry) silk comprising Tasar, Eri and Muga are produced in Jharkhand, Chhattisgarh, Madhya Pradesh, Odisha, Bihar, West Bengal, Assam, Meghalaya, Manipur and Nagaland. In 2011-12 India produced 2,760 metric tons of Eri, 1,166 metric tons of Tasar and 122 metric tons of Muga silk. Different types of ***Vanya*** silk and spun silk and noil yarn are further defined as follows :

1. **Tasar Silk.** This silk is released from cocoons of silkworms belong to saturniidae family which are fed on leaves of oak, Asan, Arjuna trees. It is mainly produced in Jharkhand, Bihar, Chhattisgarh, Madhya Pradesh, Odisha, West Bengal and Andhra Pradesh.
2. **Eri Silk.** It is spun from cocoons of silkworms belonging to saturaiidae family which are fed on castor leaves. Eri silk is mainly produced in Assam, Bihar, Manipur, Meghalaya, Nagaland and West Bengal.
3. **Muga Silk.** This type of silk is produced only in Assam from cocoons of silkworms belonging to saturniidae family which are fed on Som and Soalu leaves.
4. **Spun Silk Yarn.** As the name indicates, spun yarn is composed of silk filaments of lengths varying from 1 to 20 cm produced by breeding, dressing and spinning the silk waste which is the by-product of the raw silk reeling industry.
5. **Noil Yarn.** It is a short, staple residue obtained during dressing operations in silk spinning from silk waste. It is a by-product of spun silk industry. This can be spun into Noil yarn of course counts.

Poultry Farming

The term 'poultry' refers to domestic fowls which are reared for their flesh, eggs and feathers and includes chickens, ducks, geese, turkeys, etc. Poultry farming has assumed much importance due to the growing demand of poultry products, especially in urban areas, because of their high food value. There has been a rapid increase in the number of poultry birds. Andhra Pradesh along with Telangana has the largest number of poultry birds accounting for about 18.2 per cent of the total poultry birds of India. This is followed by Tamil Nadu, Maharashtra, West Bengal and Karnataka.

Poultry sector has emerged from entirely unorganised farming practice to commercial production system with state-of-the-art technological innovations. It involves small capital investment; provides direct and indirect employment to the people and is a potent tool for subsidiary income generation for landless and marginal farmers.

TABLE 18.5. Production of eggs in India

Year	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
No. of eggs in millions	1,832	2,281	6,172	10,060	21,101	36,632	53,583	55,562	60,267	63,024	66,450	69,730

Source : Economic Survey, 2013-14, Statistical Appendix p. 21.

At present, India is among the top five chicken meat producing countries of the world. In the year 2011-12 India produced more than two million metric tonnes of poultry meat. The production of eggs increased from 1832 million 1950-51 to 69,730 million in 2012-13 (**Table 18.5**). Per capita availability of eggs was about 55 per year in 2011-12. According to the Agricultural and Processed Food Products Export Development Authority (APEDA), exports of poultry products were around ₹ 372 crore in 2009-10.

After the initial boost given by the Central Poultry Breeding Farms to promote poultry farming on commercial lines in the country, the poultry sector has flourished and now about 70 per cent of the production management and marketing is under highly organised sector. Four Central Poultry Development Organizations (CPDOs) are at Bengaluru (Southern Region), Bhubaneshwar (Eastern Region), Chandigarh (Northern Region) and Mumbai (Western Region) are functioning to provide necessary services including training the farmers to upgrade their skills. They are playing a pivotal role for implementing the policies of the Government with respect to poultry. The mandate of these organisations has specially been re-oriented to focus on improved indigenous birds, which lay on an average 180-200 eggs per annum and have vastly improved Feed Conversion ratio in terms of the feed consumption and weight gained. CPDO Bengaluru is also imparting training to in-service personnel from within the country as well as from overseas. Diversification with species other than chicken like ducks, turkey, guinea, fowl, Japanese squail and emu is also undertaken. The Central Poultry Performance Testing Centre (CPPTC) at Gurgaon is entrusted with responsibility of testing the performance of layer and broiler varieties. The "Poultry Development" scheme comprising three components, namely Assistance to State Poultry Farms, Rural Backyard Poultry Development, and Poultry Estates, is being implemented. Further, to encourage entrepreneurship skills of individuals, a central-sector 'Poultry Venture Capital Fund' scheme is also being implemented on capital subsidy mode since 1 April, 2011, covering various poultry activities.

TABLE 18.6. Distribution of Eggs in India (2012-13)

State	Number of eggs (lakhs)	Percentage of all India production
1. Andhra Pradesh (including Telangana)	2,22,974	31.98
2. Tamil Nadu	1,19,337	17.11
3. West Bengal	47,115	6.76
4. Maharashtra	45,661	6.55
5. Haryana	42,343	6.07
6. Punjab	37,911	5.44
7. Karnataka	36,773	5.27
8. Odisha	23,230	3.33
9. Kerala	22,375	3.21
Others	99,588	14.28
All India	**6,97,307**	**100.00**

Source : Data computed from Agricultural Statistics at a glance, 2013, p. 324.

Table 18.6 makes it clear that Andhra Pradesh along with Telangana is the largest producer of eggs. In the year 2012-13, these two states produced about one third of the total eggs produced in India. This was followed by Tamil Nadu (17.11%), West Bengal (6.76%), Maharashtra (6.55%) and Haryana (6.07%). The other major producers are Punjab, Karnataka, Odisha and Kerala.

FISHERIES

Introduction

Fishing is one of the oldest occupations of man. Man learnt fishing much before he could learn something about agriculture. Fishing has assumed much importance in view of the rapidly increasing population and depleting land resources. Fish provides protein rich food and is also a big source of vitamins A, B and D. There are about 30,000 species of fish in the world out of which about 18,000 are found in India. Fish forms an important part of diet of the people living in the coastal areas of Kerala, West Bengal, Odisha, Andhra Pradesh, Tamil Nadu, Maharashtra, Karnataka, Goa and Gujarat. Inedible fish is also a rich source of animal protein for livestock feeding. Fish scales and fishery wastes are also a source of organic manure. The fish catch in India is of two types :

1. Sea or Marine Fisheries. It includes coastal, off-shore and deep sea fisheries mainly on the continental shelf upto a depth of 200 metres.

2. Inland or Fresh Water Fisheries. Rivers, lakes, canals, reservoirs, ponds, tanks, etc. contain fresh water and provide fresh water fisheries. Inland fisheries also include those obtained from estuaries, delta channels, back-waters, lagoons and coastal lakes.

Fish Production in India

India is the third largest producer of fish and second largest producer of inland fish in the world. The fisheries sector provides employment to over 14 million people engaged fully, partially or in subsidiary activities pertaining to the sector, with an equally impressive segment of the population engaged in ancillary activities and accounts for about one per cent of the total agricultural production in India. On an average a fisherman catches 2,000 to 2,500 kg of fish every year. Fish production has more than doubled in a span of about two decades from 3.8 million tonnes in 1990-91 to 9 million tonnes in 2012-13. The production of fish in selected years is shown in **Table 18.7**.

Marine Fisheries

India has a coastline of over 7,517 km including that of Andaman and Nicobar Islands and Lakshadweep Islands and its continental shelf spreads over 3,11,680 sq km. This entire area is suitable for marine fisheries. It is estimated that about 75 per cent of the marine fish landings are on the West coast and only 25 per cent is contributed by East coast.

TABLE 18.7. Production of Fish in India ('000 tonnes)

Year	Marine	Inland	Total
1950-51	534	218	752
1960-61	880	280	1,160
1970-71	1,086	670	1,756
1980-81	1,555	887	2,442
1990-91	2,300	1,531	3,836
2000-01	2,811	2,845	5,656
2005-06	2,816	3,756	6,572
2006-07	3,024	3,845	6,869
2007-08	2,920	4,207	7,127
2008-09	2,978	4,638	7,616
2009-10	3,104	4,894	7,998
2010-11	3,250	4,981	8,231
2011-12	3,372	5,294	8,666
2012-13(P)	3,275	5,744	9,019

P = Provisional

Source : Agricultural Statistics at a Glance, 2013, p. 326.

There is a vast scope of increasing the marine fish in India. It is worth mentioning here that Indian Ocean is the least exploited of all the oceans of the world so far as fishing is concerned. The important fish caught along the coast are *shark*, *sardine*, *herring*, *anchovies*, *Mumbai duck*, *fly fish*, *ribbon fish*, *mackerel* and *Indian salmon*. Mackerel accounts for about one-third of the total catch while herring and prawn account for 15 per cent and 9 per cent respectively. Kerala, Maharashtra, Tamil Nadu, Karnataka, Andhra Pradesh, Odisha, West Bengal and Gujarat are the main producers of marine fish.

India's offshore and deep sea fish catch is very poor considering the marine potential of 20-25 million tonnes annually. Only 10-12 per cent is caught at present. Only 11 per cent of the potential fishing grounds are more than 200 metres deep, even then we are not able to make proper use of the natural advantage. Following are the main reasons for this sad state of affairs.

(*i*) India has tropical climate in which fish cannot be preserved for a long time and spoils very quickly. Heavy expenditure on refrigeration and deep freezing increases the market price of the fish.

(*ii*) Indian coast does not have many gulfs, bays, estuaries and backwaters as is the case with Norway. As such, it lacks good fishing grounds.

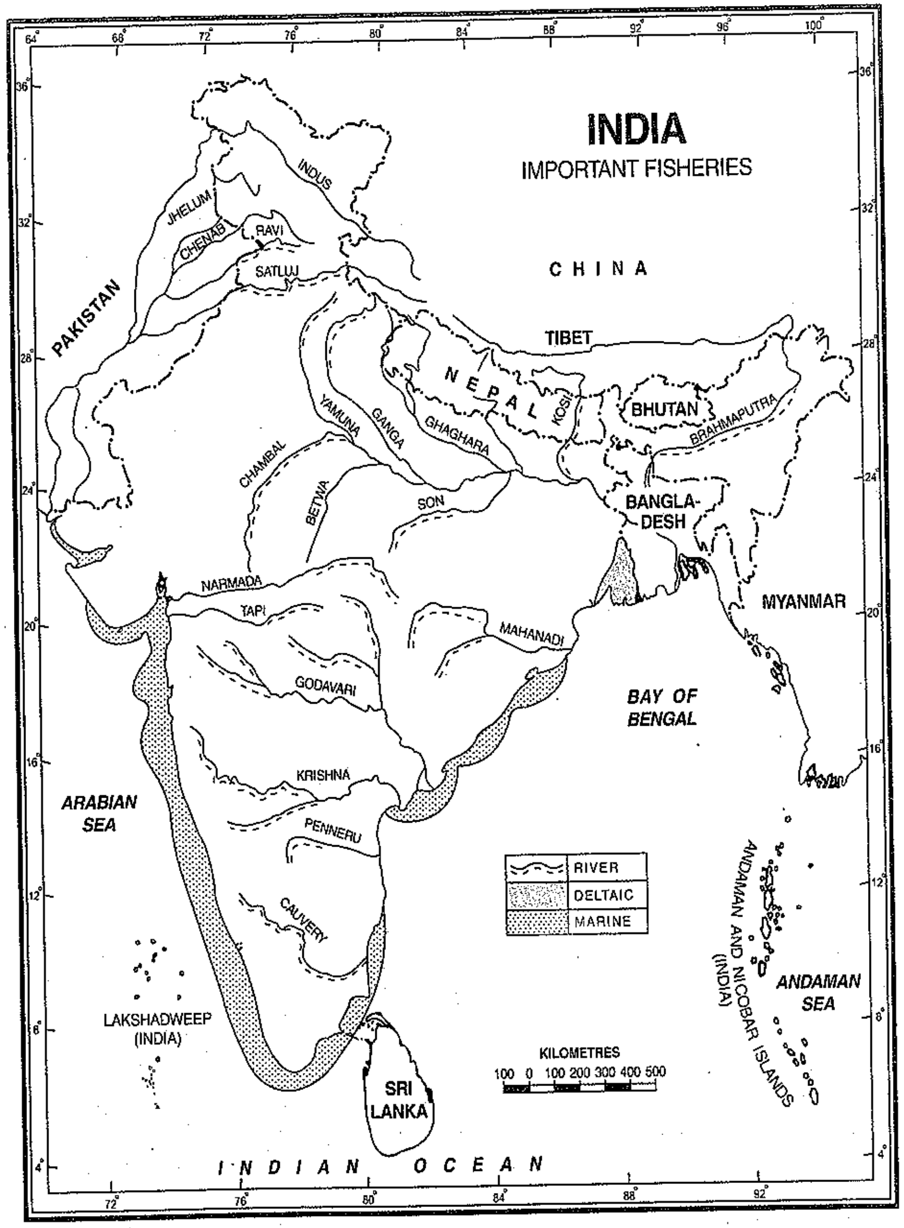

FIG. 18.4. India : Major Fisheries

(*iii*) Marine fishing in India is a seasonal phenomena. Strong winds during the monsoon season accompanied by tropical cyclones often hinder fishing operations.

(*iv*) Majority of Indians are vegetarians and do not eat fish.

(*v*) About 60 per cent of the fishermen still use small non-mechanised boats. They normally do not venture beyond 10 km from the coast and in waters more than 18 metres deep. They have to come back to the coast at night.

(*vi*) Lack of landing, freezing, canning, transport and organised markets are other handicaps faced by fishing in India.

Fresh Water or Inland Fisheries

India's inland fishery resources are one of the richest in the world. Rivers, irrigation canals, reservoirs, lakes, tanks, ponds, delta channels, backwaters, lagoons, estuaries, etc. provide the foundation for inland fisheries. The inland fish production has increased at a much faster rate as compared to marine fish. In the year 1950-51, the inland fish caught was only 218 thousand tonnes which was less than 29 per cent of the total fish caught in the country. After half a century *i.e.* in 2000-01 the inland fish was more than the marine fish which happened for the first time. After that, the inland fish production increased rapidly whereas marine fish production almost stagnated. In 2012-13, the inland fish accounted for 5,744 thousand tonnes which was about two-thirds of the total fish caught, thereby recording over four times increase in a span of 23 years. India's riverine fishery resources comprise the major river systems of the Ganga, the Brahmaputra, the Indus, the Mahanadi, the Narmada, the Tapi, the Godavari and the Krishna. The total length of the fishable rivers, along with their tributaries is 27,359 km. The length of irrigation channels is 1,12,654 km. The dam reservoirs and small lakes cover an area of 29 lakh hectares. Another 26 lakh hectares of land is covered by brackish water in the form of coastal lakes and lagoons. About 16 lakh hectares are covered by tanks and ponds out of which 6 lakh hectares are used for pisciculture.

Distribution

Although fishing is carried on in almost all parts of the country, about 97 per cent of India's marine fish and about three fourth of the country's inland fish are caught in the littoral states like Andhra Pradesh, West Bengal, Gujarat, Kerala, Tamil Nadu, Maharashtra .

TABLE 18.8. State-wise Production of Fish (2012-13) (in tonnes)

State	Marine	Inland	Total
Andhra Pradesh	4,14,349	13,93,728	18,08,077
West Bengal	1,52,352	13,37,664	14,90,016
Gujarat	6,93,500	92,586	7,86,086
Kerala	4,84,392	1,49,098	6,33,490
Tamil Nadu	4,28,441	1,91,956	6,20,397
Maharashtra	4,33,684	1,45,110	5,78,794
Karnataka	3,73,167	2,02,216	5,75,383
Odisha	1,18,311	29,183	4,10,143
Others	1,76,895	21,42,466	22,06,762
All India	**32,75,091**	**57,44,057**	**91,69,148**

Source : Data computed from Agricultural Statistics at a glance 2013, pp. 327-28.

1. Andhra Pradesh. Andhra Pradesh is the largest fishing state on the eastern coast of the Peninsular India producing about 20 per cent of the total fish of India. Its 960 km long coast is dotted by villages of fishermen in addition to the major fishing centres like, Vishakhapatnam, Machilipatnam and Kakinada. About 84 thousand fishermen use 580 mechanized and over 36,000 non-mechanized boats for fishing. There are 1,169 primary cooperatives to handle the processing of fish. *Oil sardine*, *mackerel*, *silver bellies*, *ribbon fish*, *catfish* and *soles* are important varieties of fish caught here. A large quantity of fish is sent to West Bengal where there is a great demand for fish.

2. West Bengal. West Bengal is the second larget producer of fish in India. More than 6 per cent of India's total fish is caught in West Bengal. Here the inland fish far exceeds the marine fish. West Bengal also is the second largest producer of fresh water fish accounting for nearly 23 per cent of India's fresh water fish. The Ganga Delta is inhabited by about one lakh fishermen who are engaged in fresh water fishing. Bengalis are fond of fresh water fish. The state can meet only 20 per cent of its demand and the rest is obtained from other states.

3. Gujarat. With 1,000 km long coast and over 65,000 sq km fishing ground, Gujarat is the third most important producer of fish in the northern part of western coast and accounts for over 8 per cent of the total fish of India. There are 52 big and small fishing ports on the Gujarat coast. Kandla, Porbandar, Navabandar, Dwarka, Umbergaon and Jaffarabad are important centres. Besides several small towns and a large number of villages also contribute to fishing. About 1.5 lakh fishermen are engaged in catching about 7 lakh tonnes of fish every year. *Mumbai duck*, *pomfret*, *jew fish*, *Indian salmon*, *tunnies*, *grey mullet*, *mackerel*, *eel*, *shark*, etc. are important fish varieties caught here. Local consumption being very low, about 97 per cent of the fish is transported to big markets like Mumbai, Kolkata and Delhi. Some fish is exported to Sri Lanka, Myanmar, Mauritius and Singapore.

4. Kerala. Kerala is the fourth largest fish producing state of India and accounts for about 7 per cent of the total fish production of the country. The 590 km long Kerala coast is indented and is dotted by a large number of lakes and lagoons. In fact Kerala coast is the most intensely fished area of India. There are about 1.35 lakh fishermen in Kerala. They use over 3 thousand mechanised boats and about 27 thousand country craft to catch fish. The mechanised production is 32 tonnes per boat as against about 10 tonnes by country craft. About 60 per cent of the total fish caught is consumed within the state, 22 per cent sold to other states and the remaining 18 per cent is exported. Kerala has about 85 per cent of India's total processing facilities such as freezing, ice making, cold storage, canning, etc. and processes the largest amount of fish in the country. *Oil sardines*, *prawns*, *horse mackerel*, *soles*, *lactarius* and *shark* are the most important marine fisheries. Inland fisheries include *prawns*, *barbus*, *clarius*, *mallet*, *etroplus*, and *murrels*. Thiruvananthapuram, Kozhikode, Kochi, Kollam, Azhikode, Ponnani, Kannur, Baliapatnam, Baypore, Vizhinjam, etc. are the leading centres of fish production.

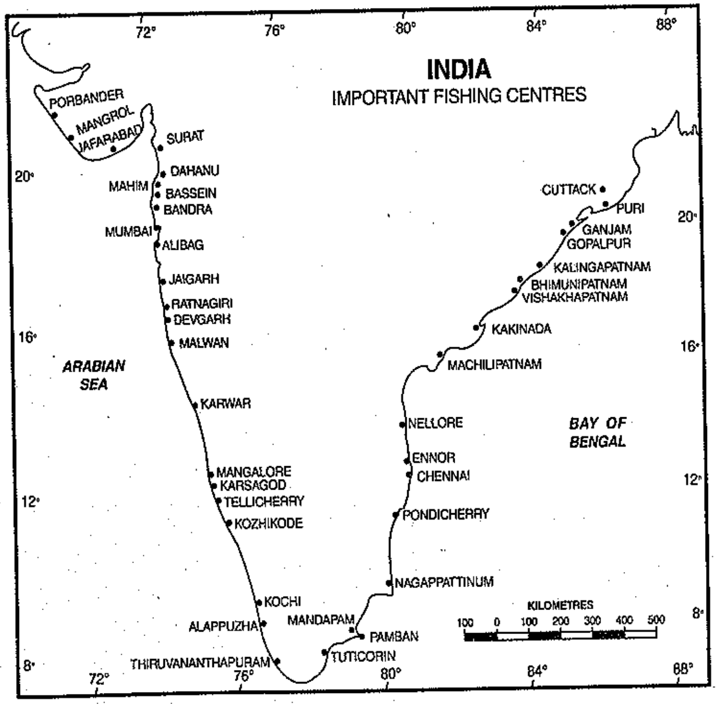

FIG. 18.5. India : Important Fishing Centres

5. Tamil Nadu. Tamil Nadu produces about 6.8 per cent of India's fish. The 1,000 km long coast of Tamil Nadu is not much indented which hinders fishing to some extent and encourages the use of mechanized boats. Presently, 96,500 persons are engaged in fishing along the Tamil Nadu coast using 2,757 mechanized boats and 43,343 country craft. *Mackerel*, *ribbon fish*, *catfish* and *soles* are the main varieties of marine fish caught here. Chennai is the largest centre. Other important centres are Tuticorin, Ennore, Cuddalore, Mandapam and Nagpattinam. The Tamil Nadu coast is dotted by about 300 villages of fishermen who solely depend upon fishing for their livelihood. Fish processing is done in 46 freezing, 60 cold storage, 3 canning and 6 fish meal units.

6. Maharashtra. Mahrashtra accounts for 6.4 per cent of the total fish catch of India. This state has 750 km long indented coast, as a result of which marine fish is more important than inland fish. There are about 250 villages along the Maharashtra coast inhabited by about 2.6 lakh fishermen. These fishermen operate on 4,718 mechanized boats and 5,662 traditional crafts. There are 530 primary fishing cooperatives, 41 freezing units, 6 cold storage units, 3 canning units and 6 fish meal units. The sea along the Maharashtra coast remains calm for about 7 months in a year which is quite convenient for fishing operations. *Mumbai duck*, *white pomfret*, *black pomfret*, *jew fish*, *Indian salmon*, *tunnies*, *grey mullet*, *mackerel*, *eel*, and *shark* are the chief varieties of marine fish here. Estuarine fisheries have been developed in Mahim and other creeks. Mumbai, Kolaba, Ratnagiri, Alibag and Bassein are the leading centres of fish production.

7. Karnataka. Karnataka produces nearly 6.3 per cent of India's fish. Mangalore, Karwar, Ankola, Kumta, Honawar, Bhatkal, Majali, Bingi, Chendia, Gangolli, Malpe, Udiayawar and Bokapatnam are the main centres. About 20,000 fishermen using 6,500 boats are engaged in fishing. *Sardine*, *mackerel*, *shark*, and *seer*, are the principal varieties caught here. The creeks of Netravati, Sharavati and Kali rivers are the most intensively used areas for inland fishing. Besides there are 30,000 minor tanks, 2,700 major tanks, 17 reservoirs and 6,885 km long stretch of rivers used for fishing.

8. Odisha. Both marine fish and inland fish are equally important in Odisha. Odisha's 720 km long coast provides about 410 thousand tonnes of fish every year which is about 4.5 per cent of the total fish catch of India. Cuttack, Puri, Sambalpur and Balasore are important fishing centres. Chilka lake is the most intensively fished area for inland fisheries. The fish from Chilika lakes is of superior quality and is in great demand.

Bihar (3.93%), Uttar Pradesh (3.68%), Assam (2.8%), Goa, Madhya Pradesh, Punjab, Haryana, Tripura and Punducherry are other producers.

Trade. India exports about 8 per cent of the total fish production mainly to Sri. Lanka, Myanmar, Mauritius and Singapore. Sri Lanka alone purchases 80 per cent of our fish and fish products. There has been a spectacular increase in export of marine products in the recent years. Marine products have been identified as a major thrust area for exports during the Eighth Plan and it continues till now.

PROGRAMME FOR DEVELOPMENT OF FISHERIES

Central Institute of Fisheries Nautical and Engineering Training (CIFNET) was established at Kochi for organising suitable fisheries training system at the national level. Subsequently two units were set up at Chennai and Vishakhapatnam. The main objective is to make available sufficient number of trained operatives for fishing vessels and technicians for shore establishments.

The Fishery Survey of India (FSI) is the nodal agency for survey and assessment marine fishery resources in the Indian Exclusive Economic Zone (EEZ). With its headquarters at Mumbai, it has seven operational bases at Porbandar, Mumbai, Marmagoa, Kochi, Chennai, Vishakhapatnam and Port Blair.

National Fisheries Development Board (NFDB) was set up on 9th September, 2006 with its headquarters at Hyderabad. The main objective was to increase the fish production to a level of 10.3 million tonnes, to achieve double the exports from ₹7,000 crores to ₹14,000 crore and direct employment to an extent of 3.15 million.

Development of Fishing Harbours. The Government has been implementing a scheme for providing infrastructure facilities for safe landing and berthing to the fishing vessels. Since the inception of

the scheme, six major fishing harbours *viz*. Kochi, Chennai, Vishakhapatnam, Roychowk, Paradeep and Season dock (Mumbai), 62 minor fishing harbours and 194 landing centres have been taken up for construction in various coastal states and union territories.

Fish Mapping. Fish species distribution maps for rivers Ganga, Yamuna, Chambal, Betwa, East Banas, Ken, Rupnarayan, Ajay, Subarnarekha, Kangshbati, Tapi, Narmada, Mahanadi, Godawari, Krishna, Kaveri, Tava, Tungabhadra, Hemavati and Pennar were declineated.

Development of Freshwater Aquiculture. This programme is being implement through Fish Farmers Development Agencies (FFDAs). A network of 429 FFDAs covering all potential districts in the country are in operation. During 2010-11, about 1,05,060 hectares of water area was brought under fish culture.

Marine Fishing Policy 2004

A comprehensive Marine Policy was launched in November 2004 to facilitate sustainable deep sea fishing. In the inland sector, the potential for fishery development in East and North-Eastern States is immense. Development of fisheries can go a long way to tackle the problem of food as well as unemployment in these states.

Following are the main features of Marine Fishing Policy 2004 :

The policy objectives are : (1) to augment marine fish production of the country up to the sustainable level in a responsible manner so as to boost export of sea food from the country and also to increase per capita fish protein intake of the masses, (2) to ensure socio-economic security of the artisan fishermen whose livelihood solely depends on this vocation, (3) to ensure sustainable development of marine fisheries with due concern for ecological integrity and bio-diversity.

Blue Revolution. The term 'blue revolution' is used to describe the phenomenal increase in fish production from a meager 0.7 million tonnes in 1950-51 to a staggering 9 million tonnes in 2012-13 by adopting a package of methods. It was coined and started in 1970 after the success of the Green Revolution in agriculture when the Central Government sponsored the Fish Farmers Development Agency (FFDA).

The fisheries industry has witnessed a massive transformation form the traditional subsistence type of enterprise to a multi-crore business industry with improved modern infrastructure. Motorised boats have replaced the traditional hand driven inefficient boats and big trawlers are a common site in the Indian seas. In fact Blue Revolution has brought a conspicuous improvement in fishing industry by adopting new techniques of fish breeding, fish rearing fish marketing and fish export. Refrigeration and fast transport system have opened up new vistas for exploring the untapped markets and have made fish a profitably marketable commodity.

AQUACULTURE

Also known as **aquafarming**, aquaculture refers to the production of aquatic animals and plans under controlled conditions. According to Food and Agriculture Organisation (FAO) "acquaculture is understood to mean the farming of aquatic organisms including fish, crustaceans, molluscs and aquatic plants." Although aquaculture has a long history and has been practised in China since, 2500 BC, it is a recent phenomenon in India. Aquaculture can be classified into two major categories *viz*. ***freshwater aquaculture*** and ***coastal aquaculture***. Coastal aquaculture can be further subdivided into two categories; namely ***sea farming*** and ***brackish water acquaculture***. Sea farming is concerned with the culture of organisms in open coastal waters and bays. Brackish water aquaculture, on the other hand, refers to land based farming systems using salt water from creeks, estuaries as well as from the coastal seas.

To encourage research and development in aquaculture, the Indian Council of Agricultural Research (ICAR), New Delhi, reorganised the fisheries research institute in 1987 and three different institutes were established. These are : (*i*) Central Institute of Freshwater Aquaculture (CIFA) at Bhubaneshwar (Odisha), (*ii*) the Central Institute of Brackish water Aquaculture (CIBA) at Chennai (Tamil Nadu) and (*iii*) the National Research Centre for Cold Water Fisheries (NRCCWF) at Bhimtal (Nainital, Uttarakhand).

Types of Aquaculture

1. Freshwater Aquaculture. The Central Institute of Freshwater Aquaculture (CIFA) has contributed a lot for breeding and rearing the air-breaching cat-fish (popularly known as magur) in vast areas of the country. This institute has adopted biotechnological approach and the fish are implanted with hormonal pellets to advance maturity. Freshwater shark has also been bred and reared by this institution. This is a very popular fish in the north-eastern part of India particularly in Manipur. Freshwater prawn or shrimp is an important form of aquaculture and prawn is raised for human consumption.

The initial step for freshwater aquaculture in India was taken with the setting up of Pond Culture Division at Cuttack in 1949 under the name of the Centre of Central Inland Fishers Research Institute (CIFRI). This type of aquaculture is popular particularly in the eastern states of West Bengal, Odisha and Andhra Pradesh. However, Punjab, Haryana, Assam and Tripura are also taking up this culture in a big way.

2. Brackish water Farming. This type of aquaculture has a long history. It is confined mainly to coastal wetlands impounded by human, locally known as ***bheries*** in West Bengal. It is also practised in salt resistant deepwater paddy fields in the coastal areas of Kerala, locally known as ***pokkali.*** These systems have sustained high production level although there has not been much additional input. This type of aquaculture got its due recognition after the initiation of an All India Coordinated Research Project (AICRP) in 'Brackish water Fish Farming' by the Indian Council of Agricultural Research (ICAR) in 1973. This project is credited for developing several technologies concerning fish and shrimp farming.

3. Shrimp Farming. Shrimp farming is a type of aquaculture in which marine shrimps are produced for human consumption. There has been phenomenal increase in area under shrimp farming due to development of more commercial hatcheries. The formation of Brackishwater Fish Farmers' Development Authority (BFDA) in marine states supplemented by various government programmes proved to be a great help to shrimp farming. Subsidies from the Marine Products Export Development Authority (MPEDA), loans from commercial banks gave financial support to this farming. Demonstration of semi-intensive farming technology provided the required technical support. The Central Marine Fisheries Research Institute (CMFRI) initiated studies on maturation in early 1970s. In late 1980s Marine Products Export Development Authority (MPEDA) established the Andhra Pradesh Shrimp Seed Production and Research Centre and the Odisha Shrimp Seed Production and Research Centre to facilitate shrimp farming in these two states and to benefit other states also. Obviously Andhra Pradesh, Odisha and Tamil Nadu have developed shrimp farming in a big way. Nellore district of Andhra Pradesh is such a prolific producer of shrimp that it has earned the distinct name of ***Shrimp Capital of India.*** A number of farm holdings are located in Kerala and West Bengal.

4. Mariculture. Mariculture is that branch of aquaculture which is concerned with the cultivation of marine organisms for food and other products in the open ocean, enclosed seas or a section of ocean, tanks, ponds or raceways filled with seawater. Fish, prawns and oysters are the main food products. Non-food products include fish-meat, nutrient agar, jewelleries (cultured pearls) and cosmetics. Mandapam (in Tamil Nadu) centre of Central Marine Fishers Research Institute made the earliest attempt at mariculture in 1958-59 with the culture of milkfish. This institute has developed different types of technologies for a number of species including oysters, mussels and clams among sedentary species, as well as for shrimps and finfish.

5. Algaculture. This type of aquaculture involves farming of varied species of algae. Majority of algae that are cultivated belong to the category of micro algae also referred to as phytoplankton, microphytes, or planktonic algae.

6. Integrated Multi-Trophic Aquaculture (IMTA). In this type of aquaculture, by-products (wastes) from one species are recycled as inputs for another. Fed aquaculture (*e.g.* fish, shrimp) is combined with inorganic extractive (*e.g.* seaweed) and organic extractive (*e.g.* shellfish) aquaculture to create balanced systems for environmental and economic sustainability as well as for social acceptability.

7. Fish Farming. Fish farming involves raising of fish in tanks or other water enclosures on a commercial scale. Products of fish farming are primarily used as food items. Salmon, catfish, cod, carp, trout, tilapia etc. are the chief species of fish reared under fish farming.

8. Seaweed culture. Marine algae are better known as seaweeds. Like other photosynthetic plants, seaweeds need sunlight. Little sunlight penetrates depths greater than 15 metres, so most of the seaweeds grow in shallow waters around shores or reefs. They are divided into three groups according to colour, brown, green and red. They provide food to tiny creatures, most of which filter dead particles from water. At present seaweed accounts for about 30 per cent of world aquaculture production. The Indian Ocean abounds in seaweeds, one-third of which occurs along the Indian coast. Seaweed has a wide range of application in the fields of food, textile, cosmetic, pharmaceutical, fodder, fertilisers etc. due to which its demand has increased tremendously in the recent past. Seaweed are rich in vitamins, minerals, trace elements and bioactive substances and have became an important ingredient of human food. There is vast scope for developing seaweed food in India.

9. Sewage-fed fish culture. Sewage-fed fish culture is an old practice in ***bheries*** in West Bengal. This is a culture in which fish are reared in sewage water. It involves multiple stocking and multiple harvesting approaches.

10. Paddy-cum-fish culture. In many parts of the country, fish are reared in paddy fields which are flooded with water for paddy sowing. It is practised in medium to semi-deep water paddy fields in low land areas. Strong dykes or field boundaries are constructed to prevent the escape of cultivated fish during floods. Although the system largely depends upon natural stocking, modern farming techniques are also practised. These techniques involve major and minor carps stocked at the densities of 5,000 to 10,000 per hectare are practised in several parts of the country. Fresh water prawns are also cultivated along with paddy-cum-fish.

Apiculture (Beekeeping)

The term apiculture has been derived from Latin *apis* which means a bee. Thus apiculture is the practice of developing and maintaining bee colonies by man. Beekeeping is practised mainly for honey, beeswax and for pollinating crops. Honey bees have tendency to live in colonies and as such they are kept in hives. Various types of hives are used depending on the local conditions and choice of the beekeepers. Fixed frame hives, movable frame hives and top bar hives are some of the popular types of hives used in the present day world. Usually there are three classes of bee in a colony : (*i*) a queen which is normally the only breeding female, (*ii*) about 30 to 50 thousand female workers which serve the queen and build hives and (*iii*) large number of male drones which may run into thousands in spring to a very few due to death in cold season. Beekeepers are generally categorised in following three classes :

(*i*) Commercial beekeepers, *i.e.*, beekeeping as primary source of income as in Himachal Pradesh.

(*ii*) Sideliners who keep bee as a secondary source of income; in different parts of the country.

(*iii*) Migratory beekeepers as of Kanniyakumari.

Beekeeping has become a reasonably important occupation which has great capacity to supplement the income of the farmers. It provides employment to rural workers and helps in improving the quality and quantity of crops. Honey bees are used to increase the production of plantation crops,. Cross-pollination by bees is very useful for crops. In addition to the significant role played by bees in crop production, they are a greater source of honey and wax. Currently beekeeping is carried on over a cultivated area of about 50 million hectares for growing vegetables, fruits, oilseeds, pulses, etc. and 3-4 colonies of honey bees are required per hectare of cultivated land.

Honey is the most important product of beekeeping. It contains vitamins and a large number of nutritions elements. Each 100 grams contains 138 mg potassium, 17 mg sodium, 13 mg calcium, 5 mg phosphorous and 1.5 mg iron. Further, it is estimated that 100 gm of honey gives 320 calories of energy. Traditionally honey is known to increase body resistance to diseases and help in weight management when taken regularly.

According to Food and Agriculture Organisation of the United Nations, India produced 52.23 thousand metric tons of honey in 2005 out of which about 45.0 thousand metric tonnes of honey was consumed within the country. On an average, one hive yields about 5 kg of honey which varies from 1.8 to 2.3 kg in south India to 5.5 to 6.8 kg in north India. It has been estimated that as much as 50 kg of honey can be obtained from one hive in one year by using modern technology. Only 30 per cent honey is collected by Khadi Gramodyog and commercial beekeepers and the remaining 70 per cent is collected by the tribal people. Most of the honey is collected in Himachal Pradesh, Maharashtra and Uttar Pradesh. Tamil Nadu, Karnataka, Kerala, Andhra Pradesh, Telangana, West Bengal, Chhattisgarh, Madhya Pradesh etc. are some other honey producing states.

There are vast potentialities for increasing the production of honey in India and for exporting it to European countries, USA and Japan. Indian honey is in great demand in the international market due to its high quality and low cost.

Species of Honey Bees. A large number of species of honey bees are found in India because of diversity in topography, climate and flora in this vast country. Some of the important species are briefly described as under :

Apis cerana are found in large areas especially in high Himalayan region where beekeepers log hives in their houses. In the South India, *Apis cerana* beekeeping is undertaken under the supervision of the Bee Research and Training Institute of Pune and Khadi and Village Industries Commission at Mumbai. This type of beekeeping is also practised in Mahabaleshwar hills of Maharashtra, parts of West Bengal, north-eastern states of Arunachal Pradesh and Sikkim, as well as in large parts of Karnataka, Kerala and Tamil Nadu.

Apis dorsata is found in higher reaches of the Himalayas, in the Terai region of Uttar Pradesh and Himachal Pradesh in North India. In the central part of India, thick forests provide congenial conditions for *Apis dorsata* where this breed of honey bees is kept mainly by the tribals. Mangrove forests of Sundarbans in West Bengal and Eastern Ghats in Andhra Pradesh provide ideal conditions for *Apis dorsata*.

Apis mellifera are steadily increasing in Himachal Pradesh, Punjab, Bihar and Madhya Pradesh. Breeding of this dorsata has also been introduced in West Bengal. In Himachal Pradesh, farmers keeping *Apis dorsata* practise **transhumance**. They move to higher reaches of the mountains in summer with thick loads of bee colonies for pollination of apple orchards and come down to plains in winter for placing the bee hives amongst eucalyptus trees and sunflower plants.

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CHAPTER 19

Land Utilization

INTRODUCTION

As in all other countries, land in India is put to various uses. The utilization of land depends upon physical factors like topography, soil and climate as well as upon human factors such as the density of population, duration of occupation of the area, land tenure and technical levels of the people. There are spatial and temporal differences in land utilization due to the continued interplay of physical and human factors. India has total geographical area of about 328.73 million hectares but statistics pertaining to land utilization were available for about 305.90 million hectares in 2010-11.

1. Net sown area

Cropped area in the year under consideration is called ***net sown area***. This area has a special significance in an agricultural country like India because agricultural production largely depends upon this type of land. There is an urgent need to increase the net area sown for meeting the food and other requirements of rapidly increasing population in India; although there is not much scope for increasing area under this category due to natural limitations such as topography, soils, climate, etc. Unfortunately the net sown area remained as 141.58 million hectures in 2010-11 as it was in 2000-01.

Net sown area accounted for about 46.05 per cent of the total reporting area of India (in 2010-11) against the world average of about 32 per cent. This is much higher than 40 per cent in the USA, 25 per cent in Russia, 16 per cent in Brazil and only 6 per cent in Canada. But the per capita cultivated land has gone down drastically from 0.53 hectares in 1951 to 0.11 hectares in 2011-12. This is a serious trend and can be checked only by population control.

Rajasthan has the largest net sown area of 18.35 million hectares which is about 12.96 per cent of the total reporting net sown area of India. This is followed by Maharashtra (17.41 million hectares).

It may be noted that agricultural prosperity does not depend as much as on the total net sown area as it does on the percentage of net sown area to the total reporting area. There are large variations in the proportion of net sown area to total reporting area from one state to another. Punjab and Haryana had some of the highest proportions of 82.6 and 80.5 per cent respectively while Arunachal Pradesh had 3 per

TABLE 19.1. Pattern of Land Utilization in India *('000 hectares)*

Year	Total reported area (according to village papers)	Net area sown	Area sown more than once	Total cropped area	Forests	Not available for cultivation	Permanent pastures and other grazing lands	Land under Miscellaneous tree crops and groves (not included in net sown area)	Culturable waste	Fallow lands other than current fallows	Current fallows
1950-51	284.32	118.75	13.15	131.89	40.48	47.52	6.68	19.83	22.94	17.45	10.68
1960-61	298.46	133.20	19.57	152.77	54.05	50.75	13.97	4.46	19.21	11.18	11.64
1970-71	303.75	140.86	24.93	165.79	63.83	44.61	13.26	4.37	17.50	8.73	10.60
1980-81	304-16	140.29	34.63	172.63	67.46	39.55	11.99	3.58	16.74	9.72	14.83
1990-91	304.86	143.00	42.74	185.75	67.81	40.48	11.40	3.82	15.00	9.66	13.70
2000-01	305.19	141.34	44.00	185.34	69.84	41.23	10.66	3.44	13.63	10.27	14.76
2005-06	305.45	141.16	51.57	192.73	69.99	42.32	10.44	3.39	13.22	10.70	14.21
2006-07	305.65	139.82	52.56	192.38	70.03	42.73	10.42	3.35	13.27	10.52	15.51
2007-08	305.67	141.02	54.21	195.23	69.96	42.90	10.36	3.40	13.04	10.33	14.65
2008-09	305.84	141.90	53.41	195.31	69.98	43.06	10.34	3.34	12.73	10.29	14.19
2009-10	305.83	139.18	49.81	188.99	69.99	43.32	10.34	3.21	12.95	10.83	16.01
2010-11	305.90	141.58	57.39	198.97	70.01	43.56	10.30	3.21	12.66	10.32	14.27

Source : Agricultural Statistics at a Glance, 2013, pp. 257-58.

cent only in 2010-11. Large parts of the Satluj, Ganga plains, Gujarat plains, Kathiawar plateau, Maharashtra plateau and West Bengal basin have high proportion of cultivated area. This is largely due to gentle slope of the land, fertile alluvial and black soils, favourable climate, excellent irrigation facilities and high density of population. In contrast, mountainous and hilly areas in the Himalayan region and some of the drier tracts are not much suited to farming because of rugged topography, unfavourable climate and infertile soils.

2. Area sown more than once

As the name indicates, this area is used to grow more than one crop in a year. According to **Table 19.1,** the total cropted area has increased from 185.34 million hectares in 2000-01 to 198.97 hectares in 2010-11. This means that the area sown more than once has increased from 44.00 million hectares in 2000-01 to 57.39 million hectares in 2010-11. Thus there is a net increase of over 13 million hectares in 'area sown more than once' in a short span of ten years. This is healthy trend and this pace of increasing area sown more than once should be kept if we really want to be self-sufficient in food grains and succeed in our mission of food security in view of the rapidly increasing population. This type of area comprises of land with rich fertile soils and regular water supply. It is clear that the percentage of area sown more than once is rather low in India as a whole. This is attributed to infertile soils, deficiency of moisture and insufficient use of manures and fertilizers. This type of land is of special significance. Since almost all the arable land has already been brought under plough, the only course left to increase the agricultural production is to increase the intensity of cropping which can be done by increasing the area sown more than once. Large tracts of the Indo-Ganga plain in

Punjab, Haryana, Uttar Pradesh and Bihar and in coastal regions have large percentage of area sown more than once.

3. Forest Area

This area includes all land classified either as forest under any legal enactment, or administered as forest whether state owned or private and whether wooded or maintained as potential forest land. The area of crops grown in the forest and grazing lands or areas open for grazing within the forests remain included under the forest area. Forests cover about 23 per cent of the reported area which is a definite improvement against 14 per cent in 1950-51. However, 23 per cent of forest land to the total reporting area is not sufficient for a tropical country like India where about 33 per cent of the total land should be under forests. This will require massive tree plantations and vigorous restrictions on the reckless felling of trees. According to the expert committee recommendations, much of the area reclaimed from the forest for agriculture should be retired from cultivation and brought back under forests to save the land from the adverse effects of deforestation.

4. Land not available for cultivation

This class consists of two types of land *viz.* (*i*) land put to non agricultural uses and (*ii*) barren and unculturable waste. The area put to non-agricultural uses includes land occupied by villages, towns, roads, railways or under water *i.e.* rivers, lakes, canals, tanks, ponds, etc. The barren land covers all barren and uncultivated lands in mountains and hill slopes, deserts and rocky areas. These areas cannot be brought under plough except at high input cost with possible low returns. The amount of this land has been variable right from 1950-51 to 2010-11, the data for which are available. Land not available for cultivation increased from 41.48 million hectares in 2000-01 to 43.56 million hectares in 2010-11 and accounted for 14 per cent of the total reported area in 2010-11. The largest amount of land in this category is in Andhra Pradesh followed by Rajasthan, Himachal Pradesh, Maharashtra, Madhya Pradesh, Gujarat, Uttar Pradesh and Bihar.

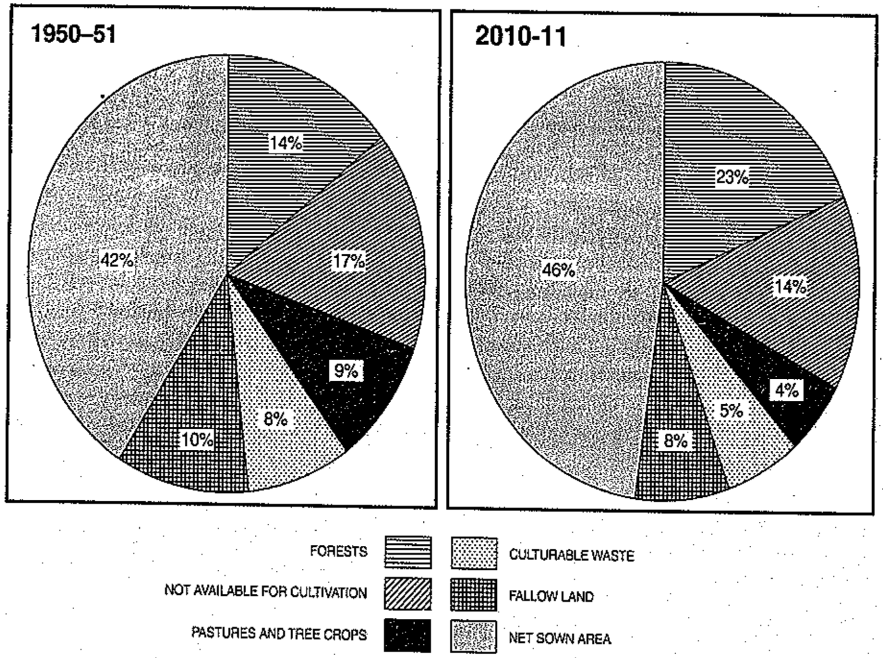

FIG. 19.1. India : Land use 1950-51 and 2010-11

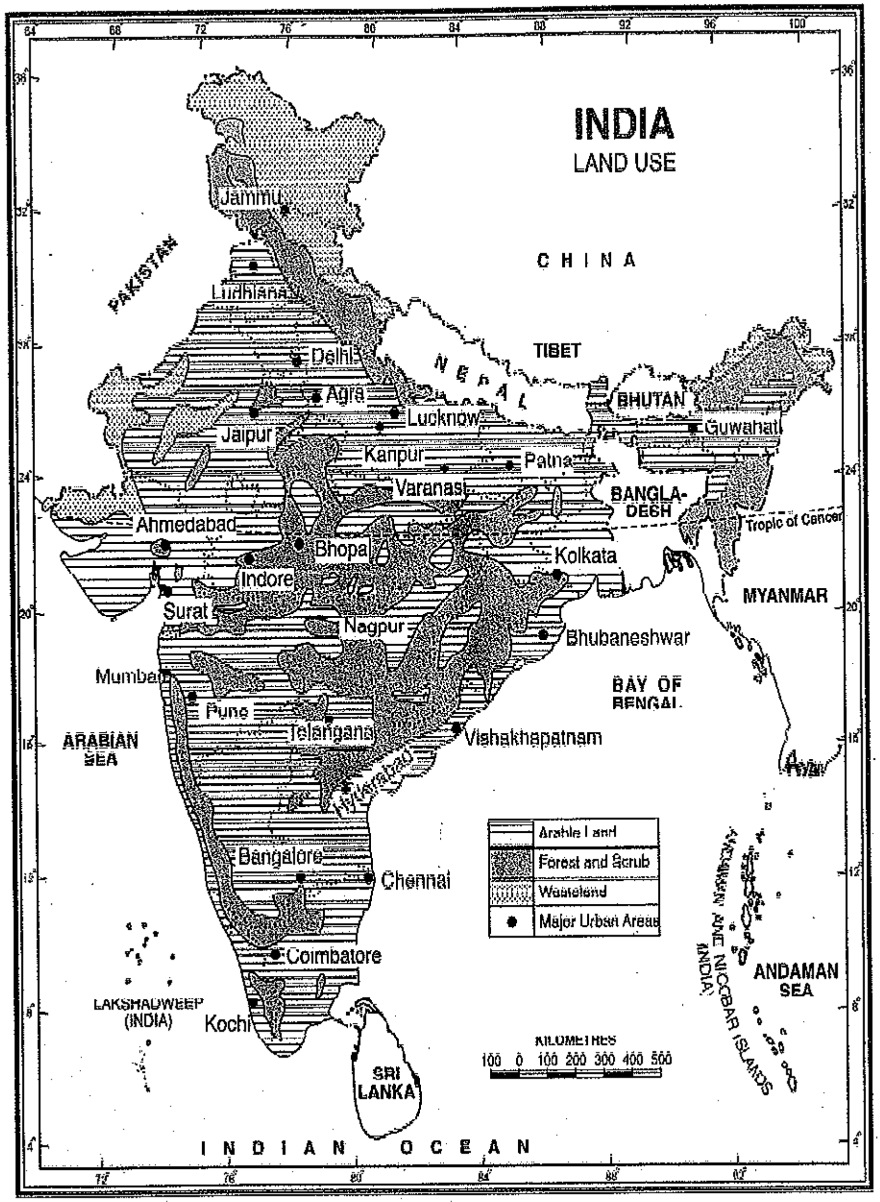

FIG. 19.2. India : Land use

5. Permanent pastures and other grazing lands

A total area of 10.3 million hectares is devoted to permanent pastures and other grazing lands. This amounts to about 4 per cent of the total reporting area of the country. Grazing takes place mostly in forests and other uncultivated land wherever pasturage is available. The area presently under pastures and other

TABLE 19.2. Pattern of Land Utilisation in India (1999-2000) *('000 hectares)*

State/Union Territory	Reporting area for land utilisation statistics	Forests	Not available for cultivation	Permanent pastures and other grazing lands	Land under Miscellaneous tree crops and groves (not included in net sown area)	Cultureable waste land	Fallow lands other than current fallows	Current fallows	Net area sown	Area sown more than once	Total cropped area
States											
Andhra Pradesh	27,505	6,230	4,890	554	290	626	1,490	2,229	11,186	3,326	14,512
Arunachal Pradesh	5,661	5,154	64	18	37	64	70	40	213	65	278
Assam	7,850	1,853	2,626	160	196	77	50	79	2,811	1,349	4,160
Bihar	9,360	622	2,131	16	245	45	122	920	5,259	1,935	7,194
Chhattisgarh	13,790	6,336	1,019	855	1	355	275	253	4,697	—	5,671
Goa	361	125	37	1	1	53	—	13	131	29	160
Gujarat	19,069	1,834	3,723	851	4	1,960	16	379	10,302	1,945	12,247
Haryana	4,370	39	624	27	11	27	3	122	3,518	2,987	6,505
Himachal Pradesh	4,550	1,103	1,122	1,503	68	135	20	59	539	410	949
Jammu & Kashmir	3,781	2,023	678	119	66	135	26	101	732	408	1140
Jharkhand	7,970	2,239	1,372	110	93	336	1,045	1,729	1,085	—	1,249
Karnataka	19,050	3,072	2,217	912	286	414	426	1,199	10,523	2,539	13,062
Kerala	3,886	1,082	510	0	4	92	96	76	2,072	575	2,647
Madhya Pradesh	30,756	8,697	3,424	1,328	28	1,088	568	503	15,119	6,927	22,046
Maharashtra	30,758	5,216	3,179	1,242	250	919	1,179	1,366	17,406	6,663	24,069
Manipur	2,125	1,742	27	1	0	8	0	0	348	0	348
Meghalaya	2,235	946	238	—	163	392	155	58	284	54	338
Mizoram	2,109	1,585	95	5	37	7	182	67	130	3	133
Nagaland	1,625	863	89	—	103	52	100	55	155	107	362
Odisha	15,472	5,814	2,279	513	220	520	567	877	4,682	747	5,429
Punjab	5,033	294	533	4	4	4	4	33	4,158	3,725	7,883
Rajasthan	34,270	2,473	4,268	1,694	21	4,233	1,726	1,235	18,349	7,216	25,565
Sikkim	693	584	11	—	4	4	5	9	77	75	152
Tamil Nadu	13,033	2,125	2,666	110	252	331	1,580	1,015	4,954	799	5,753
Tripura	1,049	629	141	2	14	4	2	2	256	94	350
Uttar Pradesh	24,170	1,658	3,321	66	354	426	538	1,215	16,593	8,790	25,383
Uttarakhand	5,673	3,485	442	199	386	310	84	43	723	—	1,170
West Bengal	8,684	1,174	1,840	5	53	29	18	574	4,991	4,035	9,563
Union Territory											
A. & N. Islands	757	717	9	4	4	3	3	3	15	4	19
Chandigarh	7	0	5	—	0	—	0	0	1	1	2
D. & N. Haveli	49	20	4	1	—	0	4	2	17	5	22
Daman & Diu	4	—	0	0	0	0	0	0	3	0	3
Delhi	147	—	1	93	0	1	10	8	12	8	20
Lakshadweep	3	0	—	—	—	—	—	—	3	4	7
Pondicherry	49	19	—	1	5	2	3	6	19	12	31

Source : Agricultural Statistics at a Glance. 2013, pp. 264-69.

grazing lands is not sufficient keeping in view the large population of livestock in the country. About one-third of the reporting area in Himachal Pradesh is under pastures. The proportion varies from 4 to 10 per cent in Madhya Pradesh, Karnataka, Gujarat, Rajasthan, Maharashtra and Odisha. It is less than 3 per cent in the remaining parts of the country.

6. Land under miscellaneous tree crops and groves

Land under miscellaneous tree crops and groves includes all cultivable land which is not included under net area sown, but is put to some agricultural use. Land under casuarina trees, thatching grass, bamboo, bushes, other groves for fuel, etc. which are not included under orchard are classed under this category. Land under this category declined sharply from 19.8 million hectares in 1950-51 to only 4.46 million hectares in 1960-61 and further to 4.29 million hectares in 1970-71. Thus the percentage of this land fell from 6.97 per cent in 1950-51 to a mere 1.49 per cent in 1960-61 and further to 1.41 per cent in 1970-71. After that juncture the area under miscellaneous tree crops and groves has shown varying trends and stood at 3.21 million hectares or 1 per cent of the total reporting area in 2010-11. Odisha has the largest area in this category followed by Uttar Pradesh, Bihar, Karnataka, Andhra Pradesh Assam and Tamil Nadu.

7. Culturable waste

The "wasteland survey and reclamation committee" defines "culturable waste" as *the land available for cultivation but not used for cultivation for one reason or the other*. This land was used in the past but has been abandoned for some reason. It is not being used at present due to such constraints as lack of water, salinity or alkalinity of soil, soil erosion, waterlogging, an unfavourable physiographic position, or human neglect. Reh, bhur, usar, and khola tracts of Uttar Pradesh, Punjab and Haryana as well as in several other parts of the country were used for agriculture in the past but had to be abandoned due to some deficiencies in the soil resulting from faulty agricultural practices. The land under this category has declined considerably from about 22.9 million hectare in 1950-51 to 13.8 million hectare in 1999-2000. In 2010-11, the culturable waste and was estimated to be about 5 per cent of the total area about which statistics were available. This decline in the wasteland is due to some land reclamation schemes launched in India after Independence. About one-sixth of the total reporting area in Goa is termed as culturable waste. Rajasthan has 4.3 lakh hectare of cultivable waste land which is about 36 per cent of the total waste land of India. The other states with considerable culturable waste land are Gujarat (13.6%), Madhya Pradesh (10.2%), Uttar Pradesh (6.93%) and Maharashtra (6.83%). The cultivable waste, if brought under cultivation can be an important factor in augmenting the country's agricultural production. However, in the interest of long term conservation and maintenance of ecobalance, this land should be put under afforestation and not under crop farming. National Remote Sensing Agency (NRSA), Hyderabad is making valuable contribution in mapping the wastelands in India through satellite imageries.

8. Fallow lands

This category includes all that land which was used for cultivation but is temporarily out of cultivation. Fallow land is of two types *viz*., *current fallow* and *fallow other than current fallow*. Fallow of one year is called ***'current fallow'*** while that of 2 to 5 years is classified as 'fallow other than current fallow'. Fallow land is left uncultivated from 1 to 5 years to help soil recoup its fertility in the natural way depending upon the nature of soil and the nature of farming. There have been varying trends in the extent of current fallow and it amounted to 5 per cent of the reported area in 2010-11. But there had been a sharp decline in fallow lands other than current fallow. In the year 2010-11 about 3 per cent of the reported areas was found to be 'follow land other than current fallow'. The largest area of over 1.7 million hectare of 'fallow land other than current fallow' is in Rajasthan followed by 1.5 million hectares in Andhra Pradesh and over one million hectares in Maharashtra. The distribution of the curent fallow on the other hand presents a slightly different picture. Andhra Pradesh with about 2.2 million hectares has the largest area as current fallow. This is followed by over 1.3 million hectares in Maharashtra, 1.2 million hectares in Rajasthan, 1.2 million hectares in Uttar Pradesh, 1.2 million in Karnataka, 1.01 million hectares in Tamil Nadu and over one million hectares in Uttar Pradesh.

There is need to reduce the extent and frequency of fallow land in order to increase agricultural production. This can be done by proper dose of fertilizers, providing irrigation facilities, crop rotation and combination and several other similar farm techniques.

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CHAPTER 20

Agriculture

INTRODUCTION

Agriculture includes raising of crops from the land, animal husbandry, agroforestry and pisciculture. India is pre-eminently an agricultural country. Agriculture has been practised in India since time immemorial. It plays a vital role in the economy of India. Till 1971, about 80 per cent of India's population lived in rural areas and depended directly or indirectly on agriculture. It contributed about 45 per cent of Gross Domestic Production (GDP) at that time. The relative importance of agriculture has reduced considerably since then due to rapid development of other occupations such as mining, manufacturing, transport, trade and services. Today, agriculture and allied sectors contribute nearly 14.4 per cent of GDP, while about 55 per cent of the population is dependent on agriculture for their livelihood, and it still forms the hub of India's economy. In addition to providing food and fodder to large population of human beings and livestock respectively, agriculture is the main source of raw materials for several key industries. Sugarcane, cotton, jute and oil seeds are some of the outstanding agricultural raw materials used in industries.

India is a unique country from agricultural point of view. Its enormous expanse of level plains, rich soils, high percentage of culturable land, wide climatic variety with adequate aggregate rainfall combined with sufficient temperature, ample sunshine and long growing season provide solid base to agriculture.

A healthy and advanced agriculture creates demand for several industrial products like tractors, harvestors, threshers, chemical fertilizers, pesticides, etc. Moreover, income generated in the agricultural sector creates ready market for various manufactured goods. Thus agriculture has double relation with industry. It acts as a supplier of raw materials to the industries and as consumer of industrial products. It goes without saying that the prosperity of industrial sector largely depends upon the agricultural prosperity. In fact, prosperity of the entire nation depends upon the prosperity of agriculture.

Agricultural sector also contributes a lot to the export trade of India. Bulk of India's export trade consists of agricultural products and agro-processed products. The major agricultural commodities of export are tea, coffee, cashew kernels, raw cotton, oil cakes, tobacco, spices, fruits and vegetables. There is great need to increase agricultural production so that sufficient exportable surplus commodities are available after meeting our domestic requirements.

From the above discussion, it can be concluded that agriculture furnishes the central sinew of Indian economy. A prosperous farmer means a prosperous nation.

SALIENT FEATURES OF INDIAN AGRICULTURE

Indian agriculture has its own peculiarities. Some of the outstanding features of Indian agriculture are mentioned as follows.

1. Subsistence agriculture. Most parts of India have subsistence agriculture. The farmer owns a small piece of land, grows crops with the help of his family members and consumes almost the entire farm produce with little surplus to sell in the market. This type of agriculture has been practised in India for the last several hundreds of years and still prevails in spite of the large scale changes in agricultural practices after Independence.

2. Pressure of population on agriculture. The population in India is increasing at a rapid pace and exerts heavy pressure on agriculture. Agriculture has to provide employment to a large section of work force and has to feed the teeming millions. While looking into the present need of food grains, we require an additional 12-15 million hectares of land to cope with the increasing demands. Moreover, there is rising trend in urbanization. As much as 31.16 per cent of the Indian population lived in urban areas in 2011 and it is estimated that over half of the total population of India would be living in urban areas by 2025 A.D. This requires more land for urban settlements which will ultimately encroach upon agricultural land. It is now estimated that about 4 lakh hectares of farm land is now being diverted to non-agricultural uses each year.

3. Importance of animals. Animal force has always played a significant role in agricultural operations such as ploughing, irrigation, threshing and transporting the agricultural produces. Complete mechanisation of Indian agriculture is still a distant goal and animals will continue to dominate the agricultural scene in India for several years to come.

4. Dependent upon monsoon. Indian agricluture is mainly dependent upon monsoon which is uncertain, unreliable and irregular. In spite of the large scale expansion of irrigation facilities since Independence, less than one-third of the total cropped area is provided by perennial irrigation and the remaining two-third of the cropped area has to bear the brunt of the vagaries of the monsoons.

5. Variety of crops. India is a vast country with varied types of relief, climate and soil conditions. Therefore, there is a large variety of crops grown in India. Both the tropical and temperate crops are successfully grown in India. Very few countries in the world have a variety of crops comparable to that produced in India.

6. Predominance of food crops. Since Indian agriculture has to feed a large population, production of food crops is the first priority of the farmers almost everywhere in the country. More than two-thirds of the total cropped area is devoted to the cultivation of food crops. Area under foodgrains increased from 121.05 million hectare in 2000-01 to 126.77 million hectares in 2010-11 and there is not much scope for further increase in area under foodgrains because more than 85 per cent of the net sown area is already under foodgrains.

7. Insignificant place to given fodder crops. Although India has the largest population of livestock in the world, fodder crops are given a very insignificant place in our cropping pattern. Only four per cent of the reporting area is devoted to permanent pastures and other grazing lands. This is due to pressing demand of land for food crops. The result is that the domestic animals are not properly fed and their productivity is very low compared to international standards.

8. Seasonal pattern. India has three major crop seasons.

(*i*) ***Kharif*** season starts with the onset of monsoons and continues till the beginning of winter. Major crops of this season are rice, maize, jowar, bajra, cotton, sesamum, groundnut and pulses such as *moong*, *urad*, etc.

(*ii*) ***Rabi*** season starts at the beginning of winter and continues till the end of winter or beginning of summer. Major crops of this season are wheat, barley, jowar, gram and oil seeds such as linseed, rape and mustard.

(*iii*) ***Zaid*** is summer cropping season in which crops like rice, maize, groundnut, vegetables and fruits are grown. Now some varieties of pulses have been evolved which can be successfully grown in summer.

9. Mixed Cropping. Mixed cropping is one of the chief characteristics of Indian agriculture particularly in the rain-fed areas. Sometimes four to five crops are grown simultaneously in the same field and in areas Jhuming (shifting agriculture) ten to fifteen area mixed in one field. The popular crops are millets, maize and pulses in the *kharif* season and wheat, gram and barley in the *rabi* season. This is done to ensure good agricultural production keeping in view the vagaries of the monsoon rainfall and uncertain weather conditions. If the amount of rainfall is good, rice crop will give better output and if there is failure of the moonsoon rains, then less water requiring crops such as maize, millets and pulses will give better yields. Mixed cropping is a characteristic of subsistent agriculture and this practice reduces the overall agricultural output and per hectare yield.

10. High percentage of reporting area under cultivation. In the year 2010-11, 141.58 million hectares was the net sown area out of total reporting area of 305.57 million hectares. Thus nearly 46 per cent of the total reporting area is under cultivation. This is a very high percentage when compared to some of the advanced countries like 16.3% in U.S.A., 14.9% in Japan, 11.8% in China, and only 4.3% in Canada.

11. Labour intensive. In large parts of India, agriculture is labour intensive as most of agricultural operations like ploughing, levelling, sowing, weeding, pruning, sprinkling, spraying, harvesting, thrashing, etc. are done by the farmers and their animals. Mechanisation of farming is prevalent in Punjab, Haryana, and western part of Uttar Pradesh and in these area too, it is the privilege of the rich farmers only. Farm mechanism in packing up in Uttarakhand, Gujarat and Maharashtra also where limited areas use farm machinery.

PROBLEMS OF INDIAN AGRICULTURE AND THEIR SOLUTIONS

Indian agriculture is plagued by several problems; some of them are natural and some others are man-made. Some of the major problems and their possible solutions have been discussed as follows.

1. Small and fragmented land-holdings. The seemingly abundance of net sown area of 141.58 million hectares and total cropped area of 198.97 million hectares (2010-11) pales into insignificance when we see that it is divided into economically unviable small and scattered holdings. The average size of holdings was 2.28 hectares in 1970-71 which was reduced 1.16 hectares in 2010-11. The size of the holdings will further decrease with the infinite sub-division of the land holdings. The problem of small and fragmented holdings is more serious in densely populated and intensively cultivated states like Kerala, West Bengal, Bihar and eastern part of Uttar Pradesh where the average size of land holdings is less than one hectare and in certain parts it is less than even 0.5 hectare. It has been estimated that over two-thirds of the landholdings are less than one hectare and only 0.7 per cent are over 10.0 hectares in size.

The main reason for this sad state of affairs is our inheritance laws. The land belonging to the father is equally distributed among his sons. According to new inheritance law, even daughters are entitled to share the father's property. This distribution of land does not entail a collection or consolidated one, but its nature is fragmented. Different tracts have different levels of fertility and are to be distributed accordingly. If there are four tracts which are to be distributed between two sons, both the sons will get smaller plots of each land tract. In this way the holdings become smaller and more fragmented with each passing generation.

Sub-division and fregmentation of the holdings is one of the main causes of our low agricultural productivity and backward state of our agriculture. A lot of time and labour is wasted in moving seeds, manure, implements and cattle from one piece of land to another. Irrigation becomes difficult on such small and fragmented fields. Further, a lot of fertile agricultural land is wasted in providing boundaries. Under such circumstances, the farmer cannot concentrate on improvement.

The only answer to this ticklish problem is the *consolidation of holdings* which means the reallocation of holdings which are fragmented, the creation of farms which comprise only one or a few parcels in place of multitude of patches formerly in the possession of each peasant. But unfortuantely, this plan has not succeeded much. Although legislation for consolidation of holdings has been enacted by almost all the states, it has been implemented only in Punjab, Haryana and in some parts of Uttar Pradesh.

2. Seeds. Seed is a critical and basic input for attaining higher crop yields and sustained growth in agricultural production. Distribution of assured quality seed is as critical as the production of such seeds. Unfortunately, good quality seeds are out of reach of the majority of farmers, especially small and marginal farmers mainly because of exorbitant prices of better seeds. In order to solve this problem, the Government of India has taken several steps so that quality seeds are made available to farmers in sufficient quantity at reasonable prices. But the benefit of schemes launched by the government still remain out of reach of the small and marginal farmers.

3. Manures, Fertilizers and Biocides. Indian soils have been used for growing crops over thousands of years without caring much for replenishing. This has led to depletion and exhaustion of soils resulting in their low productivity. The average yields of almost all the crops are among the lowest in the world. This is a serious problem which can be solved by using more manures and fertilizers. Manures and fertilizers play the same role in relation to soils as good food in relation to body. Just as a well-nourished body is capable of doing any good job, a well nourished soil is capable of giving good yields. It has been estimated that about 70 per cent of growth in agricultural production can be attributed to increased fertilizer application. Thus increase in the consumption of fertilizers is a barometer of agricultural prosperity. However, there are practical difficulties in providing sufficient manures and fertilizers in all parts of a country of India's dimensions inhabited by poor peasants. Cow dung provides the best manure to the soils. But its use as such is limited because much of cow dung is used as kitchen fuel in the shape of dung cakes. Reduction in the supply of fire wood and increasing demand for fuel in the rural areas due to increase in population has further complicated the problem. Chemical fertilizers are costly and are often beyond the reach of the poor farmers. The fertilizer problem is, therefore, both acute and complex.

It has been felt that organic manures are essential for keeping the soil in good health. The country has a potential of 650 million tonnes of rural and 160 lakh tonnes of urban compost which is not fully utilized at present. The utilization of this potential will solve the twin problem of disposal of waste and providing manure to the soil.

The government has given high incentive especially in the form of heavy subsidy for using chemical fertilizers. There was practically no use of chemical fertilizers at the time of Independence. As a result of initiative by the government and due to change in the attitude of some progressive farmers, the consumption of fertilizers increased tremendously.

Pests, germs and weeds cause heavy loss to crops which amounted to about one-third of the total field produce at the time of Independence. Biocides (pesticides, herbicides and weedicides) are used to save the crops and to avoid losses. The increased use of these inputs has saved a lot of crops, especially the food crops from unnecessary wastage. But indiscriminate use of biocides has resulted in wide spread environmental pollution which takes its own toll.

4. Irrigation. Although India is the second largest irrigated country of the world after China, only one-third of the total cropped area is under irrigation. Irrigation is the most important agricultural input in a tropical monsoon country like India where rainfall is uncertain, unreliable and erratic. India cannot achieve sustained progress in agriculture unless and until more than half of the cropped area is brought under assured irrigation. This is testified by the success story of agricultural progress in Punjab, Haryana and western part of Uttar Pradesh where over half of the cropped area is under irrigation. Large tracts still await irrigation to boost the agricultural output. However, care must be taken to safeguard against ill effects of over irrigation especially in areas irrigated by canals. Large tracts in Punjab and Haryana have been rendered useless (areas affected by salinity, alkalinity and waterlogging), due to faulty irrigation. In the Indira Gandhi Canal command area also intensive irrigation has led to sharp rise in sub-soil water level, leading to waterlogging, soil salinity and alkalinity.

5. Lack of mechanisation. In spite of the large scale mechanisation of agriculture in some parts of the country, most of the agricultural operations in larger parts are carried on by human hand using

simple and conventional tools and implements like wooden plough, sickle, etc. Little or no use of machines is made in ploughing, sowing, irrigating, thinning and pruning, weeding, harvesting, threshing and transporting the crops. This is specially the case with small and marginal farmers. It results in huge wastage of human labour and in low yields per capita labour force.

There is urgent need to mechanise the agricultural operations so that wastage of labour force is avoided and farming is made convenient and efficient. Agricultural implements and machinery are a crucial input for efficient and timely agricultural operations, facilitating multiple cropping and thereby increasing production.

Some progress has been made for mechanising agriculture in India after Independence. Need for mechanisation was specially felt with the advent of Green Revolution in 1960s. Strategies and programmes have been directed towards replacement of traditional and inefficient implements by improved ones, enabling the farmer to own tractors, power tillers, harvesters and other machines. A large industrial base for manufacturing of the agricultural mechines has also been developed. Power availability for carrying out various agricultural operations has been increased. This increase was the result of increasing use of tractors, power tillers and combine harvesters, irrigation pumps and other power operated machines. Strenuous efforts are being made to encourage the farmers to adopt technically advanced agricultural equipments in order to carry farm operations timely and precisely, and to economise the agricultural production process.

6. Agricultural Marketing. Agricultural marketing still continues to be in a bad shape in rural India. In the absence of sound marketing facilities, the farmers have to depend upon local traders and middlemen for the disposal of their farm produce which is sold at throw-away price. In most cases, these farmers are forced, under socio-economic conditions, to carry on distress sale of their produce. In most of small villages, the farmers sell their produce to the money lender from whom they usually borrow money. According to an estimate 85 per cent of wheat and 75 per cent of oil seeds in Uttar Pradesh, 90 per cent of jute in West Bengal, 70 per cent of oilseeds and 35 per cent of cotton in Punjab is sold by farmers in the village itself. Such a situation arises due to the inability of the poor farmers to wait for long after harvesting their crops. In order to meet his commitments and pay his debt, the poor farmer is forced to sell the produce at whatever price is offered to him. The Rural Credit Survey Report rightly remarked that the producers in general sell their produce at an unfavourable place and at an unfavourable time and usually they get unfavourable terms. In the absence of an organised marketing structure, private traders and middlemen dominate the marketing and trading of agricultural produce. The remuneration of the services provided by the middlemen increases the load on the consumer, although the producer does not derive similar benefit. Many market surveys have revealed that middlemen take away about 48 per cent of the price of rice, 52 per cent of the price of groundnuts and 60 per cent of the price of potatoes offered by consumers.

In order to save the farmer from the clutches of the money lenders and the middle men, the government has come out with regulated markets. These markets generally introduce a system of competitive buying, help in eradicating malpractices, ensure the use of standardised weights and measures and evolve a suitable machinery for settlement of disputes thereby ensuring that the producers are not subjected to exploitation and receive remunerative prices.

7. Inadequate storage facilities. Storage facilities in the rural areas are either totally absent or grossly inadequate. Under such conditions the farmers are compelled to sell their produce immediately after the harvest at the prevailing market prices which are bound to be low. Such distress sale deprives the farmers of their legitimate income.

The Parse Committee estimated the post-harvest losses at 9.3 per cent of which nearly 6.6 per cent occurred due to poor storage conditions alone. Scientific storage is, therefore, very essential to avoid losses and to benefit the farmers and the consumers alike. At present there are number of agencies engaged in warehousing and storage activities. *The Food Corporation of India* (F.C.I.), the *Central Warehousing Corporation* (C.W.C.) and *State Warehousing Corporation* are among the principal agencies engaged in this task. These agencies help in building up buffer stock, which can be used in the hour of need. The Central Government is also implementing the scheme for establishment of national *Grid of Rural Godowns* since 1979-80. This scheme provides storage facilities to the farmers near their fields and in particular to the small and marginal farmers. The Working Group on additional storage facilities in rural areas has recommended a scheme of establishing a network of *Rural Storage Centres* to serve the economic interests of the farming community.

8. Inadequate transport. One of the main handicaps with Indian agriculture is the lack of cheap and efficient means of transportation. Even at present there are lakhs of villages which are not well connected with main roads or with market centres. Most roads in the rural areas are *Kutcha* (bullock-cart roads) and become useless in the rainy season. Under these circumstances the farmers cannot carry their produce to the main market and are forced to sell it in the local market at low price. Linking each village by metalled road is a gigantic task and it needs huge sums of money to complete this task.

9. Scarcity of capital. Agriculture is an important industry and like all other industries it also requires capital. The role of capital input is becoming more and more important with the advancement of farm technology. *Since the agriculturists' capital is locked up in his lands and stocks*, he is obliged to borrow money for stimulating the tempo of agricultural production. The main suppliers of money to the farmer are the money-lenders, traders and commission agents who charge high rate of interest and purchase the agricultural produce at very low price. *All India Rural Credit Survey Committee* showed that in 1950-51 the share of money lenders stood at as high as 68.6 per cent of the total rural credit and in 1975-76 their share declined to 43 per cent of the credit needs of the farmers. This shows that the money lender is losing ground but is still the single largest contributor of agricultural credit. Rural credit scenario has undergone a significant change and institutional agencies such as *Central Cooperative Banks, State Cooperative Banks, Commercial Banks, Cooperative Credit Agencies* and *some Government Agencies* are extending loans to farmers on easy terms.

10. Tradition Bound. In spite of some breakthroughs, Indian agriculture remains tradition bound even at the dawn of 21st century. Established centuries ago, the structures of a self-contained rural economy, founded in caste-drain occupational land tenure, made complex by absentee and parasitic landlords still continues. The tradition bound institutions have been the greatest hindrance in the way of modernisation and Indian agriculture has been rather slow in responding to new innovative ideas.

11. Primitive Technology. A large proportion of Indian farmers use primitive technology which hinders the requisite progress in agricultural production. They are hand tools like sickel, hoe, etc. and drought animals like bullocks, male buffaloes, camels, etc. as source of motive power in agricultural operations. Although agricultural machinery is replacing the animal and human power, yet the pace of progress is very slow and use of agricultural machinery is the privilege of a few rich farmers in selected states like Panjab, Haryana, Uttar Pradesh only.

12. Dependent on Monsoon Rainfall. In large parts of India irrigation facilities are either totally absent or are partially available and agriculture depends on monsoon rainfall. Unfortunately Indian monsoon rainfall is highly erratic and least dependable. It varies in time and space and variability of rainfall is the highest in areas of least rainfall. Whenever rain fails or there is deficiency of rainfall, the agricultural production drops to a miserably low level. There is overall scarcity of agricultural products in the market and the prices of agricultural products reach sky high. In extreme cases famine conditions prevail and humans and livestock die of hunger and starvation.

13. Lack of Crop Diversification. Crop diversification means growing a large number of crops and reducing dependency on a single crop. Unfortunately in India more emphasis is laid on food crops and other crops are given a secondary status. Although top priority to food crops is necessary in the back drop of fast growing population, neglecting other crops is detrimental to balanced growth of agriculture. Only 3.3 per cent of the reported area is under fodder crops which is very insignificant in view of the fact that India has the largest number of livestock in the world. Further, nitrogen fixing leguminous crops are ignored which leads to imbalance in the composition of soil and reduction in the soil fertility.

14. Low Productivity. In spite of the rapid strides made by India in agricultural field, particularly after the advent of the Green Revolution in 1960s, agricultural productivity in India still remains at a low level. Yield per hectare of almost all the crops is much lower as compared to international standards. This is due to low fertility of soil and little care to replenish is through fertilizers, green manure, fallowing, crop rotation etc. Other inputs like machinery, irrigation, better seeds etc. are also limited to a few selected areas and to a few rich farmers.

15. Government Apathy. Indian agriculture has been the victim of negligence and step motherly treatment by the government. Although agriculture got highest priority in the First Five Year Plan in view of the acute shortage of foodgrains immediately after partition of the country in 1947, agriculture has not been given its due important and more emphasis was laid on industrial growth in the subsequent plans. Farmers do not get remunerative price of their products and most of them permanently remain under debt. Even in some of the so-called rich areas from agriculture point of view like Punjab and Maharashtra, a large number of farmers have committed suicide out of distress and depression. However, the government has become slightly more sensitive to the problems of the farmers and some recognition has been given to agriculture in Tenth and Eleventh Five Year Plans.

16. Lack of Definite Agricultural Land use Policy. There is no definite policy concerning agriculture and land use at the national or regional level and the farmers grow one or the other crop at their own sweet will. It often leads to excess or scarcity of particular crops. In the event of excess crop the farmers are forced to sell their produce at throw away prices. On the contrary consumers are the main suffers when there is shortage of a particular crop.

17. Low fertility of soils. Indian soils have been used for cultivation for the last hundreds of years without much care to restore their fertility. Most of the Indian soils are exhausted and are not capable of giving high yields. They lack in various chemicals and humus which are necessary for high rate of productivity in the agricultural field.

18. Soil Erosion and Soil Degradation. Wrong agricultural practices coupled with reckless felling of trees has led to large scale soil erosion and soil degradation both by water and by wind. Rain water washes away huge amounts of fertile top soil in areas of heavy rainfall during the rainy season and in areas of scanty rainfall, strong winds blow away the fertile top soil.

19. Low Status of Agriculture in Society. In large parts of India agriculture is not given its due place of honour and is considered to be a profession of low status. This leads to disappointment and lack of enthusiasm amongst farmers. Younger generation belonging to families of farmers are no more interested in agricultural profession and tend to opt for petty jobs in government offices. Besides, rich farmers invest their agricultural profits in more lucerative non-agricultural sectors. Rural youth migrate to urban areas in search of non-agricultural or white colored jobs and many of them end up in slums, ghettoes and shanty colonies.

20. Land Tenancy. In many parts of India the actual tillers are not the owners of land and they are forced to till the land of absentee landlords. There are big landlords who own vast stretches of land but do not till the land themselves. The poor landless tanent cultivators do not take much interest in the development of agriculture as a result of which the yields of almost all the crops are at a miserably low level.

21. Lack of Agricultural Research, Education, Training and Extension Services. Although a number of research institutions were established immediately after Independence, and many advancements in agricultural research have been made since then, yet agricultural research hardly matches international standards. Further there is lack of coordination between research laboratories and farms and there is a big vacuum between the two. Farmers, especially small and marginal farmers are deprived of the benefit of the new findings of research laboratories. In a similar way hardly any attention is paid to educate the farmers about the new techniques of agriculture for increasing the farm production. There is need to raise an army of trained and dedicated workers which can help the farmers in coming out of the age old tradition bound agriculture and adopt new innovative ideas and enhance their production and income.

DETERMINANTS OF AGRICULTURE

Agriculture in India is determined by a set of factors. Some of the important factors are listed below.

1. Physical factors. relief, climate, soil.

2. Institutional factors. size of farm holdings, land tenure, land reforms.

3. Infrastructural factors. Irrigation, power, roads, credit, marketing, insurance and storage facilities.

4. Technological factors. High yielding varieties of seeds, chemical fertilizers, insecticidesa and farm machinery.

The above mentioned factors affect the level of agricultural development, cropping patterns and agricultural productivity in a region. A brief review of these factors is given below.

1. PHYSICAL FACTORS

Man's agricultural activities depend to a great extent on the physical environment in which he lives although he often tries to minimize the restriction imposed by various factors of physical environment. For example, he has been able to extend agriculture to arid and semi-arid lands with the help of irrigation, restore soil fertility by using manures and chemical fertilizers and save crops from pests and insects by applying pesticides and insecticides. But these ventures have a limited effect and physical environment has a much deeper impact on agricultural development and agricultural productivity. This is amply clear from the following description regarding the impact of relief, climate, and soils on agriculture.

1. Relief

Relief is the difference of height between the lowest and the highest point in the region and is expressed in terms of height above sea level and gradient of slope.

Effect of Altitude on Agriculture. There is gradual decrease in temperature with increasing atitude which affects agricultural productivity, types of crops and agricultural operations. Depending on altitude following land features and associated crops can be identified.

(*a*) **Plains.** Plains are the most preferred areas for agriculture due to their low altitude and gentle slope. Agricultural operations like ploughing, sowing, weeding and thinning, harvesting etc. are much easier in plain areas than in plateaus or mountains. Plains are usually blessed with fertile soils which offer greater opportunities for agricultural growth. This is the reason the Great Plain of North India is an area of intensive agriculture where rice and wheat are the major food crops. Besides, a large number of commercial crops like cotton, jute, sugarcane, pulses, coarse grains etc. are also grown. In the coastal plains rice is the main crop and orchards of coconut are found all along in coast.

(*b*) **Plateaus.** Plateaus are also useful for agriculture but their suitability for agriculture is less as compared to that of plains. The peninsular plateau of India provides suitable conditions for cultivation of a number of crops including rice, wheat, cotton, sugarcane, tobacco and some plantation crops. However, only selected parts of this vast plateau are suitable for cultivation and several parts of this plateau are characterized by rugged topography, dissected surface, steep scarps, shallow soils, bare rocks and intervening hill slopes.

(*c*) **Mountains.** Mountains are least preferred from agricultural point of view because of high altitude, steep slope, immature soils, low temperature, low pressure, rarified air and shortage of oxygen. Temperature decreases regularly with altitude which determines the types of crops grown on different altitudes and practically no agriculture is possible above 3500 m in the Himalayas. Sher Singh Dhillon (1973 : 75) has identified six fold altitudinal agro-climatic zones based on seasonal rhythm and temperature involving different agricultural practices in the Western Himalayas (**Fig. 20.1**). On the slopes of the Eastern Himalayas and those of the Nilgiri Hills of South India, the plantations dominate the agricultural scene. In South India, coffee plantations are also seen along with tea plantations. In several hilly areas, hill slopes are used for terraced cultivation wherein rice and other crops are grown.

2. Climate

Of all the physical factors, climate is the most potent determinant of agricultural land use and cropping pattern. Various elements of climate like

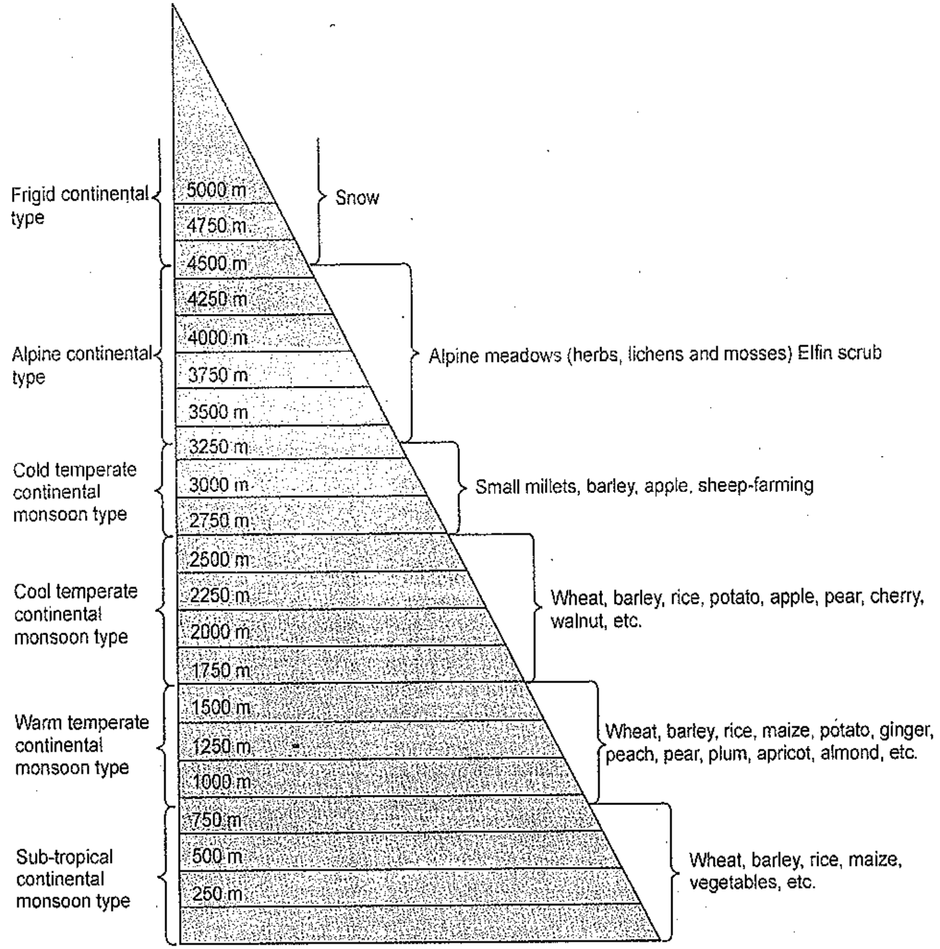

FIG. 20.1. Altitudinal agroclimatic zones in the Western Himalayas (after Dhillon)

temperature, humidity, sun shine and winds influence the agricultural activities in their own respective ways.

I. Temperature. Temperature is a dominant factor which determines the growth of plants. In the absence of suitable temperature conditions germination of seeds, growth of plants are retarded. Temperature regulates all the chemical and physical processes of plant metabolism. The metabolic processes begin at certain minimum temperature and increase with rise in temperature until they such a maximum at a temperature. which is known as ***optimum temperature.*** Further rise in temperature above the optimum level leads to slow down in metabolic activity until it ceases at a temperature called the ***maximum.*** Each species has its own minimum and maximum temperature beyond which its life activity ceases (Kochhar 1967). Each species has also the optimum temperature at which the plant growth is maximum. The minimum, the maximum and the optimum temperature required by plants species are known as ***cardinal temperature points.*** **Wilsie** (1962) has suggested cardinal temperature points for some selected crops which are reproduced in **table 20.1**.

TABLE 20.1. Cardinal temperature points for selected crops (°C)

Crops	Minimum Temperature	Optimum Temperature	Maximum Temperature
Rice	10-12	30-32	36-38
Wheat	4-5	25	30-32
Sugarbeet	4-5	25	28-30
Maize	8-10	31.5-35	38-40
Lentil	4-5	30	36
Tobacco	12.7-14	28	35
Sugarcane	21.1	32.2-37.7	38.5

Source : Wilsie (1962).

Each and every crop needs a certain number of a effective heat units for germination, growth, stalking, maturing and ripening. This is known as ***thermal constant*** which varies from crop to crop. Therefore, temperature above the minimum is effective in furthering the growth of a plant towards maturing and ripening. According to **Schimper** the crucial air temperature is 6°C above which the plants usually start growing. The ideal temperature conditions for crop production are from 18.3°C to 23.9°C.

The above mentioned temperatures conditions affecting different crops are reflected in the areal distribution of crops in India. Low winter temperatures the N.W. India encourage in cultivation of wheat crop while major rice producing areas are confined to South India. However, rice cultivation has become popular in Punjab, Haryana and Uttar Pradesh also due to availability of irrigation facilities. Sugarcane is grown both in North and South India although temperature conditions are more congenial in South India. This is the reason that sugarcane cultivation is slowly shifting from North India to South India. It is because of temperature difference that wheat is grown as a winter crop in Punjab and Haryana and as a summer crop in Ladakh region of Jammu and Kashmir because winter temperature in Ladakh is too low to permit the growth of any crop.

II. Frost. Sudden frost is enemy number one for a number of crops such as cotton. Such crops need frost free season which falls between the end of spring and the beginning of autumn. This period is generally recognized as *growing season* which is different for different crops. Statistically, frost-free season refers to all those days when the temperature continuously remains above the freezing point. The correct information of such a period helps farmers to plan their crops and also to have an idea of the extent of damage that could occur. In South India, there is no danger to crops from frost but in North India, the winter temperatures are very low and frost is common phenomenon.

III. Winds. Winds affect the growth of plants both directly and indirectly. The direct effect of strong winds is entirely of mechanical nature. In the months of May and June, strong winds raise a lot of dust and trees are uprooted, or leaves are stripped off and branches and stems of plants twist and break. A lot of raw fruits, such as mangoes, fall down and are bruished. Banana plantations need extra care, particularly when the plantations have borne fruits. Fruit trees are much damaged in the coastal regions whenever tropical cyclones originating in the Bay of Bengal and Arabian Sea hit these areas.

The indirect effect of winds is apparent on plants physiology. Transpiration from plants adds moisture to the surrounding air. Crops gradually dry up and the moisture diffuses into the surrounding atmosphere. The locally saturated atmosphere retards further transpiration and promotes the plant growth. However, if the wind is dry and strong, it will deprive the plants of its moisture and may cause heavy damage to plants.

Winds are also great agent of erosion, transportation and deposition of soil. In dry areas winds carry soil to such an extent that, sometimes, basal rock is visible and the land becomes unfit for cultivation. Such a phenomenon can often be observed in Rajasthan and the adjoining areas of Haryana and Gujarat.

IV. Snow. Snow has a deep impact on livestock and cropping in the higher reaches of the Himalayan region Snowy winter in these areas cause a severe loss to pastures due to thick snow cover on the grains. Hill sheep farming is adopted to snow conditions and flocks are moved to safer places. **Transhumance** is a common phenomenon in Jammu and Kashmir and in Himachal Pradesh. In these areas, shepherds move down slopes along with their flocks in winter and up slopes in summer to make use of pasture lands.

Winter snow blocks transport routes of all kinds and agricultural fields as well markets become inaccessible. All agricultural activities are suspended and are resumed only with the onset of summer.

Snow has a number of benefits also for agriculture. It provides cool climate to orchards, especially those of apples at sufficiently lower altitudes. Snow melt in summer provides large quantities of water for irrigation and for other purposes in daily life. Some of the snow melt water is available in the form of springs which is very rich in mineral contents and acts as fertilizer to most of the careal crops. The usual snow cover over standing potato fields in Himachal Pradesh makes farmers happy. The local adage "A good quantum of snow means to bumper potato crop in hand" still holds goods.

V. Humidity or Moisture. Humidity is of paramount importance as all crops need moisture for their proper growth. It has already been mentioned that for every crop, there is optimum temperature. Similarly for each crop there is optimum moisture. Maintenance of optimum moisture in the soil is very important because plants draw moisture from the soil through root system. Excessive moisture reduces the quantity of oxygen in the soil and increases the formation of compounds that are toxic to plant roots. Such a situation leads to stunted growth of plants. If the surface water goes to the subsoil in large quantities, it will deplete plant nutrients and hinder the development of plants. This problem can be solved by proper drainage of the ill-drained areas. On the other extreme, there can be shortage of moisture in the soil due to scarcity of rainfall which can be compensated by irrigation.

VI. Rainfall. Rainfall is the single most dominant climatic element influencing the intensity and location of farming systems and farmer's choice of enterprises. It also becomes a climatic hazard to farming if it is characterized with scantiness, concentration, intensity, variability and unreliability.

The amount of annual rainfall has a great impact on the cropping pattern in different parts of the country. For example rice is the main crop in areas of heavy rainfall whereas wheat is an important crop in areas of lesser rainfall. In fact, isohyete (line joining places of equal rainfall of) 100 cm divides the rice and wheat producing areas in India. Areas with more than 100 cm annual rainfall are predominantly rice producing areas and areas with less than 100 cm annual rainfall are mainly wheat producing regions. In areas of scanty rainfall of less than 50 cm annual rainfall, crops requiring lesser amount of water are grown. Jawar, bajra, maize etc. are such crops.

In addition to total amount of annual rainfall, seasonal distribution of rainfall is also very important. Most of the crops need sufficient amount of rainfall during the period of growth and practically dry season at the time of ripening. For example, rainfall in the month of September in northern India is extremely important for the cultivation of rice crop. Winter rainfall in north-western part of India is very useful for wheat crop. Ragi crop is adversely affected in south India if there is no rainfall in the months of October and November. Drought conditions prevail in the event of less than normal rainfall. Drought leads crop failure and famine. States of Rajasthan, Gujarat, Madhya Pradesh, Chhattisgarh, Jharkhand, Maharashtra, Andhra Pradesh, Telangana, Karnataka and parts of Punjab, Haryana, Bihar, Tamil Nadu etc. are often affected by drought conditions.

Rainfall effectiveness is as important as amount of total rainfall received in a particular area. It is usually expressed as the actual total rainfall minus the total possible evaporation. Thus the entire amount of water received from rainfall is not available to plant and it is in this context that rainfall effectiveness becomes import. Rainfall effectiveness depends on the total amount of rainfall, as well as temperature and moisture in the air and the wind velocity. It increases with the amount of rainfall and moisture present in air and decreases with increase in air temperature and wind velocity. Some water evaporates from the leaves of the plants. This is known as ***potential evapo-transpiration.*** Therefore, while assessing the rainfall effectiveness total amount of rainfall, evaporation and potential evapotranspiration have to be taken into account.

VII. Sunlight and Sunshine. Sunlight and sunshine are important to plants in two different ways. (*i*) they are useful in photosynthesis and (*ii*) they help in production of chlorophyll. Photosynthesis involves production of special sugar based substances which keeps plants alive. It is generated by the action of sunlight on green matter (chlorophyll) in leaves. Thus all plants depend on sunlight for food and growth. Better the sunlight, more stout and more compact the individual plants will be. Some plants like sunflower, are so sensitive that its floral part moves from east to west with the movement of the sun.

3. Soils

Soil is of utmost importance to agriculture as each and every plant has its roots in the soil and growth in the soils itself. Soils constitute the physical base for any agricultural enterprise. Great civilizations have almost invariably flourished in areas of fertile soils. In fact, history of civilization is the history of the soil. The agriculture productivity and hence our standard of living largely depends on a combination of physical and chemical characteristics of soils. Physical characteristics of soils include their texture, structure and porosity as well as their colour and temperature. Chemical composition shows ingradients present in the soil which exist in shape of some compounds. These and some of the biological characteristics determine the fertility of the soils which is basic to the proper growth of agricultural crops.

Each crop has some specific requirements of soil and its fertility and each soil is suitable to selected group of crops (**Table 20.2**).

TABLE 20.2. Suitability of different soils for different crops

Soils	Crops
1. Alluvial soils	Wheat, maize, barley, gram, oilseeds, pulses, sugarcane.
2. Clayey loams, fine and heavy soils	Rice, jute
3. Volcanic black soils or ragur	Cotton, wheat, oilseeds
4. Sandy loams and sandy soils	Jawar, bajra, groundnut, guar, pulses (green gram, red gram, black gram etc.)
5. Red and yellow soils	Jawar, groundnut, sugarcane.

Saline and alkaline soils are the result of wrong irrigation practices and are not fit for cultivation unless they are reclaimed by using chemical fertilizers and biological manure and fertilizers. These are cumbersome processes and involve high cost.

2. INSTITUTIONAL FACTORS

Institutional factors is the second important groups of determinants of agriculture in India. These include land tenure and land tenancy, size of holding and land reforms.

1. Land Tenure and Tenancy. Land tenure and tenancy is a system under which type of land ownership is determined. In the ancient days and in primitive societies like those of shifting cultivators, system of collective ownership was prevalent and land belonged to the entire community. At a later stage land ownership rights were vested in king, government, zamindars or talukdars. The Mughals established a comprehensive system of land revenue administration wherein Jogirdass or Zamindars were responsible for collection of land revenue from the cultivators. The Britishers introduced the system of permanent settlement or Zamindari, Roytwari and Mahalwari with a hope to make the system of revenue collection more effective and to improve agricultural production. After Independence Zamindari was abolished and a number of legislations were passed to restore the right of land to the tillers which could meet only partial success. Also not much success has been achieved to prevent division and fragmentation of holdings.

Land Holdings. As mentioned earlier in this chapter, the average size of land holding is very small. Table 20.3 shows that it reduce from 1.33 hectares in 2000-01 to 1.16 hectare in 2010-11. This table also brings to light the glaring fact that about 67 per cent of the holdings are less than one hectare with average size as low as 0.38 hectare. This size is too small to be economically viable for any effective method of agriculture. The owners of small holdings are not economically strong enough to afford irrigation, fertilizers, insecticides, pesticides, better seeds and farm machinery. Such a situation leads to low yields which India, with fast growing population, cannot afford.

Economic Holding

The Congress Agarian Reforms Committee (1949) defined "an economic holding as one which could provide a reasonable standard of living to the cultivator and give full employment for a family of "normal size". The concept of economic holding has

TABLE 20.3. Number and Area of Operational Holdings by Size Group

No. of Holdings : ('000 Number)
Area Operated : ('000 Hectares)
Average size: (Hectares)

Category of Holdings	Number of Holdings			Area			Average Size of Holdings		
	2000-01	2005-06	2010-11	2000-01	2005-06	2010-11	2000-01	2005-06	2010-11
1	2	3	4	5	6	7	8	9	10
Marginal (Less than 1 hectare)	75,408 (62.3)	83,694 (64.8)	92,356 (67.0)	29,814 (18.7)	32,026 (20.2)	35,410 (22.2)	0.40	0.38	0.38
Small (1.0 to 2.0 hectares)	22,695 (19.0)	23,930 (18.5)	24,705 (17.9)	32,139 (20.2)	33,101 (20.9)	35,136 (22.1)	1.42	1.38	1.42
Semi-Medium (2.0 to 4.0 hectares)	14,021 (11.8)	14,127 (10.9)	13,840 (10.1)	38,193 (24.0)	37,898 (23.9)	37,547 (23.6)	2.72	2.68	2.71
Medium (4.0 to 10.0 hectares)	6,577 (5.5)	6,375 (4.5)	5,856 (4.3)	38,217 (24.0)	36,583 (23.1)	33,709 (21.2)	5.81	5.74	5.76
Large (10.0 hectares and above)	1,230 (1.0)	1,096 (0.8)	1,000 (0.7)	21,072 (13.2)	18,715 (11.8)	17,379 (10.9)	17.12	17.08	17.37
All Holdings	**1,19,931 (100.0)**	**1,29,222 (100.0)**	**1,37,757 (100.0)**	**1,59,436 (100.0)**	**1,58,323 (100.0)**	**1,59,180 (100.0)**	**1.33**	**1.23**	**1.16**

Figures in parenthesis show percentages
Source: Agricultural statistics at glance 2013 p. 302.

been used to fix the upper limit for size of holdings because no Zamindar can possess more land than three times the economic holding.

Factors affecting the Size of Economic Land Holding. Size of economic land holding depends on the number of factors which keep on changing from one place to another. Some of the normal factors are briefly described below:

1. Fertility of Soil. Even a small piece of land with fertile soil can feed all the members of the farmer's family. But even a large piece of land is unable to feed the farmer's family members if the soil is not fertile and the farmer needs a larger piece of land for his sustenance. This is the main reason of smaller holdings in more fertile lands and larger holdings in less fertile lands. Simply speaking, size of lands holding is inversely proportioned to the fertility of the soil.

2. Irrigation. Crops get the required supply of water at the time of need in irrigated areas. The yields are higher and there is no fear of crop failure. Thus a small piece of land can enable the farmer to produce enough for his family members. On the contrary crops have to depend on rainfall for their growth in area lacking irrigation facilities and rainfall in India is very erratic. The yields are low and the danger of crop failure looms large. Under such a condition, the farmer needs larger piece of land to feed his family members. Therefore, holdings are usually of large size in areas lacking in irrigation.

3. Type of Agriculture. In area of intensive cultivation even a small piece of land can give high production and holdings are generally of small size. In contrast, in areas of extensive agriculture the yields are low and a large piece of land is required to sustain the farmer and his family members. Thus the size of holdings is quite large in such areas.

4. Farm Mechanisation. Use of farm machinery is not useful practically and economically on small holdings. Hence the size of holdings is large

TABLE 20.4. Average Size of Holdings by Size Group, 2010-11 (Hectares)

State/UT	Marginal	Small	Semi-Medium	Medium	Large	All Holdings
1	2	3	4	5	6	7
A and N islands	0.44	1.43	2.63	4.34	36.88	1.85
Andhra Pradesh	0.44	1.41	2.63	5.56	15.50	1.08
Arunachal Pradesh	0.55	1.34	2.76	5.54	14.90	3.51
Assam	0.42	1.38	2.69	5.15	68.11	1.10
Bihar	0.25	1.25	2.59	5.09	14.45	0.39
Chandigarh	0.46	1.43	2.86	5.70	11.08	1.29
Chhattisgarh	0.44	1.42	2.68	5.71	16.30	1.36
Dadar and Nagar Haveli	0.51	1.37	2.77	5.74	15.46	1.38
Daman and Diu	0.23	1.36	2.56	6.27	19.97	0.38
Delhi	0.42	1.32	2.69	5.56	15.13	1.45
Goa	0.31	1.40	2.74	5.57	22.91	0.93
Gujarat	0.49	1.45	2.77	5.71	19.54	2.11
Haryana	0.46	1.47	2.87	6.09	17.95	2.25
Himachal Pradesh	0.41	1.39	2.72	5.66	15.44	0.99
Jammu and Kashmir	0.35	1.40	2.68	5.43	22.34	0.62
Jharkhand	0.41	1.38	2.74	5.63	15.35	1.17
Karnataka	0.48	1.41	2.68	5.69	14.71	1.55
Kerala	0.13	1.57	2.79	5.32	64.58	0.22
Lakshadweep	0.17	1.36	2.50	6.11	24.00	0.27
Madhya Pradesh	0.49	1.42	2.73	5.76	15.77	1.78
Maharashtra	0.47	1.42	2.67	5.62	16.07	1.45
Manipur	0.52	1.28	2.48	4.86	11.00	1.14
Meghalaya	0.56	1.58	2.75	5.49	17.24	1.37
Mizoram	0.60	1.27	2.42	5.13	15.09	1.14
Nagaland	0.51	1.14	2.59	6.13	17.54	5.99
Odisha	0.57	1.63	2.95	5.99	25.46	1.04
Puducherry	0.35	1.46	2.86	5.72	16.90	0.66
Punjab	0.61	1.38	2.64	5.74	14.75	3.77
Rajasthan	0.49	1.43	2.83	6.14	17.45	3.07
Sikkim	0.37	1.20	2.49	5.44	15.77	1.42
Tamil Nadu	0.37	1.39	2.70	5.63	20.13	0.80
Tripura	0.27	1.39	2.59	4.81	14.29	0.52
Uttar Pradesh	0.37	1.39	2.72	5.52	15.01	0.75
Uttrakhand	0.44	1.43	2.71	5.45	23.11	0.89
West Bengal	0.49	1.59	2.73	4.85	38.58	0.77
Total	**0.38**	**1.42**	**2.71**	**5.76**	**17.37**	**1.16**

Source: Agriculture Statistics at a glance 2013, p. 305.

in areas where modernization of farming activities has taken place. Conversely, it can be said that mechanization of farming is possible only in areas of large holdings. One man can manage more than 50 hectares of agricultural land with the help of modern machines like tractors, harvesters, threshers etc., but a person cannot manage more than 6 to 8 hectares of agricultural land if he has to work with his hands or with primitive tools.

5. **Type of Crops.** Type of crops grown in a particular holding also determines its size to a great extent. For instant, if the farmer grows vegetables, even a small piece of land measuring two hectares is enough to give a reasonably good employment to the farmer and his family members throughout the year. In contrast, the same family requires at least eight hectares of land if the farmer grows wheat in his agricultural land.

Areal Distribution of Size of Holdings. Table 20.4 shows the average size of holdings by size group in different states and union territories of India in 2010-11. The last column of the table shows average size of all holdings. This column reveals that the size of holdings varies widely from as small as 0.22 hectares in Kerala to as large as 5.99 hectares in Nagaland although the average size for the country as a whole is 1.16 hectares. A large number of states have average size of holding much smaller than the national average. In states and union territories like Bihar, Damon and Diu, Goa, Himachal Pradesh, Jammu and Kashmir, Kerala, Lakshadweep, Puducherry, Tamil Nadu, Tripura, Uttar Pradesh, Uttarakhand and West Bengal, the average size of holdings is less than one hectare. This is really a depressing situation because no efficient cultivation, worth the name, is possible on such small holdings. The remaining states and union territories have holdings larger than the national average but the condition is not very satisfactory in these states also because in a large number of states, the holdings are less than two hectares in size. Gains of consolidation of holdings in Punjab, Haryana, Uttar Pradesh, Madhya Pradesh etc. have been nullified due to redistribution of land as a result of inheritance law. Large size of holdings in states like Nagaland and Arunachal Pradesh does not mean much because of rough terrain, thick forests and shifting agriculture. Moreover, large section of society lives in the form of clans which do not lead to division and fragmentation of holdings. Similarly large size of holdings in Rajasthan, is not of much use due to vast areas under desert conditions.

Fig. 20.2 shows the areal distribution of holdings in India characterized by lower level of fertility. This makes it necessary for the farmers to maintain large size of holdings.

Land Reforms

Two primary objectives of land reforms are (*i*) to make optimum use of limited land resources so that maximum benefit is drawn from labour and capital inputs and (*ii*) fixing the size of land holdings and redistributing the surplus land to landless and small farmers so that the actual tiller of the land feels secure and works hard to increase the agricultural production. Therefore, the scope of land reforms includes the following :

1. Abolition of intermediaries
2. Tenancy reforms
3. Ceiling of land holding and redistributing the surplus land to landless agricultural labourers and small farmers.
4. Agrarian reorganisation including consolidation of holdings and prevention of their sub-division and fragmentation.
5. Organisation of co-operative farms.
6. Improvement in the system of land record keeping.

1. Abolition of Intermediaries

Before Independence, the British rulers had introduced three categories of land tenure systems, namely Zanindari, Mahalwari and Roytwari.

(*a*) **Zamindari or Permanent System.** Although Zamindari system existed during the period of Mughal Empire the Zamindars were mere functionaries for collecting revenue on behalf of the Mughal Emperor and his representative or Diwan. The Diwan in turn would supervise the activities of he Zamindar to make sure of the rightful collection of revenue. This system underwent significant change after East India Company of the Britishers was awarded the diwani (overlordship) of Bengal by the Mughal Emperor following the Battle of Plassey in

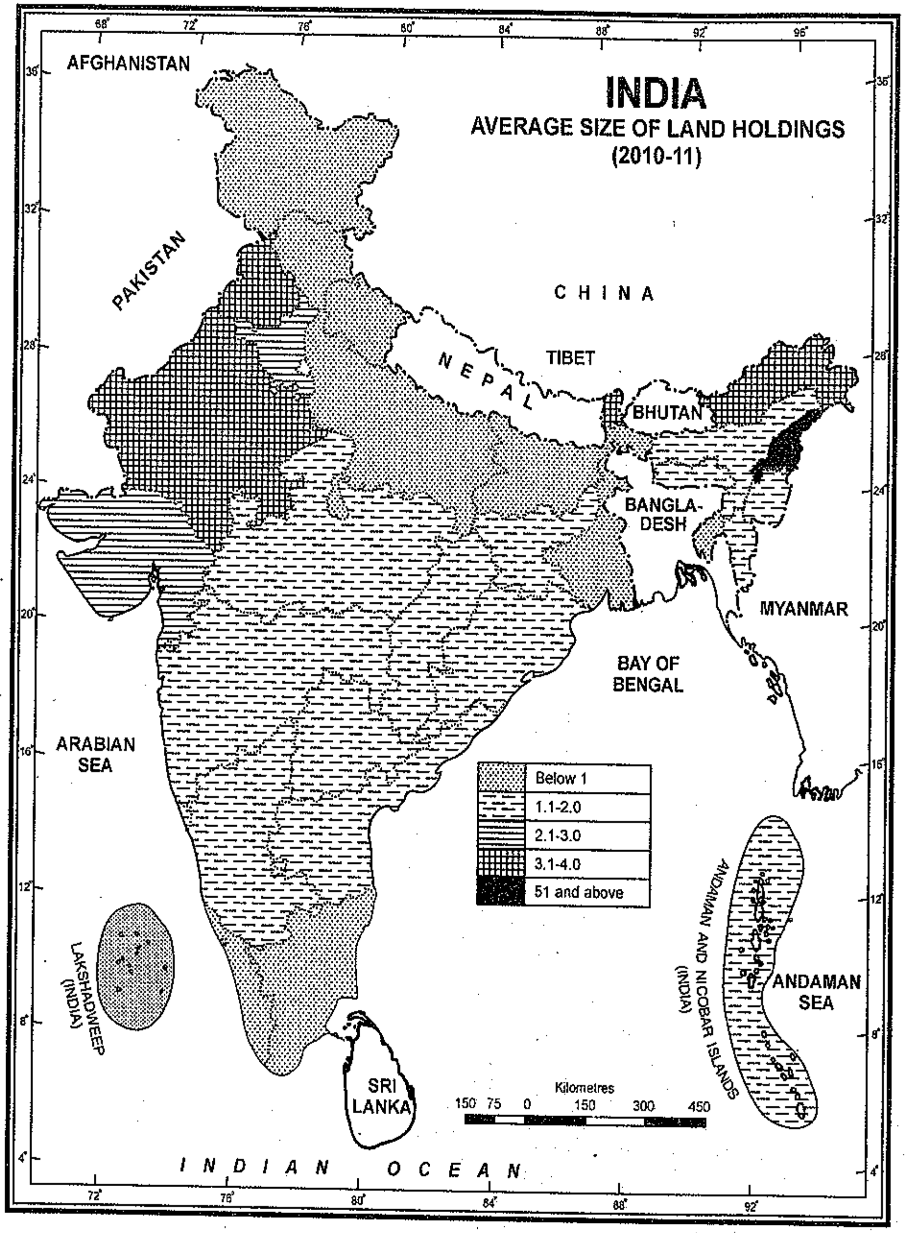

FIG. 20.2. India : Size of Land Holdings (2010-11)

1765. In the year 1793, **Lord Cornwallis** introduced 'Permanent Settlement' according to which feudal lords (jamindars, jagirdars etc.) were declared proprietors of land on the condition of fixed revenue payments to the British regime. Under this arrangement landlords were expected to pay 90 per cent of rent as revenue to the government in perpetuity and 10 per cent was left with them as

collection expenditure. This system prevailled over most of North India including the present day Uttar Pradesh, (except Awadh and Agra), Bihar, West-Bengal most of the Odisha and Rajasthan (except Jaipur and Jodhpur), and covered nearly 58 per cent of the total area cultivated. The landlords, in turn, created a hierarchy of intermediaries who were responsible for collecting rent from the cultivators. These landlords were living a luxurious life in the towns while the poor cultivators had to bear the burden of a large number of intermediaries.

In addition to permanent Zamindari with fixed land revenue in perpetuity there was temporary settlement of land revenue which used to be assessed for period ranging from 20 to 40 years and was subjected to revision. The East India Company introduced a system which could yield a regular flow of rent.

The British rulers argued that the Zamindars represent higher strata of rural society and assigning the job of rent collection will enhance the revenue and increase agricultural production. But this argument proved to be a myth. Demand for land increased due to increase in population and fall in rural industries and the Zamindars started collecting rent at higher rates. The system which was introduced to improve agriculture gave birth to ***absentee landlords*** and their number increased regularly. Thus there grew an intermediary between the state and actual tiller who was interested in land only to the extent of extracting exorbitant rent. So the Zamindara system represented large scale exploitation of the tillers by the absentee landlords and Indian agriculture was degraded to subsistence farming with low productivity.

(*b*) Ryotwari. The British rulers did not improve the above mentioned system of settlement in the rest of India after it came under their rule. Captain Munro introduced the second system of revenue collection known as the Ryotwari system of land settlement. It was first introduced in Madras in 1792 and in Bombay in 1817-18. Under this system, the individual cultivators (ryots or raiyats) were reorganised as proprietors of their land with rights to sub-let, mortgage and transfer their land by gift or sale. The individual land holder was directly responsible to the state for payment of land revenue. The settlement was concluded for a short period and the government reserved to itself the right to enhance the assessment for which no specific guidelines were laid down by law. This system of settlement was a complete contradiction to the prevailing old system where the land revenue was permanently fixed by custom and land was not a transferrable property. However, it reflected a kind cf Zamindari system because the ryat was at liberty to sublet his land to the tiller. This system was known at ***batai***.

The Ryotwari system accounted for about 38 per cent of the total cultivated area of the country and was prevalent in most of South India, including the present day Maharashtra, Karnataka, Tamil Nadu, Kerala, Andhra Pradesh, Telangana, and most of Madhya Pradesh and Assam. The princely states of Jaipur, and Jodhpur in Rajasthan also fell under Ryotwari type systems. Pockets of ***zamindari***-type tenure existed within these ryotwari areas, particularly where administered by local rajas or nawabs.

(*c*) Mahalwari. Mahalwari was the third system of land settlement under which the village lands were held jointly by the village communities, the members of which were jointly and severally responsible for payment of land revenue. Peasant farmers contributed shares of total revenue demand for the village (mahal) in proporosition to their respective holdings. The state was initially entitled to as much as 83 per cent of gross produce in revenue, although this was reduced to 66 per cent at a later stage. The Mahalwari system was introduced between 1820 and 1840 in Punjab (including) both present day Punjab in Pakistan and India, and Haryana), parts of the present day states of Madhya Pradesh, and Odisha and Princely states of Awadh and Agra in Uttar Pradesh. It covered about 5 per cent of cultivated area. Usuallly the village *lumbardar* was entitled to collect the revenue for which he received *panchortra i.e.*, 5 per cent as commission.

Zamindari, Ryotwari and Mahalwari had ill effects on land tenure and led to low productivity in Indian agriculture. For example, legislation introduction in Ryotwari and Mahalwari areas during 1850s enabled money-lenders to recover debts on loans secured on land holdings. Indebtness grow out of proportion due to exorbitantly high rates of revenue and dispossession of land led to rapidly rising tenacy. Thus, the rural society was polarized into landlords and rich peasants versus tenants and agricultural labourers and the distribution of land became highly unequal. According to Royal Commission on agriculture, 1924-25, as much as 86 per cent of the cultuivated area was held by a minority of 12 per cent of rich cultivators. In Punjab, by 1939, 2 per cent of land owners held 38 per cent of cultivated area. Since the actual cultivator had the right to land as property and the land became transferable under Ryotwari, there was larger scale alienation of land to non-agriculturist moneylenders due to excessive increase in revenue demand and increasing indebtness. In this way land gradually began to pass from the cultivators to money-lenders who were not much interested in improving the agricultural production.

In **Zamindari** areas, rural society was even more hierarchically divided between landlords, tenants with heredity rights (raiyats), sub-tanents, share croppers and agricultural labourers, and land distribution was even more unequal than in ryotwari areas (Bhalla 2007 : 21). In spite of a large number of legislations passed between 1859 and 1937 to help the cultivators very little benefits of reduction of rent reached the actual cultivator. The state of peasantry was quit dismissal. In Punjab about 40% of the cultivators were tenants at will. In Madras 48% of villagers were landless labourers. In Bengal, there was and increase of 62% in number of rent recovers between 1921 and 1931.

The above description makes it clear that the system of intermediaries was deep rooted and prevailed for a pretty long period in the agricultural history of India. Steps were taken immediately after Independence to abolish intermediaries, to stop the tyranmy and exploitation by Zamindars and to restore the tillers right over the land. The first such legislation was enacted in Madras in 1948. It was followed by Bombay in 1949-50, Hyderabad in 1951 Bihar, Madhya Pradesh, Uttar Pradesh, Central India and Assam in 1952 and Karnataka, Delhi, West Bengal and Himachal Pradesh in 1954-55. These steps led to abolitions of about 2,60,000 zamindars and intermediaries and 30 lakh tanents and share croppers acquired ownership rights of about 25 lakh hectares of cultivated land throughout the country. Also the governmet acquired vast starches of forests, barrens and waste land. Further, it resulted in the emergence of a middle class of peasantry which is now playing an important role in the development of Indian agriculture.

The Zamindari abolition act was however not without its inherent drawbacks and loopholes due to which the land could not be transferred to actual tillers and landless agricultural labourers. In many parts of the country, landlords with the connivance of local bureaucracy, were able to resume land for self-cultivation by ejecting a large number of tenants. In states like Bihar, Odisha, Rajasthan, Madhya Pradesh and West Bengal, landlords managed to keep very large holdings because of their power and influence. However, the general view is that land reforms were fairly successful in abolition of zamindari, jagirdari, inams etc. in more parts of India. Extent of tenancy declined considerably and self-cultivation became the dominant mode of production in most parts of the country.

2. *Tenancy Reforms*

Before Independence, the British rulers had introduced Zamindari, Ryotwari and Mahalwari system under which tenancy cultivation was very common in large parts of the country. Under tenancy cultivation system, small and marginal farmers as well as landless laboureres were forced to till the land of big landlords because they did not have their own land in sufficient measure. Following three types of tenants were recognized under this system:

(*i*) Occupancy or permanent tenants with permanent and heritable rights.

(*ii*) Tenants at will or temporary tanents.

(*iii*) Sub-tenants *or Shikmi-Kisan*.

The condition of temporary and sub-tenants was miserable because they were allowed to till the land on adhoc basis and were subject to ruthless exploitation. Frequent enhancement of rent, eviction on petty grounds and begari (free service) were some of the ways adopted by landlords to exploit the poor farmers and landless labourers. Even after so many reforms in the post Independence era, about 20 per cent of the agricultural land is devoted to share-cropping (*batai*) where 50 per cent of the produce is the normal rent. In certain cases, the rent may be as high as two-thirds of the total produced. In spite of the **National Policy** of giving full ownership of land to the actual cultivators, the desired results could not be achieved due to weak legislations and their faulty implementation. However, under the tenancy reforms about 112.92 lakh cultivators have acquired

ownership right over 62.13 lakh hectares of land. The tenancy reforms pertain to the following:

(*i*) regulation of rent

(*ii*) security of tenant and

(*iii*) conferment of ownership on tenants

States have made the following provisions to achieve the third objective

(*a*) All tenants have been given full security of tenure, without giving the owners the right of personal cultivation.

(*b*) Owners have been given the right to resume a limited area (not more than a family holding in any case) subject, however, to conditions that a minimum area is left with the tenant.

(*c*) A limit has been placed on the extent of land with a land-owner may resume, but the tenant is not entitled to retain minimum area of cultivation in all cases.

Regulation of Rents. As mentioned earlier, the tanents were supposed to pay very heavy rent ranging from 1/2 to 2/3rd of the total produce which left the poor farmers with little produce and led to overall extreme poverty among the majority of the farmers. As a result of legislations passed by a large number of states, the maximum rates of rent have been fixed at levels not exceeding 1/4 to 1/5th of the gross produce in all the States except in Andhra Pradesh, Haryana and Punjab. In some of the States, as in Gujarat, Maharashtra and Rajasthan, the maximum rent now stands at one-sixth of the produce. In Assam, Kerala, Odisha and Union Territories, the rent payable is about one-fourth of the produce or less. In several States, the normal level of rent is still about a third of the produce.

Security of Tenure. According to Sir Arther Young, "Give a man the secure possession of a bleak rock and he will turn it in to a garden, give him nine years lease of a garden and he converts it into a desert." It clearly implies that the tenant, who is the actual cultivator of land should be provided security against eviction and exploitation. In the absences of proper security he tries to get maximum output with minimum input. He tends to spend minimum on irrigation, fertilizers, better seeds and field boundaries and the lack of these inputs adversely affect the agricultural production. Therefore, the tenant should be provided with sufficient security for which strong legislation should be enacted. Unfortunately, the legislation and its implementation had been very weak and could not improve the conditions of tenancy to the desired level. This is because the social and economic position of tenants in the village is weak and it becomes difficult for them to seek the protection of law. Moreover, resort to legal process is costly and generally beyond the means of tenants. Thus, despite the legislation, the scales are weighted in favour of the continuance of existing terms and conditions. However, some progress could be recorded in some selected states like West Bengal, Kerala and Karnataka. In West Bengal 14 lakh share-croppers benefited from ***Operation Barga***. In Kerala 24 lakh tenant farmers achieved ownership of land as a result of efforts made by the tenants associations. Land tribunals set up in Karnataka to settle tenancy issues decided in favour three lakh tenants involving 11 lakh acres of land.

More than 20 million ***adivasis*** living in forests have been clamouring for rights over forest land and forest products for a very long period. The Scheduled Tribes and other Forest Dwellers (Recognition of Forest Rights) Act 2006 has granted heritable, inalienable right to use 2.5 hectares of forest land per family to all legitmate dwellers in forests. The Act came into force in January, 2008.

A new form of tenancy known as ***commercial tenancy*** had become popular in the agrarian economy of India. In areas where agriculture is technologically more advanced, small farmers lease and their land to bigger farmers because they cannot afford high technology inputs. For example, in Punjab this form of tenancy stands in stark contrast to the semi-feudal subsistency tenancy of the yore.

3. *Ceiling on Landholdings*

Imposition of ceiling on landholdings and distribution of surplus land among the landless labourers was the third most important objective of land reform legislation in India. It envisaged that all land more than a certain specified limit belonging to landlords would be taken over by the state and allotted to small farmers to make their holdings economic or to landless labourers to meet their demand for land. The idea of land redistribution through fixation of land ceiling has gained wide acceptance in India. The strategy basically is to ration land in such a way that poor farmers are not deprived of the land (the basic asset) while big landlords enjoy the privilege of having vast stretches of land. Ceiling laws were enacted and enforced in two phases. The first phase was from 1960 to 1972 during which ceiling legislation largely treated land holder as the unit of application. In the second phase after 1972 it was decided to have family as the basis of holding. **Table 20.5** depicts the ceiling limit on different categories of land in different states.

TABLE 20.5. Ceiling on Land Holdings

(In Acres)

State	Irrigated Land with two crops	Irrigated Land with one crop	Dry land
1	2	3	4
As recommended in 1972 National Guidelines	10-18	27	54
Proposed in Agenda Notes 1985 of Regional Ministers Conference	12	18	30
Andhra Pradesh	10 to 18	15 to 27	35 to 54
Assam	17	17	17
Bihar	15 to 18	25	30 to 45
Gujarat	10 to 18	15 to 27	20 to 54
Haryana	18	27	54
Himachal Pradesh	10	15	30 to 70
Jammu and Kashmir	9 to 12.5	9 to 12.5	15 to 23 (In Ladakh 19)
Karnataka	10 to 20	25 to 30	54
Kerala	12 to 15	12 to 15	12 to 15
Madhya Pradesh	18	27	54
Maharashtra	18	27	54
Manipur	12	12	15
Mizoram	Nil	Nil	Nil
Odisha	10	15	30 to 45
Punjab	17	27	51
Rajasthan	18	27	54 to 175
Tamil Nadu	12	30	60
Sikkim	12.5	12.5	50
Tripura	10	10	30
Uttarakhand	18	27	45
Uttar Pradesh	18	27	45
West Bengal	12	12	17
Andaman and Nicobar Islands	nil	nil	nil

Notes : 1. The actual limits for lands in Karnataka and Uttar Pradesh are higher due to classification of land.
2. The actual ceiling limits in Himachal Pradesh and Rajasthan are higher due to hilly terrain and desert lands.
3. 1 Acre = 0.404686 lectare.

Source **:** Agricultural Statistics at a glance 2013 p. 318.

Till 1972 *i.e.*, under the old ceiling laws only 9.30 lakh hectares of land was declared surplus out of which only 5.26 lakh hectares were redistributed among small and marginal farmers as well as landless labourers.

The Conference of Chief Ministers held in July, 1972 approved the following guidelines for implementation of land ceiling.

(*i*) For irrigation land with two crops per year, the ceiling was fixed from 4.05 to 7.28 hectares.

(*ii*) For irrigation land with one crop a year, the ceiling was fixed at 10.93 hectares.

(*iii*) In case of inferior dry land with practically no irrigation, the ceiling was put at a higher level of 21.85 hectares.

(*iv*) The unit of application should be a family of five members. Additional land may be allotted for each member in excess of five members subject to a maximum of twice the limit of the celings.

(*v*) The celing process was not to be applied to land under plantation crops (tea, coffee, rubber, spices, coco etc.) as well as under industrial and commercial establishments.

(*vi*) State governments were allowed to exempt religious, cheritable and educational trusts of public nature from the purview of ceiling.

(*vii*) While distributing the surplus land, priority should be given to landless agricultural labourers especially to those belonging to scheduled castes and scheduled tribes.

(*viii*) Compensation payable for surplus land as a result of ceiling should be fixed well below the market value so that it is within the capacity of the new allottees.

(*ix*) The compensation may be fixed in graded slabs and preferably in multiple of land revenue payable for the land.

The Conference of Chief Ministers (1972) was followed by Regional Ministers Conference in 1986 which suggested some changes in the ceiling on land holdings (**Table 20.5**).

In spite of ceiling laws the progress of acquiring land from big landlords and redistributing it among the poor farmers has not been satisfactory. According to Annual Report (2004-05) of the Ministry of Rural Areas and Employment, only 73.36 lakh acres of land was declared surplus during the period stretching from the time of implementation of the ceiling laws and March 2004. The area declared surplus so far is less than 2 per cent of the total cultivated area of the country. The area for which possession was taken amounted to 64.97 lakh acres and actually distributed area was 54.3 lakh acres only. The number of beneficiaries were 57.46 lakhs of which 16 per cent were scheduled castes and 15 per cent were scheduled tribes. Details of area declared surplus, area taken possession of, area distributed and number of beneficiaries are given in table 20.6.

TABLE 20.6. Achievements under Land ceiling laws (lakh acres)

Details/date	31.3.80	31.3.85	31.3.90	31.3.2004
Area declared surplus	69.13	72.07	72.25	73.36
Area taken possession	48.50	56.98	62.12	64.97
Area distributed	35.50	42.64	46.47	54.03
No. of beneficiaries (lakhs)	24.75	32.90	43.60	57.46

Source **:** Ministry of Rural Areas and Employment Annual Report (2004-05).

Failure of land ceiling laws is attributed to loopholes caused by the following :

(*i*) Provision for holding land upto twice the ceiling limits by families with more than 5 members.

(*ii*) Provision to give separate ceiling limited to major sons of the family.

(*iii*) Provision to treat every share-holder of a joint family as a separate unit for ceiling limits.

(*iv*) Exemption of plantation gardens, religious and charitable institutions from the provisions of ceiling.

(*v*) Individual states allowed landlords to retain control over land holdings, mostly through *benami* transactions namely transactions that transferred holdings in the names of deceased or ficticious persons registered with the connivance of the village *patwari*.

(*vi*) Misuse of exemption and misclassification of land.

(*vii*) Non-application of appropriate ceiling to lands newly brought under irrigation by public investment.

Furthermore, it is opined that lack of accurate updated records of rights on land was a major constraint on effective implementation of land ceilings as also tenancy reforms.

Conclusions. Following three conclusions are drawn :

(*i*) The share of small and marginal farmers both in ownership holdings and total area owned is increasing at a rapid pace. For instance, during 1953-54 the small and marginal farmers owning less than 2 hectares of land constituted 51.64% of the total holdings but accounted for only 16.31% of the total owned areas. By 2003, the share of these farmers in the number of ownership holdings had increased to 80.4% and their share of area had increased to 43.43%.

(*ii*) The proportionate share of large farmers both in total holdings and land owned has declined rapidly over the years.

(*iii*) Semi-medium and medium farmers are the main gainers in terms of share of owned land although their share in total ownership holding has declined considerably.

4. Consolidation of Holdings

As mentioned earlier, most of the land-holdings in India are small and fragmented. This results in large scale wastage of time and energy of the farmer because he has to operate his several small holdings scattered in different parts of the village agricultural land. The only way to take the farmer out of such an unwanted situation is consolidation of holdings which involves bringing together in one compact block all plots of land of a farmer which are scattered in different parts of the village. Under this scheme all land of the village is first pooled into one compact block and then divided into smaller blocks called *chaks* and then allotted to individual farmer. Laws for this purpose have been passed into 15 states.

Historically, 4.5 million hectares of land was brought under consolidation upto 31st January, 1956. This figure rose to 33 million hectares in 1972 and by the end of the Sixth Five Year Plan 45 million hectares were consolidated. Thus about one-fourth of the consolidable land was brought under consolidation. But consolidation of holdings has shown its impact in a few selected areas only. Punjab, Haryana and Western part of Uttar Pradesh are some such areas. This process has not even started in Rajasthan and some south Indian states. Among the eastern states only Bihar and Odisha have started this process. (Planning Commission, Seventh Five Year Plan-1980-85, p. 115). According to the data collected by the Ministry of Rural Development, consolidation was completed for 1663 lakh acres till 31st March, 2004. Out of this Maharashtra, 527 lakh acres or 32.2% and Uttar Pradesh 482 lakh acres or 29.4% were the main achievers. The programme of consolidation of holding has succeeded to a great extent in Punjab, Haryana and Madhya Pradesh. Efforts are being made to implement this programme in Bihar and Jammu and Kashmir. It has not been implemented in West Bengal and Assam. The states of Andhra Pradesh, Tamil Nadu, Kerala, Puducherry (U.T.) and all north-eastern states have not even passed the laws necessary for this purpose. Till now only 49% of the agricultural land of India is consolidated and the remaining 51% is yet to be consolidated. According to 2004-05 report of the Ministry of Rural Development no consolidation has been done in 9000-10,000 villages in Uttar Pradesh. These facts and figures indicate that consolidation of holdings has not yielded the desired result for which following factors may be responsible.

1. Farmers are emotionally attached to their ancestral land and are generally not willing to take advantage of this scheme.
2. Farmers possessing more fertile land are not in favour of this scheme for fear of being allotted infertile land after consolidation.
3. Consolidation of holding is a lengthy and cumbersome process. The government officials who are responsible for implementing the scheme of consolidation of holdings are usually slow, careless and corrupt.

4. Cooperation of the farmers was badly lacking with respect to implementation of this scheme.
5. A large number of farmers were unhappy with the redistribution of land after consolidation. This led to large scale litigation and many cases concerning land disputes are still pending in different courts. Such a situation has vitiated the serene social atmosphere of the rural areas.
6. Under the existing law of inheritance, the land belonging to father is divided among his heirs and land holdings continue to be divided and fragmented. Thus the initial gain of consolidation of holdings is nullified and need for a new scheme of consolidation of holding is badly felt.
7. In every consolidation about 5 to 10 per cent of the village land is taken out for providing house sites to weaker sections of society, approach (*chak*) roads and village utility services. Thus if the process of consolidation of holdings is repeated 3 to 4 times, a sizeable portion of agricultural land is lost to non-agricultural uses.
8. The cost of consolidation of holdings is realised from the farmers who are generally unwilling to bear this cost and are usually against this scheme. Further, it dries up their financial resources and has adverse effect on their economy.
9. It has been observed that small farmers usually get inferior quality of land with low fertility and low productivity. Since they do not possess enough money power, they are unable to bribe the corrupt officials and also fail to get proper justice in the court.

5. Cooperative Farming

Cooperative farming is a type of farming in which the farmers pool their resources and distribute the agricultural products in proportion to their resources. It helps in efficient farming and small farmers get the benefits which are usually available to big farmers. Problem of small and fragmented holdings is solved and economic position of poor farmers is improved. According to Planning Commission "Cooperation represents institutionalization of the principle and impulse of mutual aid. It has the merit of combining freedom and opportunity for the small man with the benefit of large scale management and organisation."(Draft Fifth Five Year Plan Vol. II, p. 76.) Although cooperative movement started way back in 1882, more emphasis on this type of farming was laid after Independence only. But like other institutional factors, cooperative farming also could not achieved its target and could not yield the desired results. About 60% of the cooperative societies are not functioning satisfactory.

6. Land Records

Updating of land records is most essential to implement the land reforms in their right earnestness. In India land records maintenance is highly unsatisfactory and is responsible for lots of land disputes leading to large scale litigation in the rural areas. Centrally sponsored scheme for updating land records and strengthening the revenue administration was introduced during the Seventh Plan. The Central Government provides financial assistance to states and union territories for using modern technology such as photo maps, areal photographs, remote sensing, computers etc. A committee on Revitalization of Land Revenue Administration submitted its report on March 2, 1995 on which necessary follow-up action was initiated by the Government of India and the State/Union Territories. Several legislations have been passed regarding land reforms and ceiling on land holdings. Till now, more than 250 land laws have been included in the Ninth Schedule of the Constitution.

3. INFRASTRUCTURAL FACTORS

Infrastructural factors include irrigation, power, roads, credit, insurance, marketing, storage facilities etc.

1. Irrigation. Need, feasibility and sources of irrigation in India have been described in details in Chapter 16. Expansion of irrigation facilities along with other infrastructural factors is the main strategy for increasing agricultural production. It is one of the most important inputs required at different critical stages of plant growth of various crops for optimum growth. Although India has made considerable progress with respect to irrigation during the planned period, more than half of the cultivated area is still without irrigation which entirely depends on monsoon rainfall for agricultural production. Since the monsoon rainfall is very erratic, there are large scale spatial and temporal variations in agricultural outputs. The adage that *Indian agriculture is a gamble in monsoons still holds time for large part of India.* However, irrigation has made a major contribution to solve the food problem in India. It is estimated that about 60% of the food grains production comes from the irrigated areas and the remaining 40% from rainfed areas. Yields of almost all the crops are much higher in irrigated areas as compared to rainfed areas.

The growth of irrigation facilities has failed to keep pace with the increasing demand for irrigation. This has been particularly the case in major/medium irrigation potential. The major/medium irrigation potential increased from 12.20 million hectares in the First Five Year Plan to 42.35 million hectares in the Tenth Five Year Plan. Whereas minor irrigation potential increased from 26.26 million hectares to 60.42 million hectares during the same period (**Table 20.7**). The chief reasons for low progress in major/medium irrigation were (a) long gestation period required for these projects (*b*) financial constraints as these projects involve heavy cost (*c*) inter-state disputes about water allocation of almost all major rivers (*d*) problems of acquisition of vast stretches of land and (*e*) resettlement and rehabilitation of the oustees.

The other major problem is the widening gap between potential created and potential utilized which increased from 1.22 million hectares in the First Five Year Plan to 15.54 million hectares in the Tenth Five Year Plan. The main gap occurs in major/medium projects. This happens due to lack of command area development, cropping pattern changes (shift to higher water consuming crops like rice cultivation in Punjab and Haryana) and lack of field channels. Regarding minor irrigation, although over 70% of the groundwater potential has been utilized, there are very serious problems of over-exploitation of ground

TABLE 20.7. All-India Irrigation Potential Created and Utilized, Planwise

(cumulative in million ha)

Period	Potential Created			Potential Utilized			Diff Col 4-7
	Major/ Medium	Minor	Total	Major/ Medium	Minor	Total	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Pre Plan up to 1951	9.70	12.90	22.60	9.70	12.90	22.60	–
I. Plan (1951-56)	12.20	14.06	26.26	10.98	14.06	25.04	1.22
II. Plan (1956-61)	14.33	14.75	29.08	13.05	14.75	27.80	1.28
III. Plan (1960-66)	16.57	17.00	33.57	15.17	17.00	32.17	1.40
Annual Plan (1966-69)	18.10	19.00	37.10	16.75	19.00	35.75	1.35
IV. Plan (1969-74)	20.70	23.50	44.20	18.69	23.50	42.19	2.81
V. Plan (1974-78)	24.72	27.30	52.02	21.16	27.30	48.46	1.56
Annual Plan (1978-80)	26.61	30.00	56.61	22.64	30.00	52.64	3.97
VI. Plan (1980-85)	27.70	37.52	65.22	23.57	35.25	58.82	6.40
VII. Plan (1985-90)	29.92	46.62	76.44	25.47	43.12	68.59	7.94
Annual Plan (1990-92)	30.74	50.35	81.09	26.31	46.51	72.85	8.24
VIII. Plan (1992-97)	32.95	53.31	86.26	28.44	48.77	77.21	9.02
IX. Plan (1997-2002)	37.05	56.90	93.95	31.01	49.99	81.00	12.05
X. Plan (2002-07)	42.35	60.42	102.77	34.42	52.81	87.23	15.54

Source *: Bhagirath,* October-December, 2011.

water and its rapid depletion, particularly in the north-western part of the country.

Another major set-back to the progress of irrigation is decelaration in irrigation investment during the Plan period. The funding for the irrigation sector as proportion of the total state plan size from the Sixth Five Year Plan onwards has been declining. It fell from 23.2% during the First Five Year Plan to only 6.0% during the Tenth Five Year Plan (**Table 20.8**).

TABLE 20.8 . Irrigation investment as percentage of state outlay

Plan	Irrigation Invest. as % of state outlay
First (1951-56)	23.2
Second (1956-61)	12.6
Third (1961-66)	12.8
Annual (1966-69)	15.6
Fourth (1969-74)	16.3
Fifth (1974-78)	10.7
Sixth (1980-85)	11.3
Seventh (1985-90)	9.0
Eighth (1992-97)	8.4
IX Plan (1997-02)	7.4
X Plan (2002-2007)	6.0

Source : Tenth Five Year Plan, and Economic Survey, 2005-06.

The Central Government initiated the Accelerated Irrigation Benefit Programme (AIBP) in 1996-97 for extending assistance for the completion of incomplete irrigation schemes. Under the AIBP ₹ 55,416 crore of central loan assistance (CLA)/grant have been released upto December, 2012. An irrigation potential of 7622.5 thousand hectares has been created by states, from major/medium/minor irrigation projects under AIBP till March, 2011. The Command Area Development Programme has also been amalgamated with the AIBP to reduce gap between potential created and potential utilized.

These are large variations in the total irrigated area and percentage of irrigated area of total area under different crops. (**Table 20.9**). For example 48.3% of the area under foodgrains is irrigated and this percentage varies from a meager 8.9% in case of Jowar to 91.3% in case of wheat. Rice, its most important food crops of India has 58.7% area under irrigation. Among the other crops sugarcane gets the maximum irrigation benefit because 93.7% of the sugarcane area gets irrigation facilities. A little over one-third of the cotton area is irrigated. Oil seeds are usually grown in the rainfed areas and a little more than one-fourth of the area under oil seeds is provided with irrigation.

Another major problem regarding irrigation is low efficiency of water use which ranges from 38 to 40% canal irrigation against an ideal value of 60%. Efficiency of water use in case of ground water irrigation schemes is about 60 percent. Low water use efficiency results in low agricultural productivity, iniquity in water supply to tail enders and water logging and salinity in water surplus areas. Among the several reasons for low efficiency of water use are dilapidated condition of irrigation canal system due to silting, weed growth and breakage of regulating structures leading to over-use of water. In several old delta systems like those of the Mahanadi, the Godavari and the Cauvery, irrigation is practiced by field-to-field flooding. Concessional water rates also lead to over use of canal water and results in low efficiency of water use. Dilapidated system of irrigation, operation and maintenance charges, low water rates and participatory irrigation system are all inter-related. Therefore the entire problem of low efficiency of water use should be tackled as a package of measures so that enough water is made available to crops and agricultural productivity is increased. The package should include modernization, conjunctive use through shallow augmentation tube wells, provision of temper-proof outlets, replacement of old canal road bridges, development of canal banks as roads for maintenance of canals and improving the rural transport system, promotion of water saving devices like sprinkler and drip irrigation systems through tax concession and subsidy-cum-loan schemes (Bhalla 2007: 130-31).

2. Power. Indian agriculture is going the industries way as more and more agricultural operations are depending on regular supply of cheap power in the form of hydro electricity and diesel. It is heartening to note that the average farm power availability for the cultivated areas has increased from 0.48 kW/ha in 1975-76 to about 2.6 kW/hr in 2014.

TABLE 20.9. Irrigated area under different crops

(Million hectares)

Year	1970-71	1980-81	1990-91	2000-01	2005-06	2006-07	2007-08	2008-09
1	2	3	4	5	6	7	8	9
Rice	14.3	16.4	19.5	24.3	25.0	25.3	25.2	26.5
%	38.4	40.7	45.5	54.4	56.6	58.1	57.8	58.7
Jowar	0.6	0.8	0.8	0.8	0.7	0.7	0.7	0.7
%	3.6	4.7	5.6	8.3	8.2	8.1	8.6	8.9
Bajra	0.5	0.6	0.5	0.8	0.9	0.9	1.0	0.8
%	4.0	5.5	5.1	7.8	9.2	9.6	10.3	9.4
Maize	0.9	1.2	1.2	1.5	1.7	1.7	2.0	2.0
%	15.9	20.1	19.7	21.8	22.5	22.4	24.4	25.2
Wheat	9.9	15.6	19.5	22.8	24.1	25.7	26.0	25.5
%	54.3	70.0	81.1	88.4	90.3	90.6	91.0	91.3
Barley	1.3	0.9	0.5	0.5	0.4	0.5	0.5	0.5
%	52.0	50.6	54.5	67.0	68.8	70.9	72.2	75.1
Total cereals	28.1	35.8	42.3	50.9	53.0	55.0	55.5	56.2
%	27.6	34.1	41.0	50.2	52.9	54.6	55.0	55.9
Total Pulses	2.0	2.0	2.6	2.7	3.4	3.6	3.9	3.8
%	8.8	9.0	10.5	12.6	14.4	15.4	15.8	16.0
Total Food grains	30.1	37.9	44.9	53.6	56.5	58.6	59.4	60.0
%	24.1	29.7	35.1	43.7	45.5	47.2	47.3	48.3
Sugarcane	1.9	2.4	3.4	4.3	4.3	4.9	4.8	4.5
%	72.4	81.3	86.9	92.2	93.2	93.8	94.0	93.7
Oil Seeds	1.1	2.3	5.8	5.5	8.6	8.2	7.8	8.2
%	7.4	14.5	22.9	22.4	28.1	28.7	27.0	27.1
Cotton	1.4	2.1	2.5	2.8	3.2	3.4	3.5	3.3
%	17.3	27.3	32.9	32.2	37.3	37.8	37.1	35.3

Source : Economic Survey 2011-12, p. A-21.

However, the current farm power availability is much lower than Korea (7 + kW/ha), Japan (14 + kW/ha) and the U.S.A. (6 + kW/ha). Thus it is concluded that more farm power should be made available to the farmers to upscale farm productivity so as to grow more foodgrains in view of stagnation in increase in net area sown.

Table 20.10 shows that there has been increasing trend with respect to consumption of electricity in agriculture. It increased from 23,422 GWh in 1985-86 to 1,26,377 GWh in 2010-11, thus registering of more than five times increase in a span of 15 years. Decline in percentage of electricity consumed in agriculture is not due to fall in total electricity consumption in agriculture but because of increase in electricity consumption in other fields like domestic, industry and commerce.

There are large spatial variations in the total consumption of electricity and percentage of share of

TABLE 20.10 . Consumption of Electricity for Agricultural Purposes

Year	Consumption for Agricultural purposes (GWh)	Total Consu-mption (GWh)	% Share of Agriculture consumption to total consumption
1985-86	23,422	1,22,999	29.04
1990-91	50,326	1,90,357	26.44
1995-96	85,732	2,77,029	30.90
2000-01	84,729	3,16,600	26.76
2005-06	96,292	4,11,887	21.92
2006-07	99,023	4,55,748	21.73
2007-08	104,182	5,01,977	20.75
2008-09	107,776	5,27,564	20.43
2009-10	119,492	5,69,618	20.98
2010-11	126,377	6,16,969	24.48

GWh = Giga Watt Hour

Source : Agricultural Statistics, at a glance 2012, p. 288.

TABLE 20.11. State-wise Consumption of Electricity for Agriculture purpose in 2009-10

Region	State/UTs	Consumption for Agricultural Purpose (GWh)	Total Energy Sold (GWh)	% Share of Consumption for Agriculture
1	2	3	4	5
Northern	Haryana	9,190.03	22,803.23	40.29
	Himachal Pradesh	36.82	5814.51	0.63
	Jammu and Kashmir	204.88	3538.71	5.79
	Punjab	10469.31	31291.49	33.46
	Rajasthan	12072.59	30622.78	39.42
	Uttar Pradesh	7340.72	41625.1	17.64
	Uttrakhand	298.10	6249.21	4.77
	Chandigarh	1.02	1237.58	0.08
	Delhi	39.67	19295.84	0.21
	Sub-Total	**39653.14**	**162484.45**	**24.40**
Western	Gujarat	12813.60	49777.64	25.74
	Madhya Pradesh	5985.65	22323.67	26.81
	Chhattisgarh	1751.60	11311.42	15.49
	Maharashtra	13264.22	77660.62	17.04
	Goa	110.76	2657.63	4.17
	Daman and Diu	2.49	1452.25	0.17
	D and N. Haveli	3.00	3329.74	0.09
	Sub-Total	**33931.52**	**16813.17**	**2.11**
Southern	Andhra Pradesh	18825.02	59677.44	31.54
	Karnataka	12384.77	36198.33	34.21
	Kerala	266.00	13967.15	1.90
	Tamil Nadu	11951.00	57722.33	20.70
	Lakshadweep	73.80	1920.96	3.84
	Puducherry	0.00	25.48	0.00
	Sub-Total	**43500.59**	**169511.69**	**25.66**
Eastern	Bihar	794.01	6067.22	13.09
	Jharkhand	65.72	13082.67	0.50
	Odisha	149.57	12227.86	1.22
	West Bengal	1322.97	31455.00	4.21
	A and N Islands	0.74	176.89	0.42
	Sikkim	0.00	301.50	0.00
	Sub-Total	**2333.0**	**63311.14**	**3.68**
North-Eastern				
	Assam	32.00	3257.00	0.98
	Manipur	0.71	220.65	0.32
	Meghalaya	0.63	898.42	0.07
	Nagaland	0.00	225.0	0.00
	Tripura	39.73	494.46	8.04
	Arunachal Pradesh	0.00	311.00	0.00
	Mizoram	0.50	191.33	0.26
	Sub-Total	**73.57**	**5597.86**	**1.31**
	Total (All India)	**119491.83**	**569618.31**	**20.98**

GWh: Giga Watt-hour

Source : Agricultural Statistics at a glance, 2012, pp. 291-92.

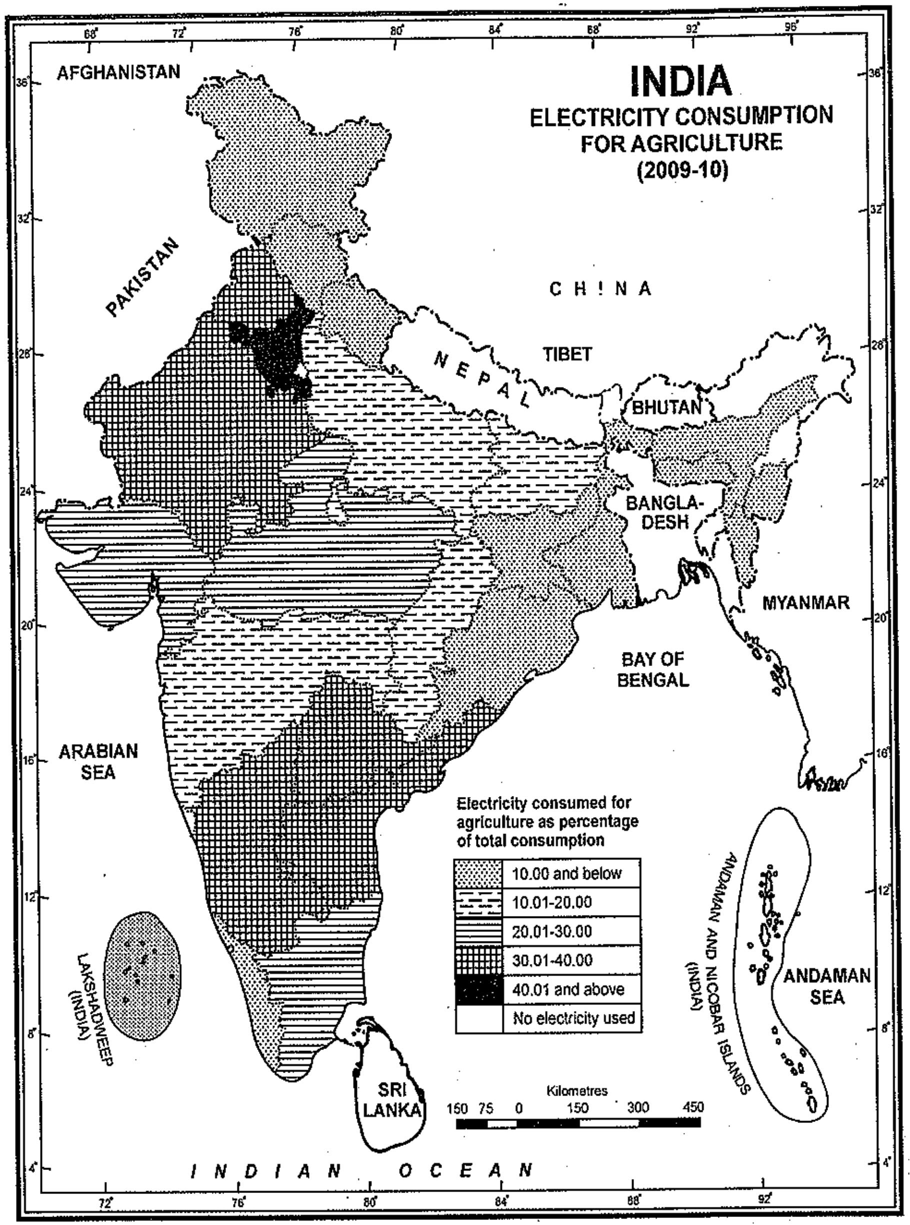

FIG. 20.3. Consumption of electricity for Agriculture Purpose (2009-10)

consumption of electricity in the agricultural field as percentage of the total consumption for agricultural purposes so far as total consumption of electricity for agriculture is concerned, Andhra Pradesh is at the top with more than 18.8 thousand GWh. The other states with more than ten thousand GWh electricity in agricultural field are : Maharashtra (13.3 thousand GWh), Gujarat (12.8 thousand GWh), Karnataka

(12.4 thousand GWh), Rajasthan (12.1 thousand GWh), Tamil Nadu (11.9 thousand GWh) and Punjab (10.4 thousand GWh). Most of the north-eastern states are least developed with respect to total consumption of electricity for agricultural purposes.

Regarding percentage share of agricultural consumption to total consumption of electrically, Haryana with 40.29 per cent is at the top. This is followed by Rajasthan (39.42%), Karnataka (34.21%), Punjab (33.46%) and Andhra Pradesh (31.54%). The other states with percentage share of electricity consumption in agriculture above the national average of 20.98% are Gujarat and Madhya Pradesh. Tamil Nadu with 20.70% is just near the national level. Sikkim, Arunachal Pradesh, Nagaland and Puducherry do not use electrically for agricultural purposes at all. The other states and union territories with less than five per cent share of agricultural consumption to total consumption are Himachal Pradesh, Uttarakhand, Chandigarh, Delhi, Goa, Daman and Diu, Dadra and Nagar Haweli, Kerala, Lakshadweep, Jharkhand, Odisha, West Bengal, Andaman and Nicobar islands, Assam, Manipur, Meghalaya, and Mizoram.

In order to increase the efficiency and productivity of agricultural operations, cheap and regular supply of electricity to farmers should be assured. Already some state electrically boards are facing heavy financial burden due to highly subsidized or almost free electricity to farmers. However, huge power shortage and erratic power supply with long declared and undeclared cuts in several parts of the country is the major cause of farmers' agitation in some of the agriculturally advanced states like Punjab, Haryana and Uttar Pradesh where tubewells are the major source of irrigation. The problem of power shortage is likely to be further complicated with sharp increase in demand for power in agriculture and other fields of economic activities. Therefore, there is an urgent need to increase power supply and make it more regular.

3. Roads. Road connectivities to villages is very essential for economic and social development of rural areas. Farmers have to frequently visit the nearby urban markets to purchase seeds, fertilizers, insecticides, pesticides, farm implements etc. and also articles of daily use. They also go the urban markets to sell their agricultural products. Village roads are lifelines for the rural folks particularly when sale of perishable commodities like vegetables, fruits, milk etc. is involved.

Although the total length of village roads is about 4.5 lakh kilometers, it is not sufficient keeping in view the size of the country and the percentage of people living in the rural areas. Further only about 15% of the village roads are surfaced. Considering the important role played by the village roads for the overall development of the rural areas, the Government of India launched hundred per cent centrally sponsored scheme of Pradhan Mantri Gram Sadak Yojna (PGSY) in December 2000 with the objective of providing connectivity by all weather roads to about 1.6 lakh unconnected habitations with population of 500 persons and above in plain areas and 250 persons and above in hill states, tribal areas and desert and left wing extremist (LWE) affected areas. Under the programme upto January 2012, about 4.41 lakh km roads had been cleared and 3,41,257 km length of roads had been completed and new connectivity was provided to a large number of villages.

Government of India has identified 'Rural Roads' as one of the six components of '*Bharat Nirman*' with a goal to provide connectivity to all eligible unconnected habitations with a population of 1000 persons and above in plain areas and 500 persons and above in hilly or tribal areas with an all weather road upto January 2012, a total of 42,531 habitations were connected out of 63,940 habitations to be connected and works for 58,387 habitations was sanctioned. In 2011-12, a target of 4000 habitations was set up to cover 33,000 kms of road length was to be constructed. Till January 2012 a total of 4142 habitations were covered and a total of 21750 kms road length was constructed.

4. Agricultural Credit. Agruicultural credit plays a significant role in improving agricultural production and productivity and mitigating the distress of farmers. Indian farmers need credit both for working capital and for investment. Demand for both for short-term and long term credit started raising rapidly with the onset of Green Revolution in mid 1960s. It happened due to the fact that farmers had to purchase costly inputs like fertilizers, better seeds, pesticides etc. Money was also required for land improvements, purchase of farm machinery, to build farm structures and dig wells.

The sources from which the farmers can borrow money can be divided into two categories viz. (*i*) non-institutional and (*ii*) institutional. The main non-institutional sources are the village money lenders who have been operating for several centuries. Borrowing money from the money lenders is very easy but they charge high rate of interest from the farmers. Often, the farmers are unable to repay loan and interest from their routine earning and have to mortgage their land to do so. Once mortgaged, the farmer finds it extremely difficult to get back his land.

In order to free the farmers from the clutches of the money lenders, the Government of India initiated institutional sources which include cooperative banks, commercial banks and Regional Rural Banks (RRBs). These institutions provide loans for productive purposes at much lower rates of interest. The state governments also provide Taccavi loans to farmers and extend financial support to State Cooperative Banks and Land Development Banks.

Although institutional credit system was initiated in the beginning of 20th century, much headway was not made till Independence. In the post-Independence era, credit institutional were developed in the following three phases.

(*i*) The ***first phase*** ranged from 1947 to 1969 during which cooperative agencies were the main institutions for providing loans to the farmers.

(*ii*) The ***second phase*** was between 1969 and 1975 during which the commercial banks were to provide agricultural credit and supplement credit by cooperatives.

(*iii*) The ***third phase*** started in 1975. During this phase, the Regional Rural Banks (RRBs) were established to provide credit to small and marginal farmers and also the weaker sections of society.

The cooperative credit services and credit structures. It consists of two wings viz., (*i*) short term credit structure and (*ii*) long term credit structure. The ***short term credit*** structure is designed to provide credit for production purposes and is based on three tier pattern consisting of (*a*) State Cooperative Banks (SCBs) (*b*) District Central Cooperative Banks (DCCBs) and (*c*) Primary Agricultural Credit Society (PACs). The **long term credit** is meant for land development and other capital expenditure. It is provided by the Primary Cooperative Agricultural and Rural Development Banks (PCARD) and State Cooperative Agricultural and Rural Development Banks (SCARD).

Finance to cooperatives is provided by National Bank for Agricultural and Rural Developmnent (NABARD) which was established in 1982. Three main functions of NABARD are development, credit and supervision.

The Government of India (GoI) is implementing a revival package for Short-term Rural Cooperative Credit Structure involving financial outlay of ₹ 13,596 crore. Twenty five states have signed memorandum of understanding with GoI and the NABARD. As of July 2012, ₹ 9002.11 crore had been released by NABARD as GoI share for recapitalization of 53,202 primary agriculture cooperative societies in 17 states.

Commercial Banks. Commercial banks started extending agricultural credit after the nationalization of 14 banks in 1969. These banks were to lend 18% of their total credit to agriculture as a priority sector and this mode of credit increased rapidly. In 1969, out of a total of 8262 bank branches, only 1860 were located in rural or semi-urban areas and there were only 2 lakh agricultural borrowing accounts. By 2004-2005, the number of agricultural borrowing accounts increased to over 16 million and the loans issued amounted to ₹ 72,886 crores. By 2005-06, commercial banks accounted for 69.52% of the total agricultural credit.

Regional Rural Banks (RRBs). These were set up in 1975 with the main objective of taking banking to the doorsteps of the rural masses, particularly in those areas where banking facilities were not existing. The idea was to serve the weaker sections of society. Initially only 5 RRBs were set up one each at Moradabad, Gorakhpur, Bhiwani, Jaipur and Malda. The number of RRBs increased to a 1996 by 2004 with 14,000 branches spreading over 516 districts.

Rural Infrastructural Development Fund (RIDF). Established in 1995-96, RIDF aims at providing loans to State Governments and State owned corporations to enable them to complete ongoing rural infrastructural projects. The total fund at its disposal amounted to ₹ 42,000 crore by 2005.

Kisan Credit Card (KCC) Scheme. This scheme was introduced in 1998-99 to provide adequate and timely credit to the farmers from the banking system for their cultivation needs in a flexible, hassle-free and cost effective manner. The farmers can use their cards for purchasing agricultural inputs like fertilizers, pesticides, seeds, etc. and also draw cash for their production needs. Credit limits are fixed on the basis of size of operational land holding, cropping pattern, scale of finance etc. It has been adopted by 27 commercial banks, 378 District Central Cooperative banks/State Cooperative Banks and 196 regional rural banks. The number of credit cards issued had risen to 16.38 crore upto 31st March. 2012. Table 20.12 gaves bankwise distribution of Kisan Credit as on 31st March, 2013.

TABLE 20.12 Distribution of Kisan Credit Cards according to categories of banks upto 31st March, 2012.

Category of Banks	Number of Kisan Credit Cards
1. Cooperative Banks	4,63,37,280
2. Regional Rural Banks	1,92,21,127
3. Commercial Banks	5,47,49,373
Total	12,03,07,780

Source : Agricultural Statistics at a glance, 2013, p. 292.

A revised Kisan Credit Card Scheme was introduced in March, 2012 in which KCC pass book has been replaced by an ATM-cum-debit card to all eligible and willing farmers in a time bound manner.

Self Help Groups (SHG) Bank Linkage. This programme was initiated in 1992 for improving the flow of credit to poor sections of the society and it has emerged as the largest and the fastest growing micro-finance programme in the country. As many as 560 banks are involved in this programme. These include 48 commercial banks, 196 RRBs and 316 cooperative banks. By December 2006, 18.29 lakh SHGs had been financed by banks with credit of over ₹ 8,719 crores. Over 90% of the SHGs are exclusive woman groups.

5. Agricultural Insurance. Agricultural insurance is necessary to provide financial compensation to farmers for losses in crop yields due to non-preventive risks including natural calamities like floods, droughts etc., pests and diseases and adverse weather conditions. It is a useful means of encouraging farmers to diversity to high value crops like fruits and vegetables which are susceptible to large fluctuations in output because of changes in weather (Bhalla 2007: 170). The government of India is currently implementing the following four Central Crop Insurance Schemes :

(i) National Agricultural Insurance Scheme (NAIS). This scheme was introduced in the rabi season of 1999-2000 with a view to providing insurance cover and financial support to farmers in the event of failure of crop due to natural calamities such as drought, flood, fire, pests and diseases. The scheme covers a wide range of crops including all food crops (cereals, millets and pulses), oilseeds and annual commercial/horticultural crops. At present the scheme is being implemented in 24 states and 2 union territories. During the 27 crop seasons from rabi 1999-2000 to rabi 2012-13, 2075 lakh farmers have been covered over an area of 3218 lakh hectares insuring a sum of ₹ 2,90,748 crore. Claims to the tune of about ₹ 25.352 crore have become payable against the premium of about ₹ 8,595 crore benefiting 524 lakh farmers.

(ii) Modified National Agricultural Insurance Scheme (MNAIS). With the aim of further improving crops insurance schemes the MNAIS is under implementation on pilot basis in 50 districts of 16 states from rabi 2010-11 season. The major changes introduced in this scheme *inter-alias* include village panchayat as a unit area of insurance for major crops, rationalization of calculation of threshold/guaranteed yield actuarial premium with adequate subsidy etc. Since the inception of the scheme from rabi 2010-11 to kharif 2012, 36.27 lakh farmers have been covered over an area of 39.35 lakh hectare insuring a sum of ₹ 8911.70 crore. Claims of ₹ 201.10 crore have been paid against premium of ₹ 897.03 benefiting about 3.47 lakh farmers.

(iii) Pilot Weather Based Crop Insurance Scheme (WBCIS). This scheme was implemented in Kharif 2007 season with the intention to provide insurance protection to farmers against adverse weather incidence such as deficit and excess rainfall, high or low temperature, and humidity that are deemed to adversely affect crop production. The scheme is based on actuarial rates of premium but to make it more attractive, premium actually charged from the farmers has been restricted to at par with

NAIS. Form kharif 2007-08 to rabi 2011-12, 370.69 lakh farmers cultivating an area of about 520.86 lakh hectares with a sum insured of about ₹ 64905 crore have been covered under the scheme. Claims of about ₹ 3208 crore have been paid against premium of about ₹ 5791 crore.

(iv) Coconut Palm Insurance Scheme (CPIS). This scheme was also approved on profit basis during the year 2009-10 and 2010-11 in selected areas of Andhra Pradesh, Goa, Karnataka, Kerala, Tamil Nadu, Maharashtra, Odisha and West Bengal. The sum insured is based on the input cost of the plantation and the age of the specific plant and it varies from ₹ 60 per palm in the age groups of 4-15 years to ₹ 1150 per palm in the age group of 16 to 40 years. The premium rate varies from ₹ 4.2 per palm in the age group of 4 to 15 to ₹ 5.75 per palm in the age group of 16 to 40 years. Fifty per cent is contributed by the Central government, 25 per cent by the concerned State Government and the remaining 25 per cent by the farmers.

6. Marketing. Although agricultural markets have existed in India for the past hundreds of years, they were largely unorganized and informal and could not play important role to help the farmers and the consumers. The farmers had limited choice because they had little surplus to sell and sold their crops to the village trader-cum-money lenders to pay of their rents, debts and to meet other cost requirements. Sometimes, farmers could venture to take their produce to a market in a nearby town where they could hardly get remunerative price for their produce due to underdeveloped nature of the markets, monopoly of a few traders, illiteracy of the farmers, malpractices like under weigthment, illicit deductions etc. and interlocking of credit and marketing. Simultaneously, price paid by the consumers used to be very high due to high profit of the traders and other middle men. It is estimated that producess received only 53% of the price of rice, 39% of the price of vegetables and 35% in the case fruit.

Although Agricultural Produce (Grading and Marketing) Act was passed way back in 1937, the rural development of agricultural marketing took place in the mid 1960s when the marketed surplus become much larger due to increased production as a result of effect of the Green Revolution. According to the Sub-Group an Estimation of Marketed Surplus Ratio Government of India (2004), 43% production of rice and other cereals and 51.5% of that of wheat were marketed during 2002-03. For pulses and oilseeds the share was 72.4% and 79.6% respectively. Commercial crops recorded a much higher marketed surplus. For example marketed surplus was about 93% in case of sugarcane and cotton. These developments necessitated the growth of agricultural markets and all the states of India enacted legislation known as the State Agricultural Produce (Markets) Act with a view to having regulated markets. The number of regulated markets was only 286 in 1950 and their number stood at 7157 as on 31st March, 2010. The advent of regulated markets has helped in mitigating the market handicaps of producers/sellers at wholesale assembling level, but rural periodic markets in general, and tribal markets in particular remain out of its development embit.

Organised marketing of agricultural products has been promoted through a network of regulated markets to ensure reasonable gains to farmers and consumers by creating a market environment conductive to fair play of supply and demand. A modal Agricultural Produce Market Committee (APMC) Act was prepared in 2003 for bringing about reforms in agricultural marketing. Many state governments have brought about amendments in APMC Act to further benefit the farmers and the consumers alike. But some states are yet to implement the provisions of the APMC Act.

Recently a major initiative has been taken to promote modern terminal markets for fruits, vegetables and other perishable in important urban centres of the country. These markets would be provided with state-of-the-art infrastructure facilities for electronic auction, cold chain and logistic and operate through primary collection centres conveniently located in producing areas to allow easy access to farmers. They are evasisaged to operate on "Hub" and Spoke" format wherein the Terminal market (the Hub) would be linked to a number of collection centres (the Spokes) conveniently locate in key production centres to allow easy access to farmer for marketing their produce. These markets would be set up under the scheme of National Horticulture Mission (NHM).

Agriculture sector requires competitive and well functioning markets with alternate choices to the

farmers. Reforms in agricultural markets were initiated to ease out restrictive and monopolistic approach of state and 2-3 grades were prescribed for each commodity. Grades help farmers/traders to get prices of agricultural commodities as per their quality and the consumers get the desired quality. As many as 105 Grading and Marketing Rules (GMR) covering 213 commodities have been notified under the provisions of Agricultural Produce (Grading and marketing) Act, 1937. These include fruits and vegetables, cereals, pulses, oilseeds, vegetable oils, ghee, spices, honey etc.

The Department of Agriculture and Cooperation (DAC) has the following three organizations dealing with marketing under its administrative control.

(i) Directorate of Marketing and Inspection (DMI) has its head offices at Faridabad (Haryana). Branch Head Office at Nagpur (Maharashtra), 11 Regional Offices and Central Agmark Laboratory at Nagpur.

(ii) Ch. Charan Singh National Institute of Agricultural Marketing (NIAM) set up Japiur on 8th August, 1988 with a mandate for Training Research Consultancy and Education in the field of Agriculture Marketing.

(iii) Small farmers Agri-Business Consortium (SFAC) registered in January, 1994 for innovative ideas, generating income and employment in rural areas by promoting private investment in agricultural project.

7. Storage and Warehousing. Farmers often find it difficult to retain their production due to lack of storage facilities and are force to opt for distress sale in the market. Storage facilities are, therefore, of utmost importance to help the farmers for getting remunerative prices and to facilitiate regular flow of agricultural products to the consumers. Considerable storage capacity has been created in the country after Independent and particularly in the post Green Revolution era, both at the national and the state levels. Whereas the Food Corporation of India (FCI) and the Central Warehousing Corporation (CWC) have created large storage facilities at the centres of all India importance, the State Governments and the State Warehousing Corporations (SWC) have built storage at centres of State/district level importance. FCI is the main agency which provides storage facilities for agricultural products. In addition to its own godowns, its hires storage capacity from other sources such as CWC, SWC and private parties. As on 1st February, 2012 the FCI had covered storage capacity 300.83 lakh tonnes (owned and hired) where the State Agencies (SWCs) had covered capacity of 155.34 lakh tonnes which is used for storage of central pool of foodgrains.

Although there had been considerable increase in storage capacity, the storage system in India came under severe stress after 2001-02 when marketable surplus in agriculture increased rapidly and the total foodgrains status with the FCI reached levels ranging from 50 to 60 million tonnes. Shortage of storage facilities results in damage of huge quantities of foodgrains. Large quantities of foodgrains are stored in open. In the year 2012-13 out of 57.85 million tons of grains stocks, 42.50 million tons were stored in covered storage and the remaining 15.35 million tons were stored in the open; a large proportion of which was exposed to rain and rodents. Rice and wheat amounting to about 11 million metric tons costing

TABLE 20.13. Procurement of major crops in India according to Marketing year (thousand Tonnes)

Crop/ year	2001-2002	2002 2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013
Rice/ (Oct-Sept)	22128	16422	22828	24684	27656	25107	28736	34104	32034	34198	35026	35.020
Wheat (April-March)	20630	19054	15801	16795	14787	9226	11128	22689	25382	22514	28335	38148
Coarse Grains	314.75	59.81	650.75	827.07	1153.50	0.20	203.56	1375.2	406.83	127.83	360.00	—

Source : Agricultural statistics at a glance 2012, p. 2 225-227 and 2013 pp. 223-24.

over ₹ 2050 crore was lost in storage and transit during three years from 2010-11 to 2012-13. (**Table 20.14**).

TABLE 20.14. Loss of foodgrains in storage and transit (matric tons)

Year	Storage loss	Transit loss	Worth (₹ in crores)
2010-11	1,74,904	1,77,037	605.72
2011-12	2,04,761	1,96,477	738.37
2012-13*	1,70,300	1,84,159	719.75

*Provisional

Source : FCI.

In order to meet the requirement of all time high stock levels of 823.174 lakh tons achieved in the year 2012-13 the FCI resorted to short term hiring to efficiently manage the stocks. Recognizing the problem of acute shortage of storage capacity, the government has set up a High Level Committee to look into the storage issues. Additional storage capacity has to be credited at suitable locations in order to meet the challenge of achieving broad objectives of food security. In this regard, the Government has formulated a scheme for construction of godowns under Private Entrepreneurs Guarantee (PEG) Scheme. Under the PEG scheme, the FCI guarantees 10 year usage of storage capacities to private investors and nine years to Central Warehousing Corporation and State Warehousing Corporations. The construction of godowns in 19 states with a total capacity of 197 lakh tons has been approved out of which a capacity of 132.73 lakh tons had been sanctioned for construction.

Gramin Bhadaran Yojna (GBY) or Rural Godowns Scheme (RGS) was lanch as on April 1, 2001 to create a network of rural godowns and to enable the farmers to retain the produce till the market prices are favourable and also to meet their credit requirements. The project for construction of rural godowns can be taken up by individuals, farmers, groups of farmers/growers, partnership/proprietory firm, Non-Government Organisations, Self Help Groups (SHGs), Companies, Corporations, Cooperatives, Local bodies other than Municipal Corporations, Federations, Agricultural Produce Market Committees, Marketing Boards and Agro Processing Corporations in the entire country. The Government provides subsidy for constructing these godowns. Since its inception from 01.04.2001 and upto 31.7.2013 a total number of 31,897 godowns having a capacity of 423.84 lakh metric tons had been sanctioned. The scheme has helped the formers to store their agricultural products near their fields and obtain pledge loans and marketing credit from banks, thereby avoiding distress sale immediately after the harvest.

4. TECHNOLOGICAL FACTORS

Technological factors pertain to high yielding varieties of seeds, chemical fertilizers, insecticides, pesticides an farm machinery etc.

Seeds. High Yielding Varieties (HYV) of seeds comprise one of the most important inputs for enhancing agricultural productivity and production. Efficiency of other agricultural inputs such as fertilizers, pesticides and irrigation is largely determined by it. Seed quality is estimated to account for 20-25 per cent of productivity. In addition to their genetic potential for high grain yield, the other important attributes of HYV seeds are (*a*) their high level of responsiveness to fertilizers and other inputs, (*b*) their high grain stalk ratios, and (*c*) photo-period insensitivity and short period maturity in most cases. The new seed varieties being short maturing also enable double cropping, have dwarf stems which are tough enough to carry heavy load, are resistant to wind damage, and have large leaf surface for faciliting photosynthesis. (Bhalla 2007: 101).

The High Yielding Variety Programme (HYVP) was launched in 1966-67 and covered 18.9 lakh hectares or 2.2% of the total cropped area of the six involved crops (rice, wheat, jowar, bajra, maize and ragi) in that year. Since then, the production and consumption of HYV seeds has been increasing steadily. At present more than four-fifth of the total cropped areas under these crops enjoys the facility of HYV seeds. The Central Government has been addressing this issue through various programmes/schemes. This include the Indian Seed Programme involving the participation of the Central and State Governments, Indian Council of Agricultural Research (ICAR), State agricultural universities, cooperatives and the private sector and farmers and plant breeders. Currently the seed production system consists of production of breeder, foundation and

certified seeds and their distribution. ***Breeder seeds*** represent the first stage of quality seed development and are prepared by the ICAR and some selected agricultural universities. ***Foundation seeds*** represent the second stage of quality seed development and are produced from the breeder seeds. These seeds are produced by the National Seeds Corporation (founded in 1963) and some selected agricultural universities. The seed multiplication and supply is done through a large number of agencies such as Central Government Seed Farms, State Seed Farms, State Departments of Agriculture, private seed producers and Seed Producers' Corporatives. Private producers produce seeds under strict supervision of scientists in the universities. ***Certified seed*** is the ultimate stage in seed production chain and is the progeny of foundation seed. The seeds have to be certified by the competent authorities before they are released to farmers for use in their fields. **Table 2.15** shows the progress in production and distribution of HYV seeds.

The Seed Act 1966 provides for legislative framework for regulation of quality seeds sold in the country. Considering the vital importance of the seed industry in promoting agricultural growth the Ministry of Agriculture has seen proposing replacement of the existing Seeds Act, 1966 by a suitable legislation. The new Act is expected to (*i*) create a facilitative climate for growth of seed industry, (*ii*) enhance seed replacement rates for various crops, (*iii*) boost export of seeds and encourage import of useful germ plasm and (*iv*) create a conductive atmosphere for application of frontier sciences in variety development and for enhanced investment in Research and Development (R & D). The Seeds Bill 2004 was introduced in the Rajya Sabha on 9th December, 2004 and is pending consideration by Parliament.

The New Policy on Seed Development (NPSO) was formulated in 1988 with a view a providing best planting material to Indian farmers. This policy has facilitated import of seeds under various categories. Initially seeds of cereals, oilseeds, pulses etc. were allowed to be imported. Subsequently seeds of more crops were allowed to be imported under prescribed conditions.

A Central Sector Scheme for Development Strengthening of Infrastructure Facilities for production and distribution of Quality Seeds with the aim of making quality seeds of various crops available to farmers at affordable price is under implementation since 2005-06. As a result of this initiative, availability of certified quality seeds has increased from 126.75 lakh quintals in 2005-06 to 328.6 lakh quintals in 2012-13. For achieving timely availability of seeds at affordable price to farmers in hilly/remote areas of north-eastern states, a transport Subsidy on Movement of Seeds scheme is in operation.

A look at the cropwise distribution of Certified/Quality seeds (**Table 20.16**) shows that food crops have been given top priority so that sufficient foodgrains are made available to the fast growing population. Oilseeds have also received considerable attention because India heavily depends on imports of oilseeds to meet her growing demand.

TABLE 20.15. Production of Breeder and Foundation Seeds and Distribution of Certified/Quality Seeds

Year	1991-92	1995-96	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Production of Breeder seeds (Thousand Quintals)	34.90	43.36	42.69	68.64	73.83	91.96	94.41	105.00	119.21	119.21
Production of Foundation Seeds (Lakh Quintals)	3.75	4.76	5.91	7.40	7.96	8.22	9.69	10.50	17.53	21.86
Distribution of Certified Quality Seeds (Lakh Quintals)	57.50	69.90	86.27	126.75	155.01	179.05	215.81	257.11	277.34	283.85

Source : Agricultural Statistics at glance, 2012, pp. 273-74.

TABLE 20.16 . Cropwise distribution of Certified/Quality seeds (lakh Quintals)

Crops/Year	1983-84	1991-92	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Cereals (weat, paddy, maize, jawar, bajra, ragi, barley)	25.67	35.35	59.97	86.73	109.87	123.80	147.43	165.15	182.62	184.52	189
Pulses (gram, lentil, peas, urad moong, arhar, cowpea, others)	2.09	3.29	3.85	7.37	9.63	12.57	14.48	19.69	20.83	22.26	23.95
Oilseeds (groundnut, rapeseed and mustard, til, sunflower, linseed castor seeds safflower, others.	6.49	9.66	12.54	24.35	27.00	34.33	39.92	50.1	50.61	61.49	62.07
Fibre crops (cotton, jute, mesta others)	1.91	2.03	2.91	2.89	3.05	2.63	2.58	2.65	2.64	3.09	2.85
Other miscellaneous crops	8.81	7.17	7.50	5.41	5.46	5.72	11.40	18.91	20.63	18.38	
Total	**44.97**	**57.50**	**86.27**	**126.75**	**155.01**	**179.05**	**215.81**	**257.11**	**277.34**	**294.85**	**299.90**

Source : Agricultural statistics at a glance, 2013, pp. 284-86.

Merits of HYV Seeds. A brief description of merits of HYV seeds has been given in the beginning of section on HYV seeds. However, a detailed description is required to appreciate the merit of these seeds and their contribution to enhancement in agricultural productivity will be very useful at this stage :

1. **Suitable for use of Fertilizers.** HYV seeds are suitable for use of fertilizers. It has been observed that new seeds give much higher yields as compared to old seeds for the same amount of fertilizers input. This is the reason that areas using higher amount of new seeds are also using fertilizers in larger quantities.

2. **Shorter Life Cycle.** HYV seeds have shorter life cycle. These seeds give early maturing crops and give greater opportunities a farmer to venture for multiple cropping. For example, new seeds of rice and wheat complete life cycles in 100 and 110 days respectively in contrast to 130 and 150 days respectively in case of traditional varieties of seeds. Thus new seeds help in increasing the farm production and economise on land.

3. **Economic on Irrigation.** Although new seeds require large amount of irrigation for proper growth of crops, yet the per quintal requirement of irrigation is much lower as compared to old seeds. This is due to the fact that per hectare yields in quintals is much higher in case of new seeds when compared with those of old seeds.

4. **Employment.** Agriculture based on HYV seeds requires more labour per unit area and generate more employment. Prior to the introduction of new seeds in the Indian agriculture, farmers were largely dependent on monsoon rainfall. This was particularly the case in the North-Plains of India. The farmers could not find any employment during the period between the harvesting of rabi crops and sowing kharif crops and were forced to sit idle from April to June. With the introduction of new seeds, the farmers can grow second crop immediately after harvesting the first and are thus able to find employment throughout the year.

5. **Easy to Adopt.** It does not require any special skill to adopt HYV seeds. They can be easily adopted by any class of farmers, whether big landlords or small farmers after elementary training. However, a little adjustment of dates of sowing the wheat crop is required because this crops requires relatively cool temperature at the time of sowing and during early period of its growth. This is due to the fact that wheat based on new seeds is of early maturing variety and has to be sown a little later. For

example, in Punjab, Haryana and western part of Uttar Pradesh wheat based on old seeds was sown in the beginning of October, but wheat based on new seeds is now sown in November-December in these areas. In contrast, rice is a kharif crop and does not require much adjustment in time of sowing. However, introduction of new seeds has enabled the farmers to take two crops of rice in place of only one crop obtained earlier on the basis of old seeds.

Constraints in Adoption of New Seeds

Although new HYV seeds have entirely transformed agricultural scenario in India and have made India a food deficit to a food surplus country even in the wake of rapidly increasing population, yet there are some constraints in the use of these seeds. Some of the major difficulties in adopting these seeds are briefly described as under :

1. **Irrigation.** New seeds do not tolerate dry weather and water shortage and need copious irrigation for the successful growth of crops based on these seeds. The monsoon rainfall occurs only for 3-4 months in the whole duration of the year and remaining 8-9 months are almost completely dry. Thus Indian agriculture is heavily dependent on irrigation and this dependency has further increased with the introduction of new seeds. New seeds have led to high crop intensity which requires much higher level of irrigation. The new seeds need right amount of irrigation at right time during the crop's growth. Under irrigation or over irrigation or irrigation at inappropriate time can hinder the proper growth of crops. It has been estimated that in areas like Punjab, Haryana and western part of Uttar Pradesh, 50 per cent increase in the wheat yields can be obtained by irrigation without other inputs like fertilizers etc. The first irrigation of wheat around the third week of sowing alone can increase the yields by as much as 30 percent. Other inputs like fertilizers, pesticides, insecticides etc. are of no use if proper irrigation at the proper time is not provided to crops.

2. **Fertilizers.** Indian soils, particularly those of the Great Plains of North India, have been tilled for thousands of years. As such they are exhausted and they have lost much of their fertility. This loss of fertility is to be compensated by using chemical fertilizers because conventional manures like cowdung, compost and green are not able to cope with the increasing demand. The introduction of new seeds has further increased the demand for chemical fertilizers because these seeds require higher inputs of fertilizers for giving higher crop yields. As mentioned earlier, new seeds have dwarf stems which are strong enough to carry heavy load, are resistant to wind damage, and have large leaf surface to facilitate photosynthesis. All these characteristics require heavy dose of chemical fertilizers. This is the reason that demand for chemical fertilizers has increased considerably since mid-1960s.

3. **Insecticides and Pesticides.** Crops based on new seeds are very delicate and are highly susceptible insects, pests and diseases. This is due to the fact that new seeds require heavy dose of irrigation, fertilizers and air as well as soil contains a lot of moisture and chemicals. These conditions lead to fast growth and multiplication of insects and pest in hot and humid climate of India. These insects and pests cause heavy damage to crops and reduce their yields substantially. This problem can be solved by spraying the crops with insecticides and pesticides at required intervals. For this purpose, the farmers are supposed to have adequate knowledge of the crop diseases and the types of chemicals to finish such diseases. The diseases may spread from one field to another as from one village to another village. Therefore quick and sufficient steps must be taken to spray the crops with the required insecticides and pesticides. Otherwise the insects and pests may damage the crop partially or wholly. Normally, insecticides and pesticides are very expensive and are out of read of the small and marginal farmers. Therefore, such farmers should be provided with financial assistance to cope with such a situation.

4. **Capital Constraint.** Use of new seeds is capital intensive because their use needs heavy inputs of irrigation (canal, tube wells), chemical fertilizers, insecticides and pesticides and agricultural machinery (tractors, harvesters, threshers, sprayers etc). All these

inputs are complimentary to one another and one cannot be of any use in the absence of the other. Their purchase requires sufficient capital which majority of the farmers, especially small and marginal farmers do possess. They should be extended loans at easy terms by different agencies like State Cooperative Banks, District Central Cooperative Banks, Primary Agriculture Credit Societies etc. Unfortunately, it is the big farmers who get the maximum advantage of loan facilities due to their strong influence and corrupt officials and poor farmers are usually deprived of such facilities. Therefore, there is urgent need to strengthen the agencies extending loans to farmers so that the most needy farmers get their due.

5. **Mechanization.** Use of modern agricultural machines is also essential for successful cultivation of HYV seeds. Raising of 2-3 crops is possible only by applying modern technology. The traditional farm implements like sickel, hoe, wooden plough, bullock cart etc. are more labour intensive and less efficient. Modern machines like tractors, harvesters, threshers, tillers, sprayers, pumping sets etc. are less labour intensive and more efficient. Since the farm machines are more efficient, they became big time savers and the farmer gets sufficient time to prepare for the second crop after harvesting the first crop. Thus it is possible for the farmer to take more than one crop during the course of year from the same field. Farm mechanization also helps in optimum utilization of the complementary inputs like irrigation, fertilizers, insecticides, pesticides etc. Availability of power in the form of hydroelectricity or diesel at cheap rates is of paramount importance for mechanisation of Indian agriculture. Power gives motion to farm machines in the absence of which the entire farm machinery comes to a stand still.

6. **Marketing and Storage Facilities.** The use of HYV seeds leads to high agricultural productivity which requires adequate facilities of marketing and storage. Food Corporation of India (FCI) was established by the Government of India for storing foodgrains which has helped in storing foodgrains after harvesting and releasing these foodgrains at the time of need. Usually the farmers take their agricultural products to the nearby urban market and sell them there. They also purchase seeds, fertilizers, pesticides, insecticides, farm machinery and things of daily use from these markets. For successful marketing of the agricultural products, it is essential that villages should be connected to the nearby urban markets by all weather metalled roads. A well developed transport system acts as blood veins for the producers and the consumers alike. Sale of perishable commodities like milk, vegetables, fruits, flowers etc. in the urban markets from the surrounding rural areas is simply impossible in the absence of a cheap and efficient transport network.

7. **Extension Services.** HYV seeds are very sensitive to irrigation, fertilizers, pesticides, insecticides, sowing, weeding and thinning etc. and mismanagement of any one of these inputs can adversely affect the farm productivity. For all these things to function properly, the farmers need to be adequately educated. This requires extension services by well trained, efficient and dedicated agents. Full utilization of extention services requires perfect understanding and coordination between farmers extension agents, farm supervisors, researchers and agricultural scientists. Any slackness on any front will lead to low agricultural productivity and overall poverty of farmers and aggravate the food problem.

8. **Human Factor.** Like all other major inputs, adoption of HYV seeds depends very much on human factor. Utilization of facilities like fertilizers, pesticides, insecticides and farm machinery for proper use of HYV seeds much depends on attitude of the farmers. There are certain farmers who are open to new ideas and technologies and adopt them easily. On the other hand there are other farmers who are conservative and orthodox in their approach towards life and do not accept new ideas in agriculture. In almost all the villages of India there are some progressive farmers who have improved their farm production and their standard of living while their conservative and orthodox counterparts are still living a life of poverty, deprevation, hunger and starvation. Unfortunately, farmers in large parts of India are still uneducated and do not adopt new technologies easily. This is the season that in spite of large scale progress in Indian agriculture after 1960s, India agricultural productivity is still far behind the world averages. The effect of Green Revolution has been maximum in Punjab and Haryana because farmers in these states are progressive and hardworking and adopt new technologies with ease and comfort. These two states have recorded unprecedented increase in the production of wheat after the advent of the Green Revolution. A similar progress has been noted in the coastal areas of Andhra Pradesh and Tamil Nadu with respect to increase in rice production because the farmers in these areas have easily adopted new techniques of rice cultivation.

Deficiencies of HYV Seed Programme

Although HYV seed programme has contributed a great deal in increasing the agricultural productivity. some glaring deficiencies in this programme have been noticed. Lack of appropriate scientific tests by the concerned government agencies before buying the seeds from seed farmers and distribution of seeds by some unscrupulous private dealers have resulted in reduced yields, variability in performance and increased growth of pests and insects. All these factors have exposed the farmers to bigger risks than ever before. Following concerns have become more serious at present :

(*i*) Inadequate inspection and certification of seeds has resulted in mushrooming seed production under lax scientific conditions. There is flood of non-"certified seeds marked as "Truthfully Marked Seeds" in the market and the farmers have to bear the brunt of this unhealthy practice.

(*ii*) Non-availability of good quality seeds has led to increasing tendency for farmers to produce their own seeds. The seed replacement rate continued to be much below 20% for most crops. As a result there is deterioration of quanlity seeds and the yields are adversely affected.

(*iii*) The major emphasis of seed programme has been on the development of better seeds for wheat and rice and other crops have received much less attention.

(*iv*) Throwing seed trade to multinationals has led to entry of genetically modified seeds in some high value crops like cotton, vegetables and fruits. Most important was Bt. cotton. Introduction of this seed led to phenomena increase in yields of cotton in the beginning to but a stage of saturation reached soon. The yield of cotton increased from 106 kg/ha in 1970-71 to 499 kg/ha in 2010-11 and fell to 486 kg/ha in 2012-13. However it increased to 529 kg/ha in 2013-14 as many farmers had discarded Bt-cotton seed. Further due to lack of affective legislation, some unscrupulous traders started selling spurious seeds to the farmers. This combined with bad weather led to ruination of many cotton farmers driving some to commit suicide. (Bhalla 2007:104). Hundreds of farmers growing cotton have committed suicide in Maharashtra and other states due to crop failure.

Fertilizers. Fertilizers is a crucial input for increasing the farm productivity and new HYV seeds are of no use without fertilizers. High level of plant nutrients is essential to achieve the objective of increasing farm production through high cropping intensity under multiple cropping programme. Green Revolution would have remained a dream for India but for the introduction of fertilizers, in spite of large scale use of HYV seeds and irrigation. In fact HYV seeds fertilizers and irrigation is that ***trilogy*** which has led to unprecendented increase in agricultural production.

Production Import and Consumption of Fertilizers. India is the third largest producer of fertilizers after China and USA and second largest consumer after China in the world. There are three main types of chemical fertilizers which are known as Nitrogenous (N), Phosphatic (P) and Potassic (K) fertilizers. Nitrogeneous fertilizers are the most important and account for about three-fourth of the total fertilizers production in the country. The remaining one-fourth are phosphatic and potassic fertilizers. The production of all fertilizers (NPK) increased from 1059 thousand tonnes in 1970-71 to 16092 thousand tonnes in 2013-14 recording more than 15 times increase within a span of four and a half decades. Similarly imports and consumption also have recorded phenomenal increase (**Table 20.17**). Uttar Pradesh is the largest consumer with a consumption of 4207.75 thousand tonnes in 2011-12. This is followed by Andhra Pradesh and Maharashtra consuming more than 3000 thousand tonnes each. Most of the north-eastern states are least dependent on chemical fertilizers. Entirely different picture emerges when we look at per hectare consumption of fertilizers. From this point of view, Andhra Pradesh is at the top consuming 266.11 kg/ha. This is followed by Punjab (243.56 kg/ha), Tamil Nadu (227.01 kg/ha) and Haryana (224.85 kg/ha). Again, north-eastern states are the least consumers per hectare. Among the union territories Puducherry is at the top consuming 674.06 kg/ha (**Table 20.18**).

India meets 80 per cent of its urea requirement through indigenous production but is largely import dependent for meeting her requirements of potassic (K) and phosphate (P) fertilizers. The government has notified the New Investment Policy 2012 (NIP-2012) in the urea sector which will encourage investments leading to increase in indigenous capacities, reduction in import dependence and savings in subsidy due to import substitution at prices below import parity price (IPP).

Although India has progressed a lot with regard to production and consumption of fertilizers, we still lag far behind several countries of the world so far as consumption of fertilizers per hectare is concerned (**Table 20.19**). Even some of the neighbouring countries like Pakistan, China and Bangladesh consume much more fertilizers than India. Most of the European countries. Egypt in Africa, Chile in South America. Japan in Asia and New Zealand in Oceanic use much larger quantities of fertilizers than India. This brings us to the conclusion that there is much scope for increasing the consumption of fertilizers so that our agricultural productivity increases and we are able to meet the growing needs of rapidly increasing population. However, proper consideration should be given to environmental problems arising out of thoughtless use of fertilizers. Already we are facing so many environmental problems resulting from unscientific use of fertilizers.

TABLE 20.17. Production Imports and Consumption of Fertilizers

(Thousands tonnes of nutrients)

	1970-71	1980-81	1990-91	2000-01	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
1	2	3	4	5	6	7	8	9	10	11	12
A. Nitrogen Fertilizers											
Production	830	2164	6993	11004	10900	10870	11900	12157	12259	12194	12338
Imports	477	1510	414	154	3677	3844	3447	4493	5240	4801	3920
Consumption	1487	3678	7997	10920	14419	15090	15580	16558	17300	16820	NA
B. Phosphatic fertilizers											
Production	229	842	2052	3748	3807	3464	4321	4223	4104	3541	3714
Imports	32	452	1311	396	1391	2927	2756	3802	4427	2797	1588
Consumption	462	1214	3221	4215	5515	6506	7274	8050	7614	6653	NA
C. Potassic fertilizers											
Imports	120	797	1328	1541	2653	3380	2945	4069	3335	1559	1926
Consumption	228	624	1328	1567	2636	3313	3632	3514	2676	2061	NA
D. All fertilizers (NPK)											
Production	1059	3006	9045	14752	14707	14334	16221	16380	16363	15735	16092
Imports	629	2759	2758	2090	7721	10151	9148	12364	13002	9157	7434
Consumption	2177	5516	12546	19702	22570	24909	26486	28122	27740	25536	NA

NA = Data Not Available

Source : Economic Survey 2013-14, Statistical Appendix p. 24.

TABLE 20.18 . Statewise / Zonewise Consumption of fertilizers in India (2011-12)

Sl. No	State/Zone	Total Consumption (Thousand Tonnes)				Consumption in kgs/hectare			
		N	P	K	Total	N	P	K	Total
South Zone									
1.	Andhra Pradesh	1977.29	1043.02	322.04	3342.35	157.43	83.04	25.64	266.11
2.	Karnataka	1215.94	786.76	332.85	2335.55	94.46	61.12	25.86	181.43
3.	Kerala	135.54	66.16	99.63	301.33	50.78	24.79	37.33	112.90
4.	Tamil Nadu	684.56	316.39	263.96	1264.91	122.86	56.78	47.37	227.01
5.	Puducherry	14.61	3.90	3.06	21.57	456.56	121.88	95.63	674.06
6.	A & N Islands	0.37	0.37	0.17	0.91	21.76	21.76	10.00	53.53
7.	Lakshadweep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
West Zone									
8.	Gujarat	1183.30	417.02	132.74	1733.06	106.24	37.44	11.92	155.60
9.	Madhya Pradesh	1061.75	750.76	79.47	1891.98	49.59	35.06	3.71	88.36
10.	Chhattisgarh	356.40	177.33	61.84	595.57	64.09	31.89	11.12	107.10
11.	Maharashtra	1610.91	1011.76	399.48	3022.15	71.24	44.74	17.67	133.65
12.	Rajasthan	913.49	416.11	26.18	1355.78	42.01	19.14	1.20	62.35
13.	Goa	3.06	2.67	1.89	7.62	19.13	16.69	11.81	47.63
14.	Daman & Diu	0.06	0.01	0.00	0.07	15.00	2.50	0.00	17.50
15.	D&N Haveli	0.60	0.41	0.00	1.01	25.00	17.08	0.00	42.08
North Zone									
16.	Haryana	1020.90	369.62	37.53	1428.05	160.75	58.20	5.91	224.85
17.	Punjab	1416.56	448.65	52.85	1918.06	179.88	56.97	6.71	243.56
18.	Uttar Pradesh	3067.10	1024.23	116.42	4207.75	123.85	41.36	4.70	169.91
19.	Uttarakhand	123.78	32.31	10.34	166.43	106.16	27.71	8.87	142.74
20.	Himachal Pradesh	32.80	9.70	8.93	51.43	35.19	10.41	9.58	55.18
21.	Jammu & Kashmir	66.13	28.65	5.29	100.07	57.76	25.02	4.62	87.40
22.	Delhi	0.35	0.22	0.01	0.58	7.61	4.78	0.22	12.61
23.	Chandigarh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
East Zone									
24.	Bihar	967.78	297.01	115.36	1380.15	129.19	39.65	15.40	184.24
25.	Jharkhand	118.02	42.01	11.34	171.37	84.36	30.03	8.11	122.49
26.	Odisha	323.41	135.48	55.80	514.69	35.51	14.88	6.13	56.52
27.	West Bengal	831.99	476.17	309.04	1617.20	87.30	49.97	32.43	169.70
North East Zone									
28.	Assam	151.05	49.08	75.52	275.65	36.85	11.97	18.42	67.25
29.	Tripura	10.42	5.49	2.73	18.64	33.72	17.77	8.83	60.32
30.	Manipur	6.59	0.97	0.44	8.00	28.28	4.16	1.89	34.33
31.	Meghalaya	3.27	1.24	0.25	4.76	9.73	3.69	0.74	14.17
32.	Nagaland	0.75	0.49	0.20	1.44	1.54	1.01	0.41	2.96
33.	Arunachal Pradesh	0.55	0.10	0.03	0.68	1.99	0.36	0.11	2.46
34.	Mizoram	0.92	0.21	0.06	1.19	7.48	1.71	0.49	9.67
35.	Sikkim	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	All India	**17300.25**	**7914.30**	**2525.45**	**27740**	**90.01**	**41.18**	**13.14**	**144.33**

Source : State of Indian Agriculture 2013, pp . 182-185.

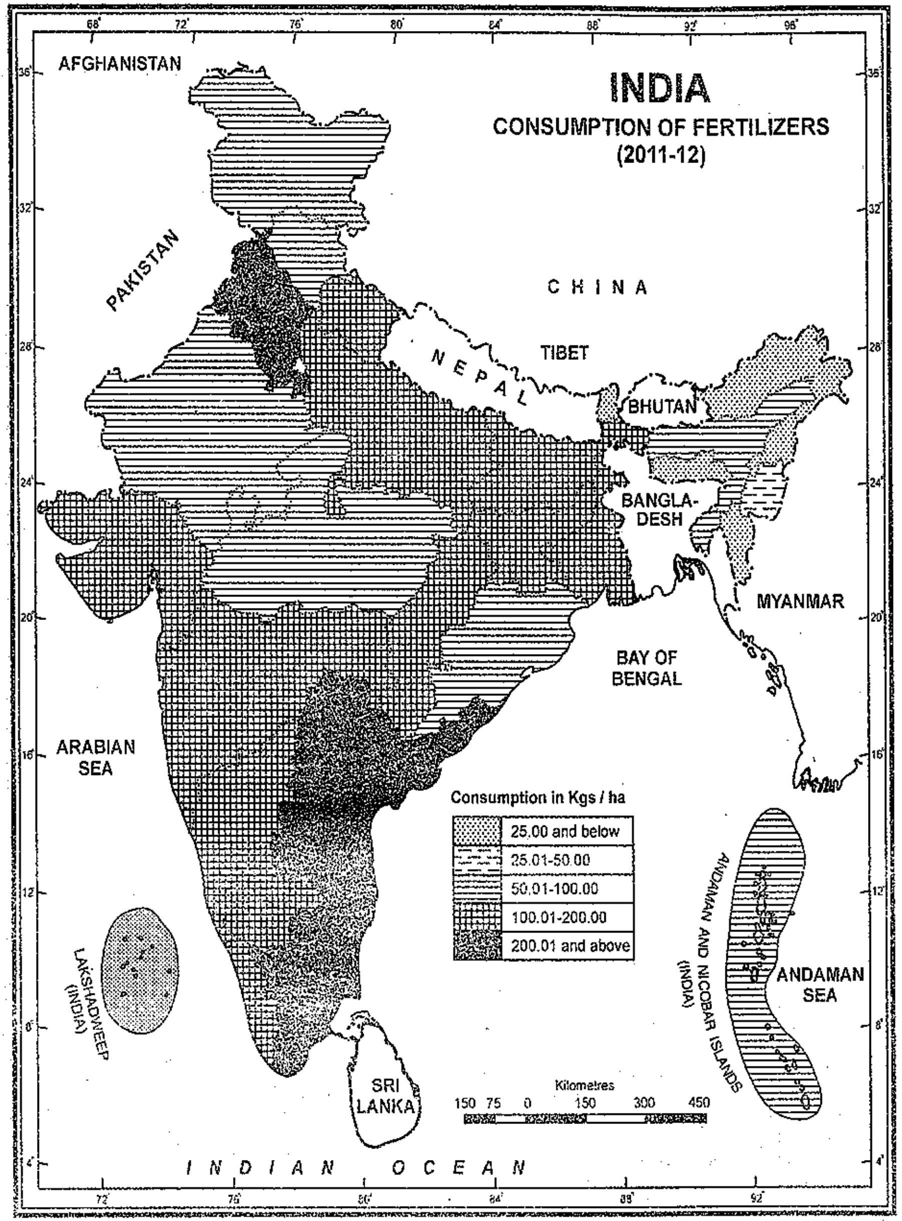

FIG. 20.4. India : Consumption of fertilizers in kilograms per hectare (2011-12)

Subsidy on Fertilisers. Under the Nutrient Based Subsidy (NBS) scheme for phosphatic and potassic (P&K) fertilizers implemented in 2010, a fixed amount of subsidy, decided on annual basis, is provided to each grade of P&K fertilizers, depending upon its nutrient content. An additional subsidy is

TABLE 20.19. Fertilizers Consumption of Arable Land and Land under permanent crops in selected countries in 2010

Country	Consumption/ Fertilizers (kg/ hectare)
1. Egypt	368.7
2. Chile	285.1
3. Bangladesh	224.0
4. China	400.3
5. India	165.8
6. Japan	212.5
7. Korea Republic	278.4
8. Malaysia	275.4
9. Pakistan	184.7
10. Belarus	253.6
11. France	176.8
12. Germany	206.3
13. Netherlands	270.6
14. U.K.	247.2
15. New Zealand	1,507.0

Source : Agricultural Statistics at a glance 2013, p. 281.

also provided to secondary and micro-nutrients. Under this scheme, manufacturers/marketers are allowed to fix the maximum retail price (MRP). Under NBS, as of Mrach 2014, farmers pay 61 to 75 per cent of the delivered cost of P&K fertilizers; the rest is borne by the Government of India in the form of subsidy. However, the government continues to share a substantial burden in the form of fertilizer subsidy (**Fig. 20.5**). Fertilizer subsidy was ₹ 67,971 crore in 2013-14 (Revised Estimate) an increase of 11 per cent over 2009-10. While the quantum of fertilizer subsidy increased, subsidy as percentage GDP has been declining since 2010.

Unbalanced Use of Fertilizers. One of the major problems of fertilizers in India is their unbalanced use. According to recommendation of the agricultural scientists, the ideal ratios in which nitrogeneous, phosphatic and potassium (NPK) fertilizers should be used is 4:2:1. This ratio was 6.0:2.4:1 in 1990-91. The prices of different fertilizers were changed after the Government of India adopted the policy of liberalization in 1991 which resulted in highly unbalanced use of fertilizers and it rose to 9.7:2.9:1 in 1993-94. Some of the agriculturally advanced states like Punjab, Haryana, Uttar Pradesh, Andhra Pradesh and Tamil Nadu showed still greater unbalanced use of NPK fertilizers. **Table 20.20** gives an idea of unbalanced use of fertilizers in Bihar, Haryana and Punjab. This led to a serious degradation of soil nutrients. In order to remove this unbalanced use of fertilizers, the Government of India come out with subsidies of varying extent to different types of fertilizers. In spite of steps taken to correct the

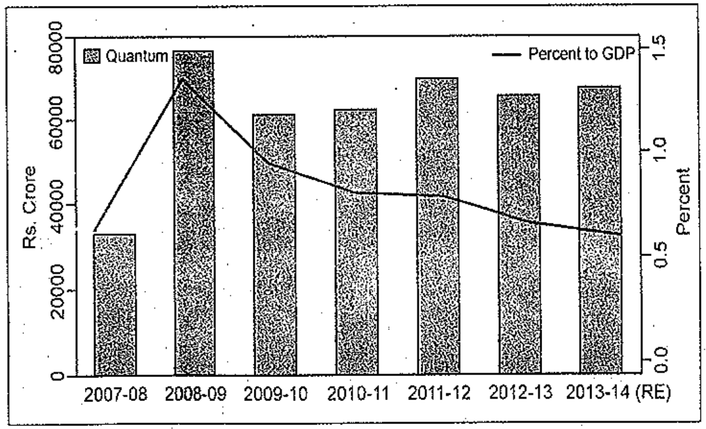

FIG. 20.5. Fertilizer subsidy disbursed

TABLE 20.20. Unbalanced use of NPK fertilizers

	2009-10	2010-11	2012-13
Bihar	5.3 : 1.5 : 1	5.8 : 1.9 : 1	12.3 : 3.6 : 1
Haryana	15.9 : 5.5 : 1	20.4 : 6 : 1	61.4 : 18.7 : 1
Punjab	18.4 : 5.9 : 1	19.1 : 5.4 : 1	61.9 : 19.3 : 1
All India	4.3 : 2 : 1	5.0 : 2.4 : 1	8.2 : 3.2 : 1

Source : Economic Survey 2013-14, p. 144.

unbalanced use, the NPK ratio stood at 8.2 : 3.2 : 1 in 2012-13 which still remained skewed in favour of N and P against K. Use of urea in higher proportion adversely affects the soil profile. Proper growth of plants occurs only when the soil contains all sixteen nutrients. The soil should have sufficient quantity of sulphur, zinc and calcium in addition to NPK.

Fatigue of the Green Revolution and stagnation in agricultural growth in 1990s was largely due to unbalanced used of fertilizers. Crop productivity has not increase in proportion to the use of fertilizers in areas of higher consumption of fertilizers. It seemed that crop production in India has reached its zenith with reference to the present day level of technological advancement but is still at a very low level where compared with some other advanced countries.

Fertilizer Quality Control. The Central Government ensures the quality of fertilizers through Fertilizers (Control) Order (FCO) issued under Essential Commodities Act 1953 to regulate the trade, price, quality and distribution of fertilizers in the country. The State Governments are the enforcement agencies for implementation of provisions of FCO, 1985. The order prohibits the manufacturing, import and sale of any fertilizer, which does not meet prescribed standards. To check the quality of fertilizers, 74 laboratories have been set up in different parts of the country. These include 4 Central Government laboratories, namely Central Fertilizers Quality Control and Training Institute at Faridabad and its three Regional Laboratories at Chennai, Navi Mumbai and Kalyani. Details of these laboratories are given in **table 20.21**.

TABLE 20.21. Fertilizer Quality Control Laboratories in India

Year laoratories	No. of Laboratories	Annual Analytical Capacity (No. of samples)	No. of Samples analysed	%age of Non-standard samples
2005-06	67	1,22,488	1,11,745	6.0
2006-07	68	1,29,250	1,16,142	6.0
2007-08	68	1,29,231	95,866	6.2
2008-09	71	1,32,965	1,04,498	5.5
2009-10	74	1,30,635	1,18,312	5.2

Source : India 2012. Reference Annual, p.107.

Farm Mechanisation

Like other inputs such as HYV seeds, fertilizers, irrigation etc., farm mechanization is a very important and has immense potential for improving farm productivity. It has been estimated that adoption of appropriate mechanization of farm operations can increase farm productivity by 10-15 per cent, cropping intensity by 5-20 per cent, fertilizers and chemicals upto 15-20 per cent and time labour upto 20-30 per cent. Unfortunately, a vast majority of Indian farmers still use primitive and inefficient farm implements thereby causing great hinderance in the path to agricultural progress. The wooden plough and the bullock cart are still most commonly used implements in large parts of the country. However, some progress has been made towards farm mechanization and impressive achievement is visible in the field of power-operated irrigation pumps. At present about 84 lakh electric pumps/tube wells are operating in different parts of the country. Tractors are the main power source for various farm operations and India is the world leader in tractor promotion. The number of tractors produced in the country increased from a modest 71 thousand in 1970-71 to 54.9 lakh in 2011-12. Uttar Pradesh has the largest number of tractors followed by Rajasthan, Punjab and Haryana. Tillers, harvesters, threshers etc. are other important machines being used in agricultural operations.

Small, fragmented and shrinking size of the holdings and low purchasing power of small and marginal farmers are making individual ownership of agricultural machinery progressively uneconomical. This requires steps for setting up of custom-hiring centres/high-tech machinery banks so that small and marginal farmers can reap the benefits of farm mechanization. So far, advantages of farm mechanization are available to rich landlords only who own vast stretches of land and have sufficient financial resources to purchase costly farm machinery. To help the poor farmers, the government initiated a Sub-Mission on Agriculture Mechanisation in the Twelfth-Five Year Plan. Introduction of technologically advanced equipments through extension and demonstration besides institutional credit has also been taken up. A huge industrial base for manufacturing agricultural machines has also been developed.

CROPPING PATTERN

Cropping pattern refers to proportion of area under different crops at a given point of time. It gives an idea of relative importance of different crops in a region or a country at specific time. Cropping pattern is not static; it changes with reference to time and space. Any change in cropping pattern reflects the change in land used to grow different types of crops. At the time of Independence, about three-fourths of the total cropped area was under food crops. There was very little diversification in the pattern of cropping and almost entire Great Plain of North India was dominated by food crops including sugarcane. Cotton in Maharashtra, tea in Assam and jute in West Bengal were the other major crops.

There was no major change in cropping pattern in the country during the first three Five Year Plans from 1951 to 1966. However, food crops gained further importance with the advent of the Green Revolution and due to rapid increase in population. As much as 82% of the cropped area was devoted to food crops. The major increase in area, yield and production was in case of wheat and rice, two main food crops of Indians. In due course of time diversification in the cropping pattern started showing its impact and in 1990-91, the pattern became rather complex as non-food crops became more prominent. Rice and wheat covered about 40% of the cropped area while oilseeds became more prominent occupying 13% and pulses occupied 14 per cent of the cropped area. **Table 20.22** shows changes in cropping pattern in India.

Identification of cropping pattern becomes easy when we work out the cropping pattern of area by considering the dominant (primary), major, secondary and minor crops. Normally dominant crops are those that are first rank crops; major crops occupy over 15 per cent of the cropped areas, secondary crops 5 to 15 per cent and minor crops less than 5 percent. Thus the number of crops and their relative strengths in land occupance makes for emergence of any number of cropping pattern regions. For the sake of simplicity minor crops are usually eliminated and are not considered while reckoning with cropping pattern.

In any cropping pattern, each crop is given its position in terms of percentage in relation to the total cropped area of an areal unit. This is expressed as

$$C_p = \left(\frac{C_a}{N}, \frac{C_b}{N}, \frac{C_c}{N} \ldots\ldots \frac{C_z}{N}\right) \times 100$$

where, C_p represents the cropping pattern : C_a, C_b, C_c etc. in cropped area under crops a, b, c ... in an enumeration unit and N is the total cropped area in the same unit.

A review of the cropping pattern of India highlights the fact that cropping pattern in the country is still tradition bound in which food crops occupy prominent place and little attention is paid to the commercial crops. Even among the food crops, rice is the most important crop which is the staple food of

TABLE 20.22. Change in cropping pattern of India

Crops/Years	1990-91	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2008-09	2009-10
Food Crops	68.82	65.29	64.72	64.83	64.90	63.06	63.14	63.80	63.86
Other Crops	31.18	34.71	35.38	35.17	35.10	36.94	36.86	36.20	36.14
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source : (*i*) Statistical Abstract of India 2007, pp. 109-111, (*ii*) Agricultural Statistics at a glance, 2012, p. 263.

people living in the southern part of the country. Wheat is the second most important food crop which is primarily grown in the north-western part of the country. Coarse grains like jowar, bajra, maize, barley, ragi etc. are given comparatively less importance. The cropping pattern in a large number of regions in India is typical of an underdeveloped agricultural economy in which most of the cultivated area is devoted to subsistence foodgrains. These are mainly produced for domestic use and there is hardly any surplus to be sold in the market. In spite of the unprecedented increase in the production of foodgrains due to positive effects of the Green Revolution, food surplus is still a far cry in view of the fast increasing population. Cash crops constitute only a negligible percentage of the cropped area (Table 20.23).

Factors affecting cropping pattern

It is but natural to find regional variations in cropping patterns in a vast country like India. These variations are due to geographical, economic and political factors.

I. Geographical Factors

Geographical factors like relief, soil, temperature and rainfall bring about regional variations in cropping patterns in their own way.

1. Relief. Most of the crops prefer plain areas where vast stretches of land are available for cultivation and agricultural operations are much easier as compared to hilly areas. But there are some crops like tea and coffee, which require large amount of water for their growth but stagnent water is harmful for their roots. Therefore, these crops are grown on hill slopes where rain water can easily drain down the slope. Some of the hill slopes are cut into terraces and terraced cultivation is practised there. Rice is the main crop on these hill terraces.

2. Soil. Rice is mainly grown in clayey soils while loamy soils are best soils for wheat. The regur soil of the Deccan Plateau is ideal for cultivation of cotton. Coarse grains such as jowar, bajra, maize, ragi, barley etc. are grown in inferior soils which include light sandy soils, light black soils, red and laterite soils etc. Fertility of soil is a major determinant of crop productivity and hence of

TABLE 20.23. Gross Cropped Area Percentage Distribution

Crop	Percentage Share of Area to Gross Cropped Area	
	2009-10*	2010-11*
1	2	3
Rice	22.52	22.05
Jowar	4.13	3.70
Bjara	4.80	4.86
Maize	4.32	4.22
Ragi	0.65	0.63
Wheat	15.10	14.99
Barley	0.33	0.36
Other Cereals & Millets	0.48	0.43
Coarse Cereals	**14.71**	**14.20**
Total Cereals	**52.34**	**51.24**
Gram	4.23	4.46
Tur	1.73	2.16
Other Pulses	5.98	6.33
Total Pulses	**11.94**	**12.94**
Total Food-grains	**64.28**	**64.18**
Sugarcane	2.41	2.66
Condiments & Spices	1.66	1.67
Total Fruits	**2.10**	**2.17**
Potatoes	0.83	0.79
Onions	0.32	0.30
Total Vegetables	**2.84**	**2.71**
Groundnut	2.87	2.93
Sesamum	1.10	1.09
Rapeseed & Mustard	2.83	2.80
Linseed	0.15	0.15
Other Oil Seeds	7.80	7.64
Total Oil Seeds	**14.76**	**14.60**
Cotton	5.28	5.50
Jute	0.43	0.39
Mesta	0.04	0.04
Total Fibers	**5.79**	**5.96**
Tobacco	0.25	0.22
Other Crops	5.91	5.84
Cross Cropped Area	**100.00**	**100.00**

*Provisional

Source : Agricultural Statistics at a glance, 2012, p. 266.

cropping pattern in any region. Delta soils of West Bengal are renewed by floods every year and are very fertile. The Ganga-Brahmaputra delta is world renowned for jute cultivation. These fertile delta soils enable the farmers to take 2-3 and sometimes even four crops in a year. In fact the whole of Great Plain of North India is drained by mighty rivers like the Ganga, the Indus and the Brahmaputra and is blessed with some of the most fertile soils of the world. It is because of its fertile soils that this region is agriculturally the most productive part of the country. Soils of the Darjiling hills in West Bengal contain sufficient quantities of humus, iron, potash and phosphorus which are necessary for tea bush to grow. This is the reason that Darjiling tea is famous all over the world for its high quality.

3. Temperature. Temperature has a great bearing on the cropping pattern of an area because each crop requires specific temperature for its growth and ripening. Most crops require lower temperature at the time of sowing and higher temperature at the time of ripening. Some crops require higher temperature and are sown in the summer season. These are known as ***kharif*** crops. There are other crops which require lower temperature and are sown in the winter season. These are known as ***rabi*** crops. India's two most important food crops viz. rice and wheat are kharif and rabi crops respectively.

4. Rainfall. Rainfall is one of the main factors that affects the choice of crops and the cropping pattern of any place largely depends on the amount and distribution of rainfall. In areas where land use depends exclusively on rainfall, the main determining factor is the duration and amount of rainfall. Depending on the amount of annual rainfall, following three types of cropping patterns can be recognized.

(*a*) Cropping pattern in Areas of Heavy Rainfall. Areas receiving more than 150 cm annual rainfall are termed as areas of heavy rainfall. They include most parts of East India and the west coastal plains. Rice is the most important crop of these areas because it requires plenty of water for its successful growth. Tuber crops, plantation crops and some cereal crops like maize and ragi are also grown. Vast areas are marked by monoculture of rice though there is considerable scope for diversifying the cropping pattern. Animal population is fairly high due to availability of grazing area.

(*b*) Cropping Pattern in Areas of Medium Rainfall. Areas receiving 75 to 150 cm annual rainfall are termed as areas of medium rainfall. Areas in the vicinity of 150 cm annual rainfall isohyets are suitable for the cultivation of rice while those near 75 cm annual rainfall isohyets usually grow maize, cotton and soyabeans. These areas are rich in natural resource but people living here are poverty sticken due to poor management of resources. Eastern part of Uttar Pradesh, Bihar, Odisha, eastern parts of Madhya Pradesh and Vidarbha region of Maharashtra receive 30 cm or more rainfall in July-August and 20-30 cm in June and September. Vast areas are to be left as fallow land in kharif season to enable the soil to recoup its lost fertility. Wheat is the principal rabi crop. Different crops require different amount of water and mixed cultivation is often practiced. Rice is grown if sufficient rainfall is received in September, otherwise millets are the natural priority. Jawar is the main crop in areas of lesser rainfall. In addition cotton, soyabean and pulses are also grown.

Areas of medium rainfall have vast potential for improving agriculture and changing the cropping patterns. The main objective should be to fit the crops into a climate rhythm prevailing in those areas. The risk in forming can be reduced considerably by growing less moisture demanding crops such as maize, soyabean and jowar.

(*c*) Cropping Pattern in Areas of Low Rainfall. These areas receive 25 to 75 cm annual rainfall and stretch in a long belt running from Kashmir in the north to Kanniyakumari in the south. Beside scarcity of rainfall, variability of rainfall is high and only those crops are grown which can survive in dry conditions and tolerate large variations in the amount of rainfall. Therefore, the major crops in this belt are millets, jowar, and bajra in the northern, jowar in central and ragi in the southern part. Wheat is the main rabi crop which is grown in irrigated areas. Mixed cropping is very common in which pulses are mixed with cereals. Groundnut is an important commercial crop grown in dry areas. Sunflower, rapeseed and mustard are other oilseeds. Cropping has been developed in such a way that no one crop dominates as is the case in areas of heavy rainfall.

II. Economic Factors

Irrigation is the most dominating of all the economic factors. The other major economic factors are those of size of land holdings, sale price of crops and income of farmers, insurance and investment.

1. Irrigation. Irrigation is an important input and assumes greater significant in arid and semi-arid areas. Rainfall is scanty and erratic in these areas and crops cannot sustain without irrigation. Irrigation provides the right amount of water at the right time and thus saves crops from the vagaries of weather. Now a days, irrigation is widely used even in areas of higher rainfall so that higher yields could be obtained. In the semi-arid areas of Punjab, Haryana and western part of Uttar Pradesh, wheat is the traditional crop which has been grown in these areas for hundreds of years. With the increase in irrigation facilities after the mid-1960s these areas have become major rice producing areas and the cropping pattern has undergone major changes.

2. Size of Land Holdings. Size of land holdings has a direct bearing on the cropping pattern. In case of small holdings, the priority of the farmers would be to grow foodgrains for his family members and opt for commercial crops only if he has same surplus land over and above his personal requirements. Obviously farmers with large holdings can opt for cash crops and help in crop diversification, leading to changes in the cropping pattern.

3. Sale price of crops and Income of Farmers. The farmers want to sell their crops at highest rate and get highest amount for their products so that their income level improves. Farmers in Punjab, Haryana and western part of Uttar Pradesh are traditionally wheat growers but they started rice cultivation with effect from second half of 1960s because rice could fetch higher prices in the market. A large number of tube wells have been sunk to irrigate, rice crop in these areas and the ground water is depleting at an alarming rate. Unmindful of this dangerous trend in depletion of the ground water resources, farmers continue grow rice crop, rather vigorously, to take maximum financial advantage of irrigation facilities. In certain areas where the farmers are unable to get remunerative prices for their products, they opt for cash crops.

4. Insurance. Indian monsoon climate is characterized by wide variations from the normal weather conditions and the farmers run heavy losses in the event of bad weather when the crops are damage partially or wholly. The farmers become bankrupt and are unable to repay their loans. In extreme cases they commit suicide out of frustration. Hundreds of cotton growers have committed suicide in the otherwise agriculturally rich areas of Maharashtra, Andhra Pradesh, Gujarat and Punjab. Under such circumstances it is of utmost importance that the farmers are provided with crop insurance at easy terms so that they can pursue agriculture without any fear and most appropriate cropping pattern is adopted. The Government has taken several steps to provide crops insurance coverage to farmers in the recent past.

5. Investment. Changing the cropping pattern requires huge investment because large sums of money are required for irrigation, seeds, fertilizers, farm machinery etc. The main reason of groundnut replacing cotton in Madhya Pradesh is easy availability of better quality groundnut seeds to the farmers. Even otherwise, groundnut has short maturing period than cotton and farmers get good return after selling groundnut in the market.

III. Political Factors/Government Policies

Government policies can influence the cropping pattern in any region to a great extent. Government can encourage any crop by providing subsidy on seeds, fertilizers, electricity etc. and discourage any other crop by putting restriction on it. Increase in the production of foodgrains and decrease in the cultivation of tobacco, indigo, poppy are largely the result of government policies. Moreover, government can change the cropping pattern by strengthening rural road transportation. Farmers tend to opt for cash crops like vegetables and fruits when the villages have direct road link to the neighbouring urban market.

AGRICULTURAL PRODUCTIVITY

Although usually treated as synonymous with agricultural efficiency, by several authors, agricultural productivity has a special meaning in agricultural geography and is defined as total agricultural output per unit of cultivated area per agricultural worker or per unit of input in monetary values. These may be referred to as 'land productivity', 'labour productivity' and 'capital productivity', respectively.

Improvement in agricultural productivity is generally the result of a more efficient use of the factors of production, viz., environment, arable land, labour, capital and the like. Productivity, which may be industrial or agricultural, is a difficult theme, both in concept and in terms of measurement of its level. Therefore, any definition that is adopted is bound to suffer from certain weaknesses. It is important to remember, however, that productivity is a physical rather than a value concept, which describes the relationship between the output and the major inputs like land, labour and capital. It is essentially a measure of the efficiency with which the inputs are utilized in production. The regional differences in agricultural productivity are the result partly of natural advantages of abiotic environment (soils and climate) and partly of farming efficiency as controlled by cultural ecology. Farming efficiency refers to the properties and qualities of various inputs and the manner in which they are combined and put to use for production. Increase in agricultural productivity is largely related to the choice of inputs, and their relative quantities, and the techniques and the skill with which they are used in the production processes. (Singh and Dhillon, 1984:226)

The level of agricultural productivity, as a concept, means the degree to which the economic, cultural, technical and organizational variables (*i.e.*, the man-made frame) are able to exploit the abiotic resources of the area for agricultural production (Singh, 1979).

Computation and delineation of agricultural productively is of great significance because of its following advantage :

(*i*) It helps in ascertaining the relative productivity of the component areal units of a region.

(*ii*) Agriculturally weakers areas with lower productivity can be identified.

(*iii*) The present agricultural productivity helps in assisting the past development.

(*iv*) A study of present productivity provides a sound base for future agricultural planning.

Several techniques adopted for computing efficiency in level of agricultural productivity per unit area per unit of time, or per unit of farm work force, etc. are detailed below :

1. Assessing the value of agricultural production per unit area.
2. Measuring production per unit of farm labour or man-hour.
3. Determining output in relation to input, or output-input ratio and profitability of farming measured in terms of the return for the sum total of human efforts or paid-out-cost in relation to the output (Khusro, 1964)
4. Expressing production of agriculture in terms of grain equivalents per head of population (Buck, 1967; E. de Vries, 1967; Clark and Haswell, 1967).
5. Considering output per unit area or yields per hectare after grading them in ranking order, thereby deriving the ranking coefficient (Kendall, 1939; Stamp, 1960; Shafi, 1960).
6. Giving weightage to the ranking order of the output per unit area with the percentage share under each crop (Sapre and Deshpande, 1964; Bhatia, 1967).
7. Using the carrying capacity of land in terms of population (Stamp, 1958, 1967).
8. Determining an index of productivity (Enyedi, 1964; Shafi, 1972, 1974).
9. Calculating the index number of agricultural efficiency by expressing the per unit area carrying capacity (in terms of population) of the component enumeration unit as a percentage of the per unit area carrying capacity for the entire region (Singh 1972, 1974).
10. Computing the crop yield and concentration indices ranking coefficient (Singh, 1976)
11. Involving the area, production and price of each cultivated crop in each of the constituent areal units of the region, and then relating the out turn in terms of money of the unit to the corresponding productivity of the region (Hussain, 1976).
12. Delimiting agricultural productivity by computing the intensity and spread indices of three variables, i.e. (i) yield, (ii) grain equivalents, and (iii) cropping system (Singh, V.R., 1979).

13. Assessing net income (farm business income) in rupees per hectare of cropped area or per adult-male unit of farm family work force (Singh, Jasbir *et al.*, 1982).

The above mentioned techniques differ widely from one another and none of them gives a flowless assessment of agricultural productivity. The first three techniques seem to require such statistics as are not readily available and even easily accessible in most of the underdeveloped and developing countries of the world. Statistics, though available at the farm level in some states of India, do not seem to be adequate for area-analysis of agricultural efficiency. Technique (3), however, has little validity in a subsistence farm economy where (*i*) foodgrains dominate and constitute 75 to 85 per cent of all agricultural production, (*ii*) the major output is retained for domestic consumption, and (*iii*) most of the inputs are provided by the farmer himself. However, Khusro (1964) has expressed himself in favour of paid-out-cost in relation to output as a measure of farm efficiency. The efficiency and profitability of agriculture measured by the surplus or deficit of output over paid-out-cost excluding the *imputed value* of farm family labour is an ideal method of determining farm efficiency at the level of different size-class of operational holdings.

Technique 4 of expressing production of agriculture in teutrs of grain equivalents per head of population was used for the first time by Buck in 1967. He realized that in a subsistence agricultural economy as in China, or for that matter in India productivity expressed in terms of monetary value has no meaning because the crops may be grown for local domestic consumption, and only a small portion of it may be sold for cash. To him, therefore the natural unit for measuring the level of agricultural productivity in such a community appeared to be the conversion of kilograms of agricultural products into grain equivalents. He considered all grains to be equal in food value. He converted agricultural products other than foodgrains into grain equivalents according to the local market price at which they are exchanged against foodgrains which are grown predominantly in a locality. Buck's grain equivalent device for measuring agricultural progress was modified and also used by **E. de Vries**. He expressed all output of grains in Asian countries in terms of *milled-rice equivalents* per head of total population. This is a better method because different types of grains are converted into rice equivalents depending on the local market price of each grain. In contrast **Buck** counted all grain equally. The main drawback in **E. de Vries** method is that he worked out rice equivalents per head of total population without caring for the fact that in many instances the effective population which contributes towards agricultural efficiency is the rural population widely engaged in agriculture.

Clark and **Haswell** (1967) used a system in terms of wheat equivalents per person. In this scale total agricultural production is expressed in terms of economic wheat equivalents/person/annum.

Technique 5 of considering output per unit area or yield per hectare was developed by Kendall in 1939 in which he devised a system of ranking coefficient. He explained by taking into account the hectare yield of ten leading crops for 48 administrative countries of England. Stamp (1960) applied Kendall's *ranking coefficient* technique for international comparisons, by selecting twenty countries and nine major crops. In India Shafi (1960) too used this technique, for determining the efficiency of the districts comprising the state of Uttar Pradesh by considering the hectare yield of eight foodgrain crops.

Kendall followed the following procedure for determining agricultural productivity :

(*i*) the enumeration units are ranked in order of output per heactare for each of the selected crops.

(*ii*) the ranks occupied by each unit in respect of the selected crops added.

(*iii*) sum of ranks of each unit is divided by the number of selected crops.

Technique 6 of giving weightage to ranking order of the output per unit area with the percentage share under each crop was devised by Sapre and Deshpande in 1964. It was a modification of Kendall's technique in the sense that this technique used *weighted average ranks* instead of *simple average ranks*. The weighted ranks for various crops is proportionate to the percentage of cropland under each crop.

Bhatia in his study in 1967 made the following two assumptions :

(*i*) hectare yields express all the physical and human factors connected with the production of crops.

(*ii*) sharing of cropland among the various crops reflects various factors involved in land utilization.

A weighted average of the yield efficiency of all crops in component regional unit, where the weights are proportionate to the share of cropland devoted to each crop, would give a measure of overall agricultural efficiency of the component regional unit relative to the entire region. This may be expressed as:

$$I_{ya} = \frac{Y_c}{Y_r} \times 100$$

where I_{ya} is the yield index of crop *a*; Y_c is the hectare yield of crop '*a*' in the component areal unit, and Y_r is the hectare yield of crop '*a*' in the entire reigion; and

$$E_i = \frac{I_{ya} \times C_a + I_{yb} \times C_b + \ldots + I_{yn} \times C_n}{C_a + C_b + \ldots + C_n}$$

where 'E_i' is the agricultural efficiency index, I_{ya}, I_{yb},..., I_{yn} are the yield indices of various crops, and C_a, C_b.......C_n are the percentages of cropland under the different crops.

With this technique a picture of overall performance of an area can be had, but this does not give any weightage to the harvested area under different crops which actually contribute to establish agricultural efficiency.

Technique 7 using the carrying capacity of land in terms of population was devised by L.D. Stemp in 1958 and modified in 1967. The idea of using carrying capacity struck him in the backdrop of fast increasing population pressure on land resources. He had taken into account, first a *standard nutrition unit*, that is, to what extent food and land are required to support one average human being and to produce that much amount of food respectively; second the *caloric value* of some leading food crops since 90 per cent of the world population depends upon foodgrains. In this approach the production of crops is converted into calories, which then can be used to measure the *optimum carrying capacity* of land in terms of population. In a sense that carrying is a measure of farming efficiency.

Technique 8 of determining an index of productivity was suggested by **Enyedi** in 1964. **Shafi** (1972 and 1974) also adopted this approach to determine the productivity indices in respect of twelve food crops of India. Enyedi's formula of productivity index is :

$$\text{Productivity Index} = \frac{Y}{Y_n} \div \frac{T}{T_n}$$

where, Y is the total production of the selected crop in unit area.

Y_n is the total production of the same crop on national scale,

T is the total cropped area of the unit area. and

T_n is the total cropped area on national scale.

Technique 9 is a modification of technique 7 in which Jasbir Singh (1972,74) calculated the index number of agricultural efficiency by expressing per unit area carrying capacity of the component enumeration unit as a percentage of the per unit area carrying capacity for the entire region. He opined that actual production of foodgrains is more important particularly in those countries which suffer from food shortage.

After making some allowances for the quality of production (*i.e.*, to change the crop production into caloric values) and the usages and wastages in the form of seed, cattle feed, storage losses, etc. it can be inferred that higher the caloric output per unit area greater is the carrying capacity of land in terms of population and hence the efficiency of farming. The carrying capacity of agricultural areas, *i.e.*, their maximum caloric return from the soils, can be considered as their index of efficiency. The variations in caloric productivity per unit area are the result of differential interaction between the combination of environmental conditions and the combination of human activities.

In 1974 **Jasbir Singh**, determined caloric output (C_o) available for ingestion per unit area under food crops and oil seeds after making a careful total deduction for usages and wastages which add up to

16.80 per cent of the total production. He then proceded to compare the calorific output with the weighted average standards nutrition (S_n) for ingestion in calories/person/annum. Finally, the carrying (C_p) was expressed as :

$$C_p = \frac{C_o}{S_n}$$

For an objective measurement of agricultural efficieny the carrying capacity per unit area in the component enumeration unit may be expressed as a percentage of the carrying capacity in the entire region to obtain index numbers, which would give a measure of the agricultural efficiency of the component enumeration unit relative to the entire region. The above may also be read as :

$$Ia_{a_r} = \frac{C_{pe}}{C_{p_r}} \times 100$$

where, I_{ae} is the index number of agricultural efficiency of an enumeration unit,

C_{p_e} is the carrying capacity in terms of population in the component enumeration unit, and

C_p is the carrying capacity in the entire region.

Technique 10 was also introduced by Jasbir Singh in 1976 in which he computed the crop yield and concentration indices ranking coefficient in order to assess the regional differences in levels of food produced and to determinate the weaker areas form the point of view of agricultural productions. He used average food crop yields proportions of these crops in the total harvested area as twin-elements for measuring the index of the level of food production. For an objective measurement of the level of agricultural productivity, the relative crop yield and concentration indices arranged in ranking order and computed into average coefficient, would give a measure which one may call *the crop yield and concentration indices ranking coefficient.* The procedure may be explained as follows :

$$Y_i = \frac{Y_{a_e}}{Y_{a_r}} \times 100$$

where, Y_i is the crop yield index,

Y_{a_e} is the average yield per hectare of crop *a* in the component enumeration unit, and

Y_{a_r} is the average yield if the crop *a* in the entire region or country.

$$C_i = \frac{P_{a_e}}{P_{a_r}} \times 100$$

where C_i is the crop concentration index,

P_{a_e} is the percentage strength of crop '*a*' in the total harvested area in the component enumeration unit, and

P_{a_r} is the percentage strength of crop '*a*' in the total harvested area in the entire region or country.

The crop yield and concentration indices thus derived for all the regional units and the crops are ranked separately. Yield and concentration ranks for individual crops are added and thereafter divided by 2, thus giving the *crop yield and concentration indices ranking coefficient*. The equation is :

$$\text{Crop yield and concentration indices ranking coefficient for crop 'a'} = \frac{\text{Crop yield index ranking of crop 'a'} + \text{Crop concentration index ranking of crop 'a'}}{2}$$

The result thus derived will give us an idea of the level of agricultural productivity, the lower the ranking coefficient, the higher the level of agricultural productivity and *vice versa*.

Technique 11 was devised by Hussain in 1976 while establishing agricultural productivity of the Satluj-Ganga plains. He converted the agricultural production into money value of the regional unit in proportion to the whole region. He argued that other things remaining the same, higher the return in terms of value in money, greater is the productivity of land.

V.R. Singh (1979) used 12th technique in technique 13 which is concerned with delimiting agricultural productivity by computing the intensity and spread indices of three variable, namely (*i*) yield, (*ii*) grain equivalents and (*iii*) cropping system.

Jasbir Singh *et al.* (1985 followed technique 13 while studying the agricultural productivity in Haryana. The technique involves assessing net income (farm business income) in rupees per hectare of cropped area or per adult male unit of farm family work force. Adult male unit (adult male equivalent)

for standardization 2 children (7-15 age group), 1.5 female (15-59 age group and 1 male (15-59 age group) may be considered equal to one adult male unit. It was found that agriculturally productive regions registered highest net income per hectare of the cropped area. Besides net income increases with size of the farm with a few exceptions here and there.

AGRICULTURAL INTENSITY OR INTENSITY OF CROPPING

Agricultural production and productivity, can be increased in two ways; by expanding the cropped area and by increasing the intensity of cropping. Since much of the physically suitable land for cultivation is already under plough, there is little scope for expansion of net sown area. The only alternative left is the intensification of cropping. *The intensity of cropping refers to the number of crops raised on a field during an agricultural year. The total cropped area as percentage of the net sown area gives a measure of cropping intensity.*

$$\text{Thus, cropping intensity} = \frac{\text{Total cropped area}}{\text{Net sown area}} \times 100$$

The above formula can be illustrated by taking example of a village. Suppose the total cropped area (net sown area + area sown more than once) in the village is 1,200 hectares (700 hectares in the rabi season and 500 hectares in the *kharif* season) and the net sown area in the entire village is 1,000 hectares, then the agricultural intensity in this village will be :

$$\frac{700 + 500}{1,000} \times 100 = 120\%$$

Agricultural intensity in India has undergone significant change after Independence (**Table 20.24**).

The above table shows that there has been gradual increase in the cropping intensity between 1950-51 and 2009-10. This is an indication of our success in increasing agricultural production by bringing more area under **'area sown more than once'** category. This has been made possible due to a variety of inputs like irrigation, fertilizers, early maturing varieties of seeds and farm modernization.

Cropping intensity for India as whole was calculated to be 137.3% which is just an average figure. There are large variations in intensity of cropping at the state level as indicated in **Table 20.25** and **Figure 20.6**.

It varies from 100 per cent in Manipur, Mizoram, Daman and Diu and Lakshadweep to 178.9 per cent in Haryana, 181.13 per cent, in West Bengal, 186.0 per cent in Sikkim, 189.4 per cent in Punjab and 204.3 per cent in Delhi. It is easy to understand higher rate of cropping intensity in agriculturally advanced states like Punjab and Haryana where Green Revolution has shown its maximum impact with respect to two basic foodgrains like wheat and rice. Similarly, some parts of West Bengal gets three crops of rice in a year and the cropping intensity is high there. Most parts of Delhi are engaged in cultivation of vegetables which have ready local market in one of the most urbanized areas of the country. Both rabi and kharif vegetables are grown which keep the farmers busy throughout the year and high cropping intensity of more than two hundred per cent is recorded. But high cropping intensity in the hilly state of Sikkim is a real surprise which needs further investigation. On the whole 14 states and union territories have cropping intensity higher than the national average of 137.7 per cent. The remaining 21 states and union territories have cropping intensity lower than the

TABLE 20.24. Temporal change in cropping intensity in India (Million hectares)

Year	1950-51	1960-61	1970-71	1980-81	1990-91	1995-96	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10
Net area sown	118.75	133.20	140.86	143.00	141.63	142.20	141.34	141.34	139.85	141.38	141.93	140.02
Total cropped area	131.89	152.77	165.79	185.74	185.70	187.47	185.34	192.76	192.41	195.14	195.36	192.20
Cropping Intensity (%)	111.06	114.69	117.69	129.88	131.12	131.84	131.14	136.55	137.58	138.02	137.64	137.27

Source : Calculation made on the basis of data available in Agricultural Statistics at a glance 2012 pp. 259-260.

TABLE 20.25. State level variations in cropping intensity in India (2009-10)

State/Union Territory	Net area sown (Thousand hectares)	Total cropped area (Thousand hectares)	Cropping Intensity (%)
1. Andhra Pradesh	9,991	12,560	125.7
2. Arunachal Pradesh	212	276	130.2
3. Assam	2,811	4,099	145.9
4. Bihar	5,332	7,491	140.5
5. Chhathisgarh	4,683	5,561	118.7
6. Goa	132	160	121.8
7. Gujarat	10,302	11,138	108.6
8. Haryana	3,550	6,351	178.9
9. Himachal Pradesh	542	932	171.9
10. Jammu & Kashmir	735	1,145	155.7
11. Jharkhand	1,250	1,399	111.9
12. Karnataka	10,174	12,368	121.6
13. Odisha	5,574	9,107	163.6
14. Punjab	4,158	7,875	189.4
15. Rajasthan	16,976	21,745	128.1
16. Sikkim	77	144	186.0
17. Tamil Nadu	4,892	5,572	113.9
18. Tripura	280	309	110.3
19. Uttarakhand	741	1,166	157.4
20. Uttar Pradesh	1040.4	12,873	123.7
21. Kerala	2,079	2,669	126.4
22. Madhya Pradesh	14,972	21,411	143.0
23. Maharashtra	17,401	22,612	129.9
24. Manipur	233	233	100.0
25. Meghalaya	283	336	118.9
26. Mizoram	123	123	100.0
27. Nagaland	361	486	134.8
28. West Bengal	5,256	9,530	181.3
29. Andaman & Nicobar Islands	15	17	112.4
30. Chandigarh	1	2	151.5
31. Dadra and Nagar Haveli.	22	46	204.3
32. Daman & Diu	4	4	100.0
33. Delhi	22	46	204.3
34. Lakshadweep	3	3	100.0
35. Puducherry	19	32	170.3
All India	14,40,022	1,92,197	137.3

Source: Agricultural Statistics at a glance 2012, pp. 266-270.

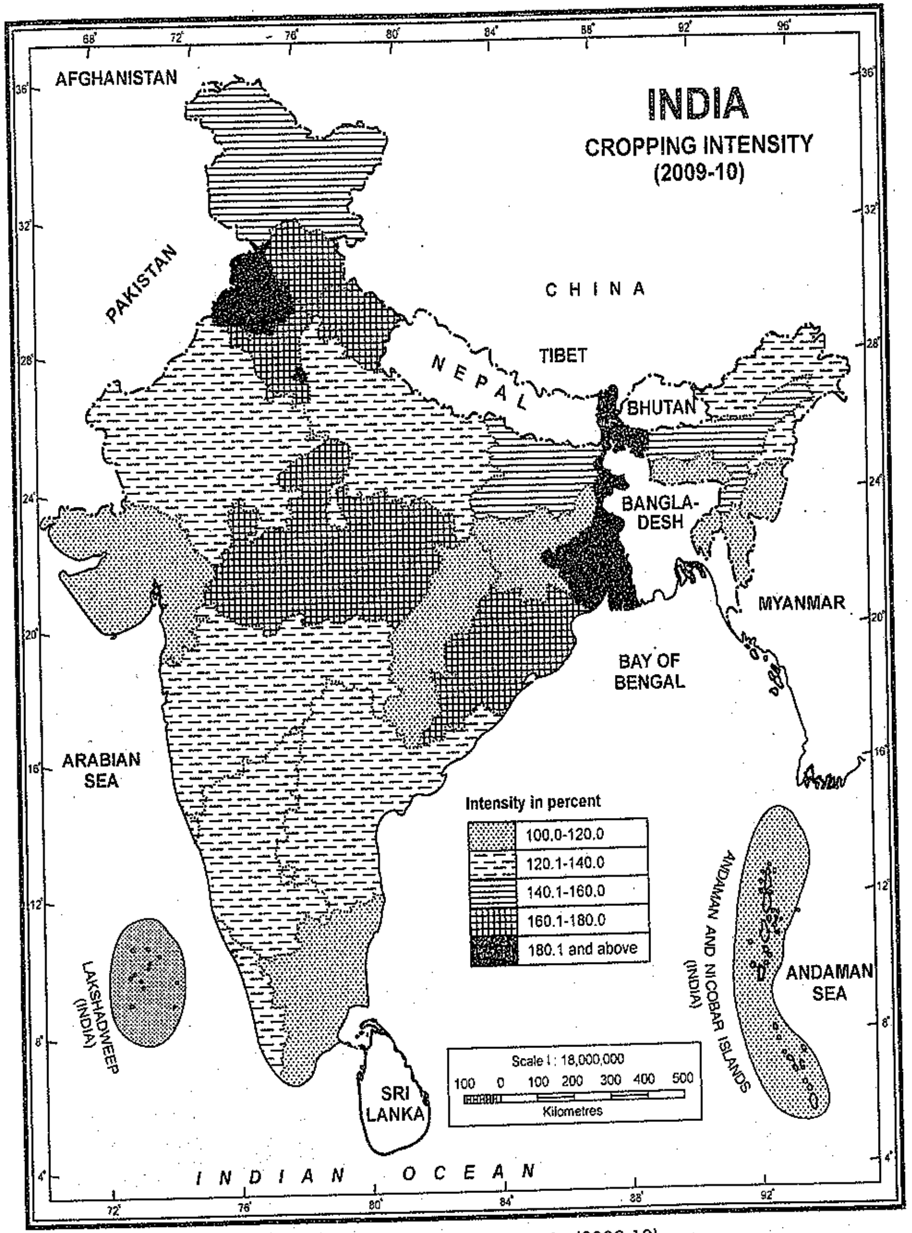

FIG. 20.6. India : Cropping Intensity (2009-10)

national average. Most of the north-eastern states as well as states like Gujarat, Chhattisgarh, Jharkhand and Tamil Nadu have very low cropping intensity of less than 120 per cent.

The index of the intensity of cropping depends upon the extent of area sown more than once. Higher the extent of area sown more than once, higher will be the intensity of cropping. In other words, intensity of cropping is the indicator of the efficiency of land use. Higher the index of intensity of cropping, higher is the efficiency of land use. The main factors influencing intensity of cropping are irrigation, fertilizer, early-maturing high yielding varieties of seeds, mechanisation of agriculture and plant protection measures through the use of insecticides, pesticides and weedicides. The availability of water for irrigation ensures the use of higher doses of fertilizers which, in turn, reduces the extent of fallow land. The quick-ripening varieties of seeds help in taking more than one crop from the same field in one agricultural year and result in higher intensity.

CROP COMBINATION

Crop combination is concerned with the number or diversity of crops grown in a particular area during a specific interval of time. Study of crop combinations has a greater significant in Indian agriculture because it presents a true picture of crop distribution and provides a solid base for agricultural regionalisation of the country. In a predominantly agricultural country like India, crops are grown in selected combinations, except a few small pockets of plantation agriculture. These crops assemblages are fairly stable because ecological, socio-economic and other conditions suitable for such combinations in various parts of the country have remained stable since long. The relative positions and strengths of different crops or livestock in different enumeration units can better be comprehended with combination analysis. **Weaver** (1954) listed the following advantages of studying crop combinations:

(*i*) The establishment of crop, livestock or ranking combinations is essential for an adequate understanding of geography of crops, livestock etc. that hold variable ranks in the combinations.

(*ii*) The combinations of crops, livestock or agricultural enterprises are composite realities that guide distributional analysis.

(*iii*) Such combination are essential, and they must be made available if one wishes to build still more complex structure for valid agricultural regions.

In fact, crop, livestock or agriculture combination analysis is one of the most vital methods of studying agricultural patterns. It is invaluable in providing a comprehensive basis for basic regional planning for rural areas.

Study of crop combinations help knowing the density and concentration of individual crops and it is still more important to view the integrated assemblage of various crops in a region. For example in India, isohyet of 100 the annual rainfall separates rice producing areas from wheat producing areas. Area receiving more than 100 cm annual rainfall are predominantly rice producing areas whereas those receiving less than 100 cm annual rainfall are popular for wheat cultivation. But other food and commercial crops are also grown in these areas which cannot be ignored.

Several attempts have been made for demarcation of crop combinations regions of which Weaver's attempt is the most popular. In India Jasbir Singh (1971), Singh and Dhillon (1984) and Tirath and Krishan (1996) made significant contributions. However, all these studies are based on data which has become obsolete now. Moreover, their coverage was limited, often to the crop groups and areal strength of individual crops is not recognised well in these studies. Therefore, there is great scope for a fresh look on the subject and give it a new orientation. Following two categories of methods are applied for determining the crop combination regions :

1. The arbitrary choice method
2. The statistical method.

1. Arbitrary Choice method

In this method, first two or three crops grown in an area are included and the remaining are excluded from the combination. When only one crop covers maximum percentage of area, then only the first crop is shown on the map. Similarly, first two or three crops are shown in two crop or three crop combination on the crop combination map of an area. This fact is universally known that rice growing areas are different from wheat growing area in India. It implies that rice growing areas do not grow wheat and wheat growing area do not grow rice. (In this context, it should be noted that traditionally wheat growing areas of Punjab, Haryana and western part of Uttar Pradesh have started growing rice by taking advantage of irrigation facilities available in these areas). Therefore macro level production zones are demarcated on the basis of these two major crops only. Micro regions are delineated on the basis of other crops which are important at the micro level. This method suffers from the following limitations :

1. Only first two or three crops are taken for consideration and other crops are excluded from the combination irrespective of the percentage of area covered by them and also their monetary value. Therefore this is an unscientific method of determining crop combination.
2. There is always a fear of repetition while presenting and analysing the crop combinations.
3. This is not a very sensitive method because subjectivity often overpowers the objective analysis.
4. The number of crop combinations increases with the number crops which makes the process very complicated.
5. Some times the cumulative area covered by the crops which are included in the combination is less than 50% and a large number of crops of lesser importance are not included. This leads to erroneous results.

In spite of its above mentioned limitations, this is a widely used method because of its simplicity.

Statistical Method

Since this method is based on statistical analysis, it is more scientific, accurate and hence more popular than the arbitrary choice method. It has greater capacity to handle the strongly developed cropping diversity or even agricultural diversification in an area. It was proposed by **J.C. Weaver** in 1954 for studying the complex structure of crop-combination regions and the Middle West (U.S.A.). He computed the percentage of the total cultivated area in each of the 1081 counties covered in his research work. He adopted such an approach that could provide an objective, constant and precisely repeatable procedure and would yield comparative results for different years and localities. First of all, he determined the percentage of each of the selected crop to the total cropped area. Then he considered each percentage against a standard norm and determined the right crop combinations with the help of theoretical standard deviations. The theoretical curve for the standard measurement was employed as follows :

Monoculture = one crop accounts for 100.00 per cent of total harvested or cropped area.

2 crop combination = each crop 50 per cent
3 crop combination = each crop 33.33 per cent
4 crop combination = each crop 25.00 per cent
5 crop combination = each crop 20.00 per cent
6 crop combination = each crop 16.67 per cent
7 crop combination = each crop 14.29 per cent
8 crop combination = each crop 12.50 per cent
9 crop combination = each crop 11.11 per cent
10 crop combination = each crop 10.00 per cent

For accurately comparing the actual percentages within the individual regional units with the theoretical distribution, following formulae concerning variances and standard deviation were used :

1. Variance $= \frac{\sum d^2}{n}$

2. Standard deviation (SD) $= \sqrt{\frac{\sum d^2}{n}}$

where d = difference between actual crop percentage in a given country (regional unit) and the percentage in the theoretical distributions.

and n = number of crops in a given combination.

Weaver's technique can be illustrated by following example :

Suppose in a region the area occupied by crops in percentages is as given in the following table :

Crop	Percentage of area
Wheat	40
Jowar	30
Bajra	15
Pulses	10
Maize	5

If it is one crop region, then $\frac{(100-40)^2}{1} = 3{,}600$

If it is two crop region, then

$$\frac{(50-40)^2 + (50-30)^2}{2} = \frac{100+400}{2} = 250$$

If it is three crop region, then

$$\frac{(33.33-40)^2 + (33.33-30)^2 + (33.33-15)^2}{3}$$

$$= \frac{44.89 + 11.08 + 335.99}{3} = \frac{391.96}{3} = 130.65$$

If it is four crop region, then

$$\frac{(25-40)^2 + (25-30)^2 + (25-15)^2 - (25-10)^2}{4}$$

$$= \frac{225 + 25 + 100 + 225}{4} = \frac{575}{4} = 143.75$$

If it is five crop region, then

$$\frac{(20-40)^2 + (20-30)^2 + (20-15)^2 + (20-10)^2 + (20-5)^2}{5}$$

$$= \frac{400 + 100 + 25 + 100 + 225}{5} = \frac{850}{5} = 170$$

It is clear from the above computation that the minimum deviation from the normal curve is in three crop-region. Therefore the concerned area is three crop region (wheat, jaws and bajra).

Weaver's technique suffers from the following drawbacks :

(*i*) Sometimes, there may be crops covering insignificant area but they might be of great importance for that particular region. However, weaver tried to solve this problem by imprinting the name of such crop(s) on the map after the crop combination has been prepared.

(*ii*) Weaver himself admitted that this technique occasionally tends to show lowest deviation for a crop combination which includes even a crop occupying as less and one per cent of the total harvested cropland.

(*ii*) This method gives most unwieldy combinations for areas of high crop diversification.

(*iv*) It involves laborious calculations.

Doi (1959), **Peter Scot**, **Thomas** (1963), **Coppock** (1964), **Singh** (1974) and several other scholars have tried to modify Weaver's technique with the help of standard statistical algorithm, namely the *lest squares*. Doi presented a modification of Weaver's technique by substituting the variance $\left(\frac{\sum d^2}{n}\right)$ or least standard deviation $\left(\sqrt{\frac{d^2}{n}}\right)$ of Weaver with the sum of square deviations ($\sum d^2$) *i.e.*, of actual percentages from the theoretical distributions. **Peter Scot** made some modifications in Weaver's technique by suggesting that animals are as important as crops while determining the crop combination regions of Tasmania. **Thomas** modified the version of minimum variance or least standard deviations approach of Weaver. His technique was designed to make use of data available for all crops in an enumeration unit for the calculation of variances for crop combinations. **J.T. Coppock** modified Scot's method by suggesting conversion of all animals on the farm to a common unit according to the quantity of food taken by the animals and then each type to be expressed as a percentage of the total animals. He even prepared the following scale of conversion for the type of animals and the common unit on the basis of the quantity of food taken by them.

Types of animals	Number of animals on the basis of food units
Horses	1
Cows, oxen, buffaloes	1
Other animals (more than 1 year but less than two years)	2/3
Other animals (less than 1 year)	1/3
Sheep	1/15
Chicken (more than 6 months)	1/50
Chicken (less than 6 months)	1/200

Coppock demarcated 11 crop region (of first order) and 38 crop combinations by using the least square method. These 11 crop regions were based on first rate crops. These crops included rice, jowar, wheat, maize, bajra, pulses, ragi, barley, cotton, groundnut and tea. These crops are grown over larger areas while other crops are grown over limited areas.

Generalised Crop Combinations in India. Although crop combinations keep on changing with time and space, yet generalised crop combinations can be visualised as under :

1. Rice. Rice is the staple food of a vast majority of India's population and it is grown as the first crop in the following seven regions.

(*i*) ***Monoculture of rice.*** The areas exclusively growing rice are called areas of rice monoculture. These areas include large parts of Chhattisgarh and

adjoining areas of east Madhya Pradesh, Chotanagpur Plateau, West Bengal, delta regions of the Krishna, the Godavari and the Cauvery rivers, coastal areas of Odisha, the Brahmaputra valley, Tripura, Manipur and Nagaland in the north-east region and Andaman and Nicobar Islands in the Bay of Bengal.

(*ii*) ***The West Coastal Plains.*** It includes the Malabar and the Konkan coastal regions. Besides rice, these areas grow rubber, coconut, ragi, vegetables and fodder crops.

(*iii*) ***The East Coastal Plains.*** It includes the non-deltaic coastal regions of Tamil Nadu and Andhra Pradesh. Crops other than rice include groundnut, bajra, jowar and maize.

(*iv*) ***Middle Ganga Valley in eastern Uttar Pradesh and Bihar.*** Rice is the first ranking crop which is followed by wheat, pulses, sugarcane, barley and maize.

(*v*) ***South Karnataka Plateau.*** In this region, rice is followed by coffee, ragi, pulses, cardamom, coconut and citrus fruits.

(*vi*) ***Hilly areas of northern part of West Bengal.*** This area spreads in the Jalpaiguri district where rice is the first ranking crop and maize is the second ranking crop.

(*vii*) ***Meghalaya Plateau.*** Potato, maize and cotton are the crops grown in this area in addition to the first ranking crop of rice.

2. Wheat. Wheat is the second most important food crop of India next only to rice. Nowhere in India, one would find monoculture of wheat. Hence areas having more than 40 per cent the cropped area are called wheat regions. Following four wheat regions may be recognised :

(*i*) ***The Ganga-Yamuna Doab.*** This is the most prolific wheat growing region of the country. Apart from wheat, rice, maize, sugarcane, bajra, pulses and fodder are the main crops.

(*ii*) ***Eastern Haryana.*** Pulses, bajra, jowar sugarcane, and fodder crops are grown in combination with wheat.

(*iii*) ***Himachal Pradesh and the neighbouring areas of Punjab.*** It is a plain tract adjoining the hilly area where pulses, jowar, bajra, sugarcane, and fodder are the main crops in addition to wheat.

(*iv*) ***Rest of Punjab.*** The rest of Punjab, excluding the foothill areas is famous for maize, rice, and pulses in combination with wheat.

3. Jowar. This is the first ranking crop in the following five regions.

(*i*) ***Tamil Nadu highland (Salem-Coimbatore).*** The other crops grown in this region are groundnut, bajra, rice, ragi, barley, pulses and cotton.

(*ii*) ***North Karnataka Plateau and western Maharashtra.*** Here jowar is followed by bajra, ragi, barley, rice, groundnut and pulses.

(*iii*) ***North Maharashtra and Madhya Pradesh.*** Crop combination found here is that of jowar, pulses, wheat, cotton and rice.

(*iv*) ***Telangana and Chandrapur.*** Rice and plusses are the main crops in addition to jowar.

4. Maize. Maize is the first ranking crop in the following two regions :

(*i*) ***South-east Rajasthan and contiguous areas of Madhya Pradesh and Gujarat.*** This area is known for wheat, rice, groundnut, gram, fodder and pulses in combination with maize.

(*ii*) ***Himachal Pradesh and hills of Kashmir.*** Apart from maize, this region grows plantation crops on the hill slopes and rice in the valleys.

5. Bajra. This is the first ranking crop of large parts of Rajasthan, Kachchh region of Gujarat, and some parts of Uttar Pradesh and Haryana. Wheat fodder and pulses are grown in combination with bajra.

6. Ragi. This is the first ranking crop of South Karnataka and Dharmapuram district of Tamil Nadu. The other crops grown in combination with ragi are rice, pulses, groundnut, jowar and coconut.

7. Barley. This is the first ranking crop of Lahul-Spite and Kinnaur districts of Himachal Pradesh. Jai and wheat are grown in combination with barley in these districts of higher mountain ranges.

8. Cotton. Cotton is grown as the first ranking crop in eastern and northern parts of Maharashtra, eastern parts of Gujarat and some parts of Madhya Pradesh. This is primarily based on the black cotton soil(regur of these areas). The other crops grown in combination with cotton are j[illegible] and fodder.

9. Groundnut. This is the first ranking crop of Anantpur-Cuddapah and Chittoor districts of Andhra Pradesh and Kathiwar region of Gujarat. Jowar, bajra and some other dry crops are grown in combination with groundnut.

10. Tea. Tea is the first ranking crop on the hill slopes of Darjeeling district of West Bengal and Nilgiri district of Tamil Nadu. Tea represents more or less monoculture in Darjeeling but it is associated with coffee and vegetables in Nilgiri.

11. Pulses. Pulses comprise the first ranking group of crops in comparatively elevated areas south of the Ganga river and in the north-eastern parts of Rajasthan. These are also the first ranking crops in some parts of Odisha, Telangana and Andhra Pradesh.

Factors affecting Crop Combinations

Most parts of India are characterised by 3-4 crop combination although 7 crop combinations are also very common. The factors which affect crop combinations in different parts of the country include physiography, soil fertility, amount of rainfall, weather conditions, irrigation and priorities of the farmers. Increase in irrigation facilities in arid and semi-arid areas has considerably changed the crop combinations in large parts of the country. The number of crops included in crop combinations is limited in areas of extremely dry, extremely wet, extremely cold and extremely hot climate. Other factors remaining the same, areas receiving 30-100 cm annual rainfall have higher crop diversity as compared to the other areas. Crop diversity is also large in hilly areas of the Himalayas.

LAND CAPABILITY

Land capability takes into account the existing fertility and productivity at the current level of technology and the potentiality of land for production of crops on the basis of physical and chemical characteristics of the soil. (Shafi 2006 : 485). In order to understand land capability, it is essential to conduct *land capability survey* which gives direct information in connection with the soil potentiality of different areas. The land *capability classification map* is one of the basic documents for preparing any development plan for agriculture. Land capability classification investigates into the physical characteristics of the land, its soil qualities and farm management qualities. In view of food shortages, it is very essential to make an inventory of the soil resources to ascertain which uncultivated land can be brought into production and which cultivated soils can be made to produce more than what they do at present. Land capability has to be surveyed in view of the fact that some areas are more fertile than others. **L.D. Stamp** expressed the view, during his Land use Survey of Britain in 1930-31, that it is more important to know about the land capability rather than present status of land use.

There is basic difference between land classification and land capability. Under 'land classification', land is divided into different categories. Land capability, on the other hand involves a scientific appraisal of several factors, of which physiography, climate and physical as well chemical characteristics of soils are important. In addition, some social and economic factors are also considered. Maps based on land capability surveys are helpful in identifying the problem and the potential areas. It gives information about those areas which can provide higher level of production by using modern technology and by arranging for better administration.

In a developing and over-populated country like India, it is of utmost importance to know how much increase in farm production can be achieved by improving technological inputs. Land capability classification is of great help in assessing the capability of different soils and to take proper steps to remove the deficiencies. Land capability survey was devised by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) for delimiting land capability regions of Australia. Subsequently such surveys were conducted in European and Aglo-American countries and in some of the Third World countries. The United States Department of Agriculture (1951) has recognised eight classes, with a primary division into land suited to cultivation and land not suited to cultivation. *Hill* and *Partilance* presented land capability classification of Ontario State of Canada in 1960 which aimed at preparing a social plan for land use.

In India soil survey was conducted with the primary aim to achieve land classification on the lines adopted by the U.S. Department of Agriculture. But this system was more suited to the American conditions and did not yield the desired results in Indian conditions. Consequently, various workers and organizations tried to evolve a land capability or suitability classification that is suited to the conditions and planning purposes in a developing country like India. One such example was an attempt made in India by the All India Land-Use Survey Organisation in 1960. Many inadequacies in the Soil Survey were removed in the subsequent years and revised Soil Survey Manual was published in 1970. The All India Soil and Land Use Survey Organization (1970) has identified eight different land-use capability classes with a broad classification into :

(*i*) land suitable for cultivation, and (ii) land not suitable for cultivation; these are presented here in summary form :

***Land suitable for cultivation* :**

Class I. Very good cultivable land with no special difficulty in farming.

Class II. Good cultivable land which needs protection from erosion or floods, drainage improvement, and conservation of irrigation water.

Class III. Moderately good cultivable land where special attention has to be paid to erosion control, conservation of irrigation water, intensive drainage, and protection from floods.

Class IV. Fairly good land suited for occasional or limited cultivation needs intensive erosion control, intensive drainage, and very intensive treatment to overcome soil limitations.

***Land not suitable for cultivation* :**

Class V. Very well suited for grazing but not for arable farming, needs protection from gulying.

Class VI. Well suited for grazing or forestry but not for arable farming.

Class VII. Fairly well suited for grazing or forestry, but not for arable farming.

Class VIII. Suited only for wild life, recreational facilities and protection of water supplies.

Evidently, the suitability classification given above is valuable for the assessment of land productivity. It is a classification in terms of the limitations of soils for agricultural land use. It is also an interpretive grouping according to capability. Its utility for development plan can be enhanced if due consideration is given to the physical factors.

DRY FARMING

As its name indicates, dry farming is practised in the dry parts of India. The western half of India is characterised by cry climate where arid and semi-arid conditions prevail. The average annual rainfall in these areas is less than 75 cm and the isohyet of 75 cm annual rainfall marks its eastern boundary. The area of dry farming extents from Kashmir in the north to Kanniyakumari in the south with a small gap in Himachal Pradesh and Jammu region of Jammu and Kashmir. The Bay of Bengal monsoons are almost exhausted when they reach western part of Uttar Pradesh, Haryana, Punjab and Rajasthan and cause little rainfall. The northern parts of Jammu and Kashmir are almost out of reach of monsoon winds and Ladakh region is known as cold desert. South of the Tapi river upto Kanniyakumari, the whole region is in the rain shadow area of the Western Ghats and receives less than 75 cm annual rainfall from the Arabian sea monsoons. Map in **figure 20.7** shows that dry farming area comprises a continuos belt-encompassing whole of Rajasthan, Punjab and Haryana, and large parts of Gujarat, western parts of Madhya Pradesh, and Uttar Pradesh, Vidharbha and Marathwada regions of Maharashtra, plateau region of eastern Karnataka, Rayalseema and Telangana and large parts of Tamil Nadu except coastal areas north of Ramnathpuram. Apart from the main belt the north eastern parts of Jammu and Kashmir are also known for dry farming. It is estimated that dry farming is practised on 31.7 million hectares which accounts for about 22.% of the total agricultural land of the country.

Salient Features of Dry Farming

(*i*) Dry Climate. As mentioned earlier, dry farming is done in dry areas of the country where annual rainfall is less than 75 cm. The eastern parts of this belt receiving nearly 70 cm of annual rain are areas of sub-humid climate which are deficient in humidity for about 8 months in the year. Areas with 25-50 cm of annual rainfall have semi-arid climate which suffer from deficiency in humidity throughout

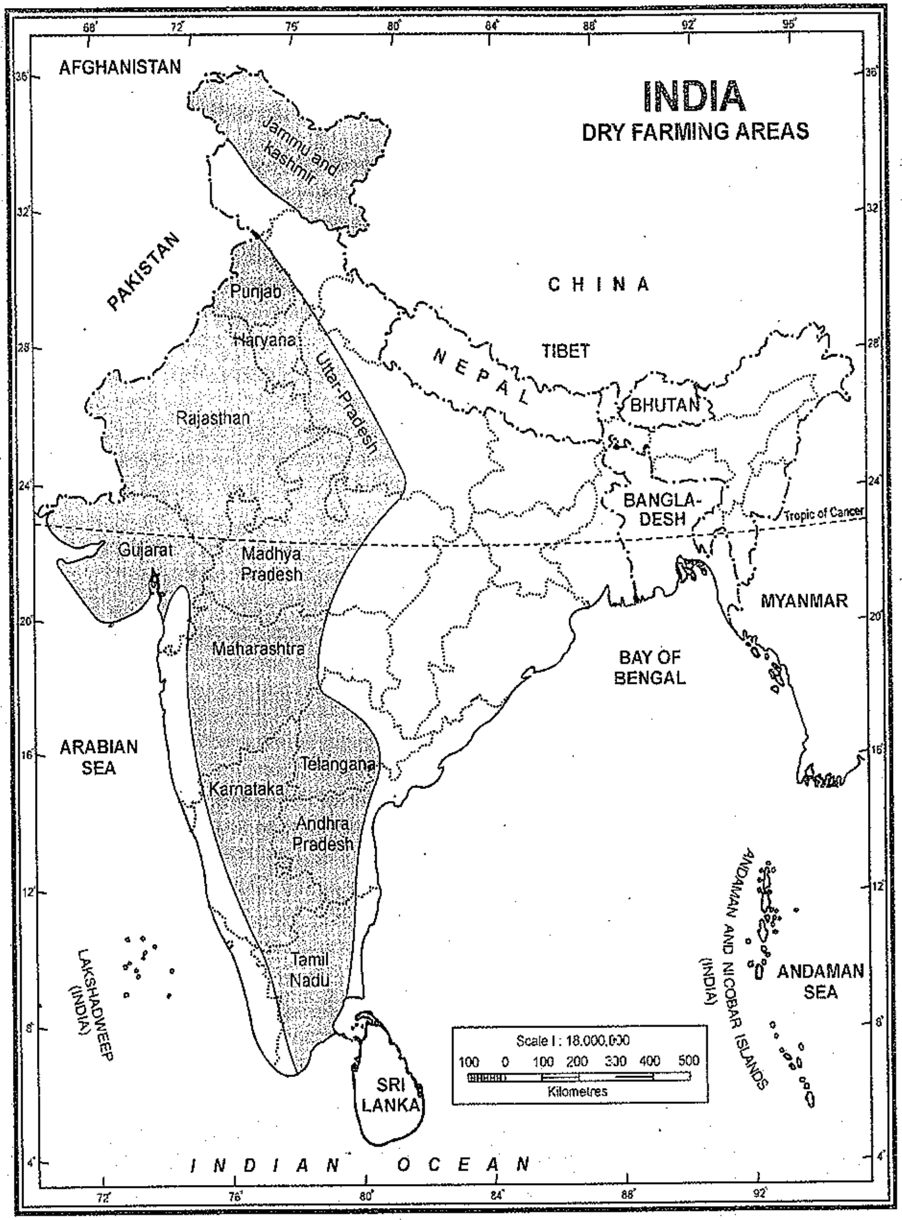

FIG. 20.7. India : Dry Farming Areas

the year. Jaisalmer and Barmer districts of Rajasthan receive less than 25 cm of annual rainfall and are completely dry areas.

It is now abundantly clear that these areas suffer from the problem of scarcity of rainfall and shortage of water is a perpetual problem. In addition, variability

of rainfall is very high which varies from 20 to 60 per cent. Rainfall is seasonal and occurs only in 3-4 months, leaving 8-9 months almost completely dry. Moreover, rainfall is erratic and unreliable. Late arrival or early retreat of the monsoons increase unreliability of rainfall. Break in the monsoon is also harmful for the crops. There is almost complete crop failure in the event of a drought.

(*ii*) **Lack of Irrigation.** Most areas of dry irrigation lack in irrigation and have to depend on rainfall. Punjab, Haryana and western parts of Uttar Pradesh have canal and tubewell irrigation facilities. However, keeping in view the change in the cropping pattern (introduction of rice cultivation) and high level of agricultural intensity, irrigation facilities in these areas are found to be inadequate. Rajasthan does not have any major river flowing through its territory and ground water is brackish. There is, thus, not much scope of canal and tube well irrigation. The Indira Gandhi Canal, taken from confluence of Satluj and Beas in Punjab, has provided irrigation facilities to western parts of Rajasthan. This has led to increase in agricultural productivity and change cropping pattern. Most parts of South India are made up of hard rocks and lack in ground water resources. Sinking of tube wells is also difficult in hard rocks. As a result of these geographical conditions, tanks are the major source of irrigation. These tanks dry up during the dry season and fail to provide water when the crops need it the most.

(*iii*) **Subsistence Agriculture.** Dry farming is mainly practised by small and marginal farmers who work in the field along with their family members. The agricultural production is just sufficient to feed the family members of the farmer and there is not much surplus for sale in the market. These farmers lack financial resources and are not able to buy modern inputs like better seeds, fertilizers and farm machinery. They have to face a hunger, starvation and unemployment whenever there is any drought.

Methods of Dry Farming

(*i*) Field is ploughed repeatedly in order to conserve moisture in the soil. This process is necessary especially during the raining season so that rain water is properly utilized.

(*ii*) Soil fertility is reduced when cultivation is continued for a number of years. This problem becomes serious particularly in the background of farmer's inability to make use of fertilizers and manures. In order to solve this problem, land is left as fallow land. It helps in recuperation of soil fertility.

(*iii*) Pulverisation of soil is done before sowing. This process converts soil into small particles which permits easy flow of water in the soil and plant roots find ample opportunity to grow in strength and support the plants.

(*iv*) Hoeing, weeding and pruning are done at regular intervals. Hoeing allows air to enter the soil space and helps in plant growth. It is generally done before sun-rise so that night dew can enter soil and provide moisture to plants. Through weeding, unwanted plants in the fields are removed and pressure on the soil to feed the plants is reduced. Pruning removes unwanted parts of the plants and wanted plants find ample opportunity to grow.

(*v*) Land is usually covered with straw to reduce evaporation of the soil moisture and to control soil erosion by wind.

(*vi*) In order to improve their income level, the farmers keep themselves engaged in allied agricultural activities such as livestock keeping and dairying.

Significance of Dry Farming

Dry land is an agriculturally dominant region wherein more than two-thirds of the total population (against national average of 55%) depend on agriculture. Here agriculture occupies 65% of the total area while 2.9% of the total geographical area is occupied by permanent portures. Although this region is plagued with a large number of problems like scanty rainfall, inadequate irrigation, lack of basic inputs like better seeds, fertilizers, and farming machinery etc., as well as widespread poverty among the farmers, yet this region accounts for 85% of pulses production of the country. Pulses comprise a great source of protein in a vegetarian country like India. This region also produces 75% oilseeds, 80% maize, and 95% jowar and bajra of India. About 40% foodgrains of India are also produced by this type of agriculture. There has been some change in the cropping pattern of this region. Farmers have started to give priority to main foodgrains like wheat and rice which has adversely affected the production of pulses and oilseeds. India has to spend huge amounts of foreign exchange on the import of oilseeds.

Problems

Following are the main problems of dry zone agriculture :

(*i*) Rainfall is scarce, erratic, unreliable and uncertain which makes this region susceptible to floods, droughts and famines.

(*ii*) Large areas are covered by sandy soil which lack in nutrient materials for soil fertility.

(*iii*) The area is prone to soil erosion, particularly erosion by wind.

(*iv*) Yields are low and crops are susceptible to pests and diseases.

(*v*) Due to lack of moisture and inadequate irrigation facilities it is difficult to use HYV seeds and new technologies.

(*vi*) Majority of the farmers are poor and cannot afford costly inputs like better seeds, fertilizers, farm mechanies, etc.

(*vii*) Large areas of dry farming lack basic infrastructural facilities like market, transport, storage, refrigeration etc. The farmers are forced to opt for distress sale in the absence of these facilities and fail to get remunerative prices for their products.

Development Strategies

Following development strategies may be undertaken for developing dry farming.

1. Conservation and Optimum use of Water Resources. The greatest problem faced by dry farming is scarcity of water for which water conservation and optimum use of water resources is of paramount importance. Water present in the soil can be saved by deep and surface ploughing. Deep ploughing is suitable for kharif crops because it breaks deep layer of the soil where rain water can easily percolate. Besides, it is useful for sowing and weeding. Surface ploughing is useful for rabi crops because it plays an important role in conserving the soil moiture.

Wastage of water through run off can be avoided by contour bunding, embankments and dams. Efforts should also be made to arrange for rain water harvesting for which government and non-government organisations can be of greater help.

2. Checking Soil Erosion. Soil erosion by strong winds is a serious problem in areas of dry farming because loose particles of soil are easily blown by wind. Several strategies can be adopted to solve this problem. Important strategies include planting trees in rows so that they can act as obstruction to the blowing wind, making sand-dunes stable by plantation and ploughing along he contours.

3. Drought Resistant Crops. As far as possible, drought resistant crops should be encourage so that effect of drought condition is minimised. Early maturing crops can also be helpful in this regard. Better quality seeds of maize, wheat, barley, mustard and some pulses have responded very well to arid and semi-arid conditions in these areas.

4. Use of Weedicides and Pesticides. Proper arrangement should be made to use weedicides and pesticides to save the crops from weeds, pests and diseases. However, care should be taken to replace these chemicals by eco-friendly bio-technical materials.

5. Proper areal distribution of crops. Proper areal distribution of crops can go a long way in increasing the farm productivity and safeguard against vagaries of climate. For example, crops requiring more moisture such as rice should be grown in lower parts of catchment areas of tanks and reservoirs. Cotton should be confined to areas of more dependable rainfall and areas where sprinkle irrigation is available. Crops like sunflower, mustard etc. should be popularised in areas of scarce rainfall.

6. Diversification of Crops. It is always better to opt for crop diversification rather than choosing a few selected crops. This can solve the twin problem of uncertainty of weather and soil degradation. If one crop is destroyed due to unsuitable weather condition, the other crop may compensate for the loss. For example, legumes can be grown along with foodgrains. Legumes add nitrate to the soil.

7. Use of Manures. Majority of the farmers in dry farming areas are poor and cannot afford to purchase costly chemical fertilizers. Under such a condition, the farmers should be encouraged to use cow dung and other biological manures. This will economise agricultural inputs and also save environment from pollution.

8. Alternative land use planning. Following two alternative land use planning strategies are suggested to avoid crop failure and to increase income of the farmers :

(*i*) Encourage agro-forestry and devote large areas to legumes.

(*ii*) Develop graze lands and social forestry in marginal lands and in cultivable wastes.

Government Schemes. The Government has initiated the following schemes to develop dry farming.

1. It forms an important part of the 20 point programme.

2. Identification of 4,609 micro-watersheds has been done for comprehensive and systematic development covering an area of about 35,45,000 hectares. Each micro-watershed covers an area of about 1,000 hectares. The programme includes scientific management of rain water, land development, use of drought resistant seeds, plantation of trees, and development of animal husbandry and allied activities. As many as 46 model watersheds have been identified for development as focal points.

3. A pilot project, taken up with the assistance of the World Bank, envisages the development of identified watersheds of about 25 to 30 thousand hectares in Madhya Pradesh, Maharashtra, Andhra Pradesh, Telangana and Karnataka.

4. Crops requiring less moisture such as maize, sunflower, soyabean, mustard and coarse grains, are being promoted in rain shadow areas of Karnataka.

5. A national waterlogging, development plan was initiated during the Seventh Five Year Plan in 99 selected districts of 16 states.

6. Agro-forestry, agro-horticulture and silvipasture etc. have been initiated by the government for alternative land use systems.

AGRICULTURAL REGIONALISATION

India is a vast country with varied physical and socio-economic features which give rise to different types of agriculture in different parts of the country. Therefore, it is desirable that an agricultural regional study should be undertaken to understand the whole garment of agriculture in India. *Agricultural region is defined as an area which depicts homogeneity with respect of agricultural land use and cropping pattern.* It may be identified on the basis of crops and livestock and the ecological factors which affect these important elements of agricultural An agricultural region depicts broad similarities in the nature of crops, crop combination patterns, methods of cultivation, quality and quantity of inputs and orientation of the farming activities. Such a region is generally used as a device for selecting and investigating regional groupings of the complex agricultural phenomena found in different parts of the country. Agricultural region is not static but a dynamic concept which changes in space and time. The introduction of rice cultivation in Punjab and Haryana and that of wheat cultivation in the lower Ganga plain as a consequence of the Green Revolution are example of such changes.

Agricultural regions have the following four characteristics features :

(*i*) they have location.

(*ii*) their boundaries are not well defined and they have transitional belts.

(*iii*) they may be either formal or functional.

(*iv*) they may be hierarchically arranged.

As mentioned above, agricultural regions do not have sharply defined boundaries. Rather two neighbouring agricultural regions have a transitional zone between them because characteristics of one region give way to those of the other region slowly and gradually. Thus precise delineation of the boundary of agricultural regions is a difficult task for which following techniques may be applied.

(*i*) Empirical Technique

(*ii*) Single-element Technique

(*iii*) Multi-element (Statisical) Technique

(*iv*) Quantitative-cum-Qualitative Technique

(*i*) Empirical Technique. This technique was first of all used by **Oliver E. Baker** for demarcating agricultural belts of the U.S.A. He was able to demarcate the Cotton Belt, the Corn Belt, and the winter as well as the spring wheat belts of the U.S.A. on the basis of the observed data. Since this technique is largely based on the experience of the farmers, it just gives a generalised picture of the cropping patterns and agricultural regions. This technique was used by a number of scholars like **C.F. Jones, Taylor, Van Valkenberg,** and **G.B. Cressey** for demarcating agricultural regions in different parts of the world. However, the technique has been criticised by a large number of scholars because it is not objective and lacks scientific approach.

(*ii*) **Single Element Technique.** This is an arbitrary technique in which only the first ranking crops are plotted for demarcating agricultural regions. Its main drawback is that it conceals the position and importance of other crops grown in that particular region. It is not of much use in India because most parts of the country grow crops in combination and not in isolation.

(*iii*) **Multi-Element (or Statistical) Technique.** This technique is more objective and scientific because it involves more than one crop. The agricultural regions may be demarcated with the help of the following :

(*i*) Cropping patterns, crop concentration, and crop diversification

(*ii*) Crop combination

(*iii*) Regional patterns of agricultural productivity.

Several scholars like Shafi, Jasbir Singh, Aujer Hussain, Sapre, Deshpande, Tiwari etc. have used this technique for demarcating agricultural regions of India with fairly good results. However, non-availability of reliable data puts constraints for applying this technique.

(*iv*) **Quantitative-cum-Qualitative Technique.** This technique involves consideration of physical, socio-economic, cultural and political factors. The physical traits include (*i*) relief, (*ii*) climate, (*iii*) surface and sub-soil water, (*iv*) soil, (*v*) sub-soil and (*vi*) vegetation. The six functional traits are (*i*) rural population, (*ii*) cultural and religious values, (*iii*) technology, (*iv*) farming operations, (*v*) dependent rural population and (*vi*) degree of commercialisation. In this method also non-availability of reliable data is a big hindrance.

Several scholars have attempted to divide India into agricultural regions of which mention may be made of **E. Simkins** (1926), **D. Thorner** (1956), **L.D. Stamp** (1958), **M.S.A. Randhawa** (1958), **Chen Han Sen** (1959), **O.H.K. Spate** and **A.T.A. Learmonth** (1960), **Ramchandran** (1963), **E. Siddiqui** (1967), **P. Sengupta** and **G. Shasyuk** (1968), **O. Slampa** (1968), **B.L.C. Johnson** (1969 and 1979), **R.L. Singh** (1971) and **Jasbir Singh** (1975). Planning Commission of India has made its own contribution for delineating agro-climatic regions of India. The following section of this chapter gives a brief description of some of the important agricultural regions of India.

AGRO-CLIMATIC REGIONS

Climate is one of the most potent factors which influence the agricultural scenario of a region. It plays an important role in involving crop ecology of a region and is responsible for regional variations in agriculture. Such variations are more prominent in a large country like India where there are large variations in climatic elements. Effects of climatic elements are reflected in crop calendars, crop productivity and cropping patterns in different parts of the country. Several scholars have used climate as the basis of dividing India in agro-climaic regions. Some of the outstanding attempts have been those of Randhawa (1958), Slampa (1968) and Sengupta and Shasyuk (1967). The latest attempt has been made by the Planning Commission of India in 1989 in association with the National Remote Sensing Agency (NRSA) which divide into agro-climatic regions on the basis of commodity of agro-climatic factors like soil type, rainfall, temperature, water resources etc. The development profile for each region is formulated through an optimal mix of land stock management, crop production, animal husbandry, horticulture, forestry and agro-processing activities.

Objectives. The primary objectives of agro-climatic regional planning are to optimise agricultural production, increase in farm income and crate more employment opportunities through scientific utilisation of agricultural and allied resources. Thus the Planning Commission of India laid down four primary objects for agro-climatic regional planning.

These objectives were : (*a*) to attempt a broad demand-supply balance of major commodities at the national level but based on a careful analysis of the potential and prospects of the various zones; (*b*) to maximize the net income of the producers; (*c*) to

generate additional employment, particularly for landless labourers, (*d*) to provide a frame-work for scientific and sustainable use of natural resources, particularly land, water and forests in the long run.

Keeping the above mentioned objectives in mind, the Planning Commission divided India into 15 major agro-climatic regions in 1989. These regions are :

1. The Western Himalayas
2. The Eastern Himalayas
3. The Lower Gangetic Plains
4. The Middle Gangetic Plains
5. The Upper Gangetic Plains
6. The Trans Gangetic Plain
7. The Eastern Plateaus and Hills
8. The Central Plateaus and Hills
9. The Western Plateaus and Hills
10. The Southern Plateaus and Hills
11. The East Coastal Plains and Hills
12. The West Coastal Plains and Western Ghats
13. The Gujarat Plains and Hills
14. The Western Dry Region
15. The Islands Region

Table 20.26 gives a synoptic views of the agro-climatic features or the typology of the above mentioned 15 regions.

In addition to resource considerations and land productivity level, relative pressure on land and environmental factors have been considered in framing this typology necessary to identify the zones and providing general guidelines for overall agricultural development.

TABLE 20.26. Zonal Characteristics as Typologies

Sl. No.	Typology	Zone
1.	Rich water and soil resources, high land productivity (major crops), moderate population pressure on land.	Trans-Gangetic Plains (No. 6)
2.	Rich Soil and water resources, medium productivity level and moderate population pressure on land, deteriorating land quality.	Gangetic Plains (No. 5)
3.	Rich water and soil resources, low productivity level, high population pressure on land increasing proportion of problems of soils.	Gangetic Plains (Nos. 3 and 4)
4.	Large Volume of land and water resources, very low productivity of land with predominance of subsistence agriculture, low population pressure, high proportion of problem soils	Eastern and Central Plateaus and Hills (Nos. 7 and 8)
5.	Less favourable soil and water resources, low land productivity, low-medium population pressure, deteriorating environment in respect of soil erosion and water quality.	Western and *southern* Plateaus and Hills (Nos. 9 and 10)
6.	Rich water resources but relatively poor land, medium land productivity, medium-high population pressure, fragile eco-system.	East Coast and West Coast Plains and Hills and Islands (Nos. 11, 12 and 15)
7.	Less favourable land and water resources, low land productivity, low population pressure and fragile eco-system.	Himalayan Regions (Nos. 1 and 2)
8.	Semi-arid to arid conditions, moderately good land quality and productivity, moderate population pressure.	Gujarat Plains and Hills (No. 13)
9.	Arid conditions, large but less fertile soil resources, very low land productivity, low population pressure and fragile eco-system.	Western Dry (No. 14)

Source: Yojana, October 1-15, 1990.

TABLE 20.27. Zone-wise Agroclimatic/Geographical Area in India

Zone No.	Regions	Geographical area ('000 sq. km)	Population density (Persons/ sq. km)	Net sown area (%)	Forest area (%)	Per capita cultivable land (ha/person)
1.	West Himalaya	245	62	18.2	45.3	0.195
2.	East Himalaya	274	118	18.7	42.8	0.189
3.	Lower Ganga Plain	69	692	63.8	11.0	0.010
4.	Middle Ganga Plain	164	526	62.8	8.7	0.141
5.	Upper Ganga Plain	143	466	70.1	4.5	0.172
6.	Trans Ganga Plain	116	331	80.9	3.2	0.268
7.	Eastern Plateau	395	136	35.9	35.2	0.323
8.	Central Plateau	370	137	45.0	14.2	0.446
9.	Western Plateau	331	170	59.7	11.8	0.396
10.	Southern Plateau	395	200	48.4	17.1	0.319
11.	Eastern Coast	197	321	43.3	18.7	0.181
12.	West Coast	117	441	37.2	29.0	0.123
13.	Gujarat	196	175	51.4	10.9	0.363
14.	Western Drylands	175	58	47.7	1.2	1.314
15.	Islands	8	29	4.2	88.1	0.210
	India	**3,195**	**215**	**47.0**	**19.3**	**0.260**

Source : *Yojna*, October 1-15, 1990, pp. 4-8.

Table 20.27 gives details of geographical area, population density, net sown area, forest area and per capita cultivable land for all the 15 agro-climatic region.

It may be seen from **table 20.28** that different agro-climatic regions have different cropping pattern and crop specialisation varies from one set of regions to another. For example rice has main concentration in zone 3 (Lower Ganga Plain), 4 (Middle Ganga Plain), 7 (Eastern Plateau) and 11 (Eastern Coast), while concentration of wheat is found in 4 (Middle Ganga Plain), 5 (Upper Ganga Plain), 6 (Trans Ganga Plain) and 8 (Central Plateau). Similarly other crops like jowar, pulses, oilseeds, cotton, sugarcane and fruits and vegetables have their own respective zones of concentration. It may also be seen that crop specialisation is more in certain crops like sugarcane, cotton, jowar, and wheat. The distribution is most widespread in case of rice, pulses, fruits, and vegetables.

A brief description of 15 Agro-climatic regions is given below :

TABLE 20.28 . Cropping Specialisation in the Zones

S. No.	Crop/ croup group	Zones of Concetra-tion	Percen-tage to total area	Percen-tage to total produc-tion
1.	Rice	3, 4, 7, 11	62.0	55.3
2.	Wheat	4, 5, 6, 8	80.0	86.2
3.	Jowar	8, 9, 10	86.3	87.0
4.	Pulses	6, 8, 9	66.6	65.5
5.	Oilseeds	8, 9, 10, 13	70.0	70.3
6.	Cotton	6, 9, 10, 13	92.0	85.3
7.	Sugarcane	4, 5, 9, 10	74.3	72.6
8.	Fruits and Vegetables	3, 4, 5, 12	56.4	60.8

Source : Yojna 1-15, 1990.

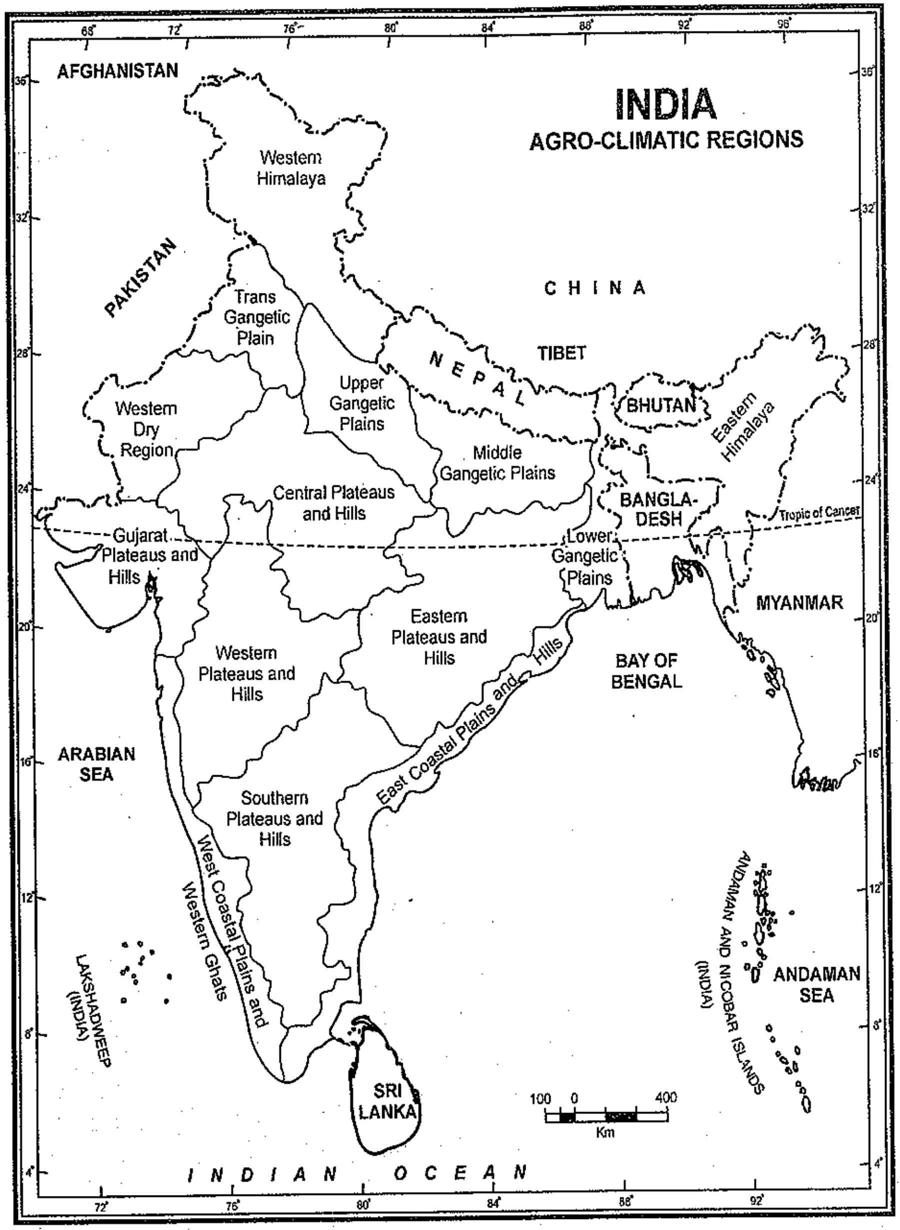

FIG. 20.8. India : Agro-climatic Regions

1. Western Himalaya. The Western Himalayan Region stretches over Jammu and Kashmir, Himachal Pradesh and Uttarakhand. This region has great variations in topography which consists of lofty mountains, deep valleys, steep slopes and a large number of topographical features of local importance. The climate of this region is characterised by mild summer with July average temperature varying from

5°C to 30°C and severe winter with January temperature varying from 0°C to –4°C. The mean annual rainfall varies from 75 cm to 150 cm, except in Ladakh where it is below 30 cm. The valleys like those of Kashmir and Kullu as well as duns like those of Dehra Dun are covered with thick layers of alluvium while hill slopes have thin brown soils. The region is drained by a number of perennial rivers which originate in the snow covered mountain ranges. These include the Ganga and its major tributary the Yamuna and the Indus and its major tributaries like the Jhelum, the Chenab, the Beas and the Satluj. Some of the rivers are utilised as sources of canal irrigation and hydro-electric power. Unfortunately, the increased human interference in the natural set-up of the region has led to overall deterioration of ecological system. Rapid and unplanned construction activities, unscrupulous mining and reckless falling of trees have made the region more prone to floods, droughts, landslides receding glaciers and environmental pollution. The Uttarakhand tragedy of 15-16 June, 2013 is on eye opener in this regard.

Rice, maize, wheat, barley and vegetables are grown in the terraced fields on the hill slopes. But the plantations do not need terracing and are set up along the hill slopes. The region is well known for temperate fruits like apples, peach, pears, almond, walnut etc. The environmental conditions of this region are quite congenial to development of garden and plantation crops and there is much scope for improvement in this regard. Alpine pastures above 2000 m are known as *dhoks* or *margs* which are used by Gujjar and Gaddis for rearing sheep and other animals.

This region requires a more judicious land use planning for increasing farm productivity. There should be rational allotment of land for different purposes like cultivation of crops, horticulture, pastures and forestry. The most suitable recommendations are (*a*) agriculture on land upto 30 per cent slopes, (*b*) horticulture/fodder development on land having slope 30-50 per cent and (*c*) all land over 50 per cent slopes under tree cover.

2. The Eastern Himalaya. This region encompassed the eastern part of the Himalayas consisting of Sikkim, Darjeeling hill area of West Bengal, Assam Hills, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura and Meghalaya. It is characterised by rugged topography, steep slopes, thick forests and swift flowing rivers. The climate is sub-humid with annual rainfall over 200 cm. The July and January temperatures vary from 25°C to 30°C and 10°C to 20°C respectively. The soil is red-brown and less fertile. About one-third of the total cultivated area is under shifting agriculture locally known as Jhuming. Rice, maize, potato and fruits (orange, pine apple, lime, lichi, etc.) are the main crops. Tea plantations are found on the hill slops of Assam and Darjeeling.

Shifting agriculture is causing heavy damage to soil and forest resources and there is urgent need to check this type of agriculture and replace it by other forms of agriculture like subsistence type of agriculture. Soil erosion can also be checked by developing terraced cultivation and planting more trees, especially on the hill slopes. Also, there is vast scope for improving infrastructural facilities. There is too much wastage of water by surface run-off. Steps should be taken to check it and water thus conserved should be used for minor irrigation. A programme to grow fruits above 30% slopes in the hills needs to be framed. Supportive activities like sericulture, handicrafts, poultry, piggery, etc. should be encouraged to supplement the income of the farmers. A long-term quality seed production, suiting the ecological conditions of the region, needs to be implemented on priority basis.

3. The Lower Gangetic Plains. This region spreads over eastern part of Bihar, West Bengal (excluding Darjeeling hilly area) and Brahmaputra valley in the Assam. It is made up of rich alluvial soil deposited by big rivers. The Ganga delta is the largest in the world. Most of the area is characterised by extremely gentle slope and oxbow lakes. The area has hot and humid climate where the annual rainfall varies from 100 to 200 cm and January and July temperatures range between 12°C to 18°C and 25° to 30°C respectively. The region has enough storage of ground water and the water table is very high. The region suffers from waterlogging and marshy areas area found over vast stretches of land. Wells and canals are the main sources of irrigation. Hot and humid climate and rich alluvial soils provide ideal conditions for the cultivation of rice and jute crops. In some parts of West Bengal, three successive crops of rice (Aman, Aus, and Baro) are grown in a year. The Hugli basin is world nonowned for jute cultivation. Wheat has become popular as a winter crop as a consequence of the Green Revolution. Maize, pulses, potato etc. are other important crops. The development strategy includes improvement in rice farming, horticulture (banana, mango and citrus fruits), pisciculture, poultry, livestock, forage production and seed supply. A large number of farmers engage themselves in fishing in ponds and reservoirs.

4. The Middle Gangetic Plains. It spreads over eastern part of Uttar Pradesh and whole of Bihar. It is a gently sloping plain which is made up of fertile alluvial soil that has been deposited by the mighty Ganga and its tributaries. This is an area of hot and humid climate where the annual rainfall is 100-150 cm. The temperature ranges from 25°C to 40°C in July and 10° to 25°C in January. The region has vast potential of ground and run-off water from the perennial rivers which is used for irrigation through tube wells and canals. Rice, maize, millets etc. are the main *kharif* crops while wheat, gram, barley, peas, mustard and potato are important *rabi* crops. Mango, guava, lichi, banana etc. are the main fruit crops.

There is vast scope for improvement of agriculture in this region. Efforts should be made to improve the yield of kharif paddy crop which occupies over 40 per cent of the gross cropped area of the region. Diversification of crops by giving more area to vegetables, fruits, and floriculture can yield better results. Dairying, silviculture, agro forestry, and pisciculture can also help a lot in supplementing the income of the farmers.

5. The Upper Gangetic Plains. This plain stretches over the Ganga-Yamuna doab, Lucknow division and Rohilkhand of western Uttar Pradesh and Hardwar and Udham Singh Nagar districts of Uttarakhand. This is more or less a plain area with gentle slope which has been made by fertile soils deposited by the Ganga and its tributaries. This is a region of sub-humid continental climate where the annual rainfall varies from 75 to 150 cm. The temperatures vary between 10°C and 25°C in January and between 25°C and 40°C in July. The soil varies from sandy loam to clayey loam. The area has developed adequate facilities of canal and tube well irrigation. This is an intensive agricultural region where wheat, rice, sugarcane, millets, maize, pulses, gram, barley, oilseeds and cotton are widely grown. Like Punjab and Haryana, this area has taken maximum advantage of the Green Revolution.

This region has great potential for improvement in agriculture and efforts should be made to increase the agricultural productivity of this region. The strategy should include greater emphasis on mixed cropping, horticulture, floriculture, judicious use of irrigation facilities, lining of canals to check seepage, reclaiming saline/alkaline soils, improving cattle breed and bringing more areas under fodder crops.

6. The Trans-Ganga Plain. This plain consists of Punjab, Haryana, Delhi, Chandigarh and Ganganagar district of Rajathan. The plain is made up of highly productive alluvial soils which have been deposited by the rivers draining this region. The climate has semi-arid characteristics where the annual rainfall varies from 40 to 100 cm. Most of the rainfall is received form the south-west monsoons during the summer season but some rainfall is also brought by the western disturbances during the winter season. Being an area of continental climate, the region experiences extremes of temperature which may soar to 45°C during day in May/June and dip to almost freezing point during night in December/ January. However, the average temperatures for January and July vary from 10°C to 20°C and 25°C to 40°C respectively. The perennial rivers draining this region provide ample opportunities for canal irrigation. Besides, the region has lakhs of tube wells. In fact, tube wells irrigate much larger area as compared to canals. Both Punjab and Haryana have some of the highest intensities of agriculture. Wheat, rice, sugarcane, cotton, gram, maize, millets, pulses and oilseeds are the main crops. The area has the distinction of introducing the Green Revolution in India when HYV seeds of wheat and rice were introduced in the mid 1960s. Along with seeds, this area was the first to adopt other modern methods of farming like fertilizers, irrigation and farm mechanisation. However, the region is facing serious problems waterlogging, salinity, alkalinity and soil degradation due to over irrigation by canals. The region is also facing a serious crisis of falling water table due to over exploitation of ground water through tube-wells.

Although this is the highly productive part of the country with respect to agriculture, yet it can be made more productive if some corrective measures are taken. Wadia (1996 : 100) has suggested the following measures :

(*i*) diversion of 5 per cent of rice-wheat area to other crops like maize, pulses, oilseeds, and fodder.

(*ii*) development of genotypes of rice, maize and wheat with inbuilt resistance to pests and diseases.

(*iii*) promotion of horticulture besides pulses like tur and peas in upland conditions.

(*iv*) cultivation of vegetables in the vicinity of industrial clusters.

(*v*) supply of quality seeds of vegetables and planting materials for horticulture crops.

(*vi*) development of infrastructure for transit godowns and processing to handle additional fruit and vegetable production.

(*vii*) implementation of policy and programmes to increase productivity of milk and wool.

(*viii*) development of high quality fodder crops and animals feed by stepping up area under fodder production by 10 per cent.

7. The Eastern Plateaus and Hills. The region includes the Chotanagpur plateau, Rajimchal Hills and Chhattisgarh plains. It consists of red and yellow soils with occasional patches of laterites and alluviums. Most of the soils are not very productive. Fertile soils are found only in the Mahanadi basin. The region receives annual rainfall varying from 75 cm to 150 cm. The mean January and July temperatures range from 10°C to 25°C and 25°C to 40°C respectively. The region is deficient in surface water due to non-perennial streams and ground water due to hard and impermeable rocks. The agriculture is mainly rain-fed in which rice, maize, millets, *ragi*, gram, oilseeds, tobacco, potato, etc. are the main crops. Fallowing is the common practice in areas lacking irrigation.

This area needs improvement in agriculture. The strategy for this may include larger use of HYV seeds, cultivation of high value crops like oilseeds, pulses, vegetables, improvement of indigenous breeds of cattle and buffaloes, water-harvesting and water-shed development, soil conservation, renovation of old tanks and excavation of new tanks and rehabilitation of degraded forest land.

8. The Central Plateaus and Hills. Most of this region spreads over eastern part of Madhya Pradesh and adjoining parts of Rajasthan and includes Bundelkhand, Baghelkhand, Bhander plateau, Malwa plateau and Vindhyanchal hills. The region is characterised by semi-arid climatic conditions where the annual rainfall varies from 50 to 100 cm. The mean January and July temperatures are 10°C to 25°C and 25°C to 40°C respectively. The soils are mixed red, yellow and black in which crops like millets, wheat, gram, pulses, oilseeds, cotton, sunflower etc. are grown. Water scarcity is the main problem of this region. Among the main strategies for improving agriculture are water conservation through devices like sprinklers and drip system, opting for dry farming, crop diversification, dairy development and poultry farming.

9. The Western Plateaus and Hills. The region spreads over the southern part of Malwa plateau and the Deccan plateau of Maharashtra. This is a region of black soil known as *regur*. The region is characterised by semi-arid climate with average annual rainfall varying from 25 cm to 75 cm. The January and July temperatures range from 5°C to 25°C and 25°C to –40°C respectively. Irrigation facilities lack badly and only a little over 12% of the cropped area enjoys irrigation facilities. Therefore, most of the crops have to depend on rainfall and mostly drought resistant crops are grown. Jowar, cotton, sugarcane, rice, bajra, wheat, gram, pulses, potato, groundnut, oilseeds are the main crops. Agricultural production can be increased by adopting water saving devices like sprinkle irrigation, drip system, water harvesting, replacing low value crop by high value crop, providing market and storage facilities, developing dairy and poultry farming.

10. The Southern Plateaus and Hills. It includes southern Maharashtra, Karnataka, Telangana, Andhra Pradesh and northern Tamil Nadu. The area has semi-arid climate with annual average rainfall of 50-100 cm. Temperatures for January and July are 13°C to 21°C and 25°C to 40°C respectively. Since the rainfall is less and the temperatures remain high throughout the year, this is essentially an area of dry farming where millets, pulses, oilseeds, coffee, tea, cardamom are the main crops. Development of poultry, dairy farming, horticulture, restoration of tank irrigation, use of water saving devices and diversion of jowar/bajra/ragi to groundnut/sesamum/sunflower can improve the situation.

11. The East Coastal Plains and Hills. This region extends all along the eastern coast from Baleshwar in Odisha to Kanniyakumari in Tamil Nadu. Its northern part is known as Northern Circar and southern part is called Coromandal coast. It has been formed by the depositonal work of rivers like Mahanadi, Godawari, Krishna and Cauvery and the deltas of these rivers are the chief characteristic features of this region. The region has sub-humic marine climate where the annual rainfall varies between 75 cm and 150 cm. Since the climate of this coastal area is influenced by the Bay of Bengal, there is not much difference between summer and winter temperatures. Here, the January and July temperatures vary from 20°C to 30° and 25°C to 35°C respectively. The soils are alluvial, loam and clay. These soils suffer from the serious problem of alkalinity. The main crops are rice, jute, tobacco, sugarcane, maize, millets, pulses, groundnut, and oilseeds.

The main strategies for agricultural development in this region are discouraging mono-culture of rice and encouraging crop diversification, replacing coarse grains by high value crops like pulses and tobacco, increasing cropping intensity, cultivation of spices like pepper and cardamom, proper use of water resources and improving tank irrigation system, treating areas suffering from alkalinity and water logging and increasing potential of animals and fisheries.

12. The West Coastal Plains and Western Ghats. This region extents from the Tapi estuary in the north to Kanniyakumari in the south and covers coastal areas of Maharashtra, Karnataka and Kerala. Its northern part is known as Konkan and southern part is called Malabar. The Sahyadri range running in north-south direction is also included in this region. South-west monsoons originating in the Arabian Sea strike against the Western Ghats and cause heavy rain. The average annual rainfall exceeds 200 cm. The mean January and July temperatures are 18°C to 30°C and 26/C to 32°C respectively. Therefore the climate of this region may be termed as hot and humid. Rice, coconut, oilseeds, sugarcane, millets, pulses and cotton are the main crops. Slopes of the Western Ghats are famous for plantation corps.

The strategies for development include devoting more area to high value corps like spices, pulses, fruits and coconut, improvement in drainage, sinking of dug wells, improvement in infrastructure, and promotion of prawn culture in brackish waters.

13. The Gujarat Plains and Hills. This region encompasses the plains and hills of Kathiawar and the fertile valleys of Mahi and Sabarmati rivers. This is an arid and semi-arid region where the average annual rainfall varies from 50 cm to 100 cm. The amount of rainfall increases from west to east. January and July temperatures are 15°C to 30°C and 25°C to 42°C respectively. Different types of soils are found in this region. For example, soils are regur in the plateau region, alluvial in the coastal plains and yellow to red in the Jamnagar area. Groundnut, cotton, rice, millets, oilseeds, wheat and tobacco are the main crops. Wheat is the main rabi crop in irrigated areas. Kachchh is a dry area and is not much suitable for agriculture. The whole region is famous for production of oilseeds.

The development strategies should include surface and ground water management, rain-water harvesting, dry land farming, agro-forestry development, wasteland development and development of fishing and acquaculture in coastal zone and river deltas.

14. The Western Dry Region. This region stretches over the western part of Rajasthan (west of the Aravali range) which spreads over the waste desert of Marwar and the Mewar hills. This is totally an arid region where the annual rainfall does not exceed 25 cm. The January temperature ranges between 5°C and 20°C (and sometimes even touches the freezing point) which soars to over 40°C in July. Most of the region is sandy desert and is characterised by sand dunes. Luni river flows through the Jodhpur basin. Rainfall is scarce and erratic and famines and droughts are very common. Bajra, jowar and moth are the chief *kharif* crops while wheat and gram are grown in the *rabi* reason. However, livestock rearing is the main occupation of the people. Camel, goat and sheep are the main animals. Irrigation by the Indira Gandhi canal has changed the cropping pattern and raised the income levels of the farmers.

The development strategies should include enhancement in irrigation, promoting use of fertilizers and better seeds, increasing yields of fruits like date, palm, watermelon and guava and improving pastoral system.

15. The Islands Region. This region includes Andaman and Nicobar Islands in the Bay of Bengal and Lakshadweep Islands in the Arabian Sea. Being near the equator and surrounded by see on all sides, these islands have typically uniform equatorial climate where the average annual rainfall exceeds 200 cm and January and July temperatures are 25°C and 30°C respectively. The soils vary from sandy along the coast to clayey loam in valleys and lower slopes. Rice is the main crop which is followed by maize, jowar, bajra, pulses and plantation crops like arecanut, cassava, turmeric etc. Nearly half of the cropped area is under coconut. A large part of area is covered by forests and agriculture is in a backward state.

The main development strategies should lay more emphasis on crop improvement, water management and fisheries. The farmers should be encourage to take two crops of rice in a year by adopting modern methods of agriculture. Old less productive coconut trees should be replaced by young and more productive trees.

Agro-Ecological Regions of India

The concept of 'agro-ecological regions' is a modified and improved version of 'agro-climatic regions'. Several scholars have tended to use these two terms in the same way but there is basic and distinct difference between the two. Food and Agriculture Organisation (FAO) classified the difference between these two terms in 1983 and stated that agro-climatic region is a land unit in terms of major bio-climatic and length of growing period and which is climatically suitable for certain range of crop cultivation. On the other hand, agro-ecological region is a land unit carved out of agro-climatic region when superimposed on land form and soil condition that acts as modifier of length of growing period. Therefore, there may be a few agro-ecological regions within an agro-climatic region, depending on soil condition. This approach has been used for the purpose of delineating agro-ecological regions of India.

Methodology. For preparing agro-ecological region map, the soil-scap (soil map) is superimposed on bio-climatic map. On the resultant map, the growing period map is incorporated by using Geographical Information System (GIS) technology.

For demarcating agro-ecological regions of India, the agro-climatic regions of the country have been sub-divided on the basis of soil types. Thus the maso regions are obtained and the length of growing period (LGP) has been superimposed on them. By using this method, India has been divided into 20 agro-ecological regions (**Fig. 20.9**) and 60 agro-ecological sub-regions. A brief description of 20 agro-ecological regions is given below :

1. The Western Himalayan Cold and Dry Region. Located in the north-eastern part of Jammu and Kashmir, this region is out of reach of the south-west monsoon and receives less than 20 cm annual rainfall. The region has very severe winters due to its high altitude. Thus this region is known as **cold desert.** This region is not very useful for cultivation because the growing period here is less than 90 days.

2. The Western Plain Kachchh and part of Kathiawar Peninsula Region. This is hot and dry region where the annual rainfall is less than 40 cm. In the vast area of Jaisalmer, Barmer and Bikaner, the annual rainfall is less than even 20 cm. Similarly Kachchh and Kathiawar areas also receive scanty rainfall and have dry climate. The isohyet of 25 cm annual rainfall divides the entire region into two parts *viz.* (*i*) dry desert (Masusthali) and (*ii*) semi-arid transitional zone. The summer temperature soars to over 40°C as a result of which it is known as hot and dry region. The area has vast stretched of sandy and saline soils which are not much suited to agriculture. Land use data for 12 western districts of Rajasthan from 1951-52 to 1971-74 had shown that most of the area is unfit for cultivation and about 50 per cent of the land is either fallow or waste land. Limitation for cultivation can be appreciated by the fact that growing period here is less than 90 days. The Indira Gandhi canal has created problems of waterlogging, salinity and alkalinity.

3. The Deccan Plateau Hot Arid Region. This region has red and black soils. This region receives scanty rainfall because it is located in the rain-shadow area of the Western Ghats. However, black soil is

quite fertile and supports agriculture wherever tank irrigation is available. The growing period is less than 90 days due to scanty rainfall.

4. The Northern Plains and Central Highlands including Aravalis. This is a hot semi-arid ecoregion where its annual rainfall varies from 40 to 70 cm. The Northern Plain area has alluvial soil but the soils of the Central Highlands and the Aravali region have been derived from the decay and decomposition of the parent rocks. Here the growing period varies between 90 and 150 days.

5. The Central Mawa Highlands, Gujarat Plains and Kathiawar Peninsula. This is also a hot and semi-arid region where the annual rainfall is 40 to 60 cm. The summer temperatures are very high due to which this region has been termed as hot and semi-arid area. The region has medium to deep black soils which are capable of giving high yields if sufficient water is available. Here also the growing period varies between 90 and 150 days.

6. The Deccan Plateau. It lies in the rain shadow area of the Western Ghats in the states of Maharashtra and Karnataka and receives about 60 cm annual rainfall. It is termed as hot and semi-arid region due to high temperature during the summer season. This region is blessed with rich fertile black soil which is ideal for cotton cultivation. The growing period varies from 90 to 150 days.

7. The Deccan (Telangana) Plateau and the Eastern Ghats. This is also located in the rain shadow area of the Western Ghats and receives less rainfall. Most of it lies in Telangana and Andhra Pradesh. This hot and semi-arid region has red and black soils which are used for agriculture with the help of irrigation. The region has a growing period varying from 90 to 150 days.

8. The Eastern Ghats, Tamil Nadu Plateau and Deccan (Karnataka). This is also a hot and semi-arid region where red and loamy soils are found. Agriculture is based on tank irrigation. Growing period is 90-150 days.

9. The Northern Plain. Located in the south of the Western Himalayas, this flat plain has been formed by depositional work of the rivers draining through the region. It stretches from North Punjab in the west to Bihar in the east. The average annual rainfall is 50 cm in the west which increases to 100 cm in the east. The climate of this region is hot and sub-humid due to high temperature during the summer season. The region is blessed with rich alluvial soils. Wheat in the west and rice in east are the main crops. Several other crops are also grown depending o the local conditions. The growing period varies from 150 to 180 days.

10. The Central Highlands (Malwa, Bundelkhand and Eastern Satpura). This is a hot and sub-humid region with black and red soils. Most of this region is in Madhya Pradesh and Vidarbha region of Maharashtra. Irrigation is required for successful growth of crops. The growing period is between 150 and 189 days.

11. Eastern Plateau (Chhattisgarh). Major part of this region lies in Chhattisgarh and has hot and sub-humid climate. The region has red and yellow soils and is well known for rice cultivation. In fact this region has earned the destination of *rice bowl of India* due to its intensive rice cultivation. The growing period in this region varies from 150 to 180 days.

12. The Eastern (Chotanagpur) Plateau and Eastern Ghats. This agro-ecological region includes major part of the Chotanagpur plateau of Jharkhand and the Eastern Ghats area of Odisha. With the annual rainfall of about 150 cm, this region has hot and sub-humid climate. The red and laterite soils of this region are not much suitable for agriculture although it has a long growing season from 150 to 180 days.

13. The Eastern Plain. This agro-ecological region is in the north-east of the Northern Plain and stretches over northern parts of Uttar Pradesh and Bihar. The northern part of this region consists of Bhabar and Tarai. The whole region has been formed by the depositional work of the perennial rivers originating in the snow cover Himalayas. There is plenty of fertile alluvial soil which has provide a solid base to agriculture in this region. The region has a long growing period of 180 to 210 days which enables farmers to take two crops per year.

14. The Western Himalayas (Warm sub-humid to humid). This agro-ecological region lies between the Western Himalayan cold arid region in the north and the North Plain region in the south and stretches over Uttarakhand, Himachal Pradesh and

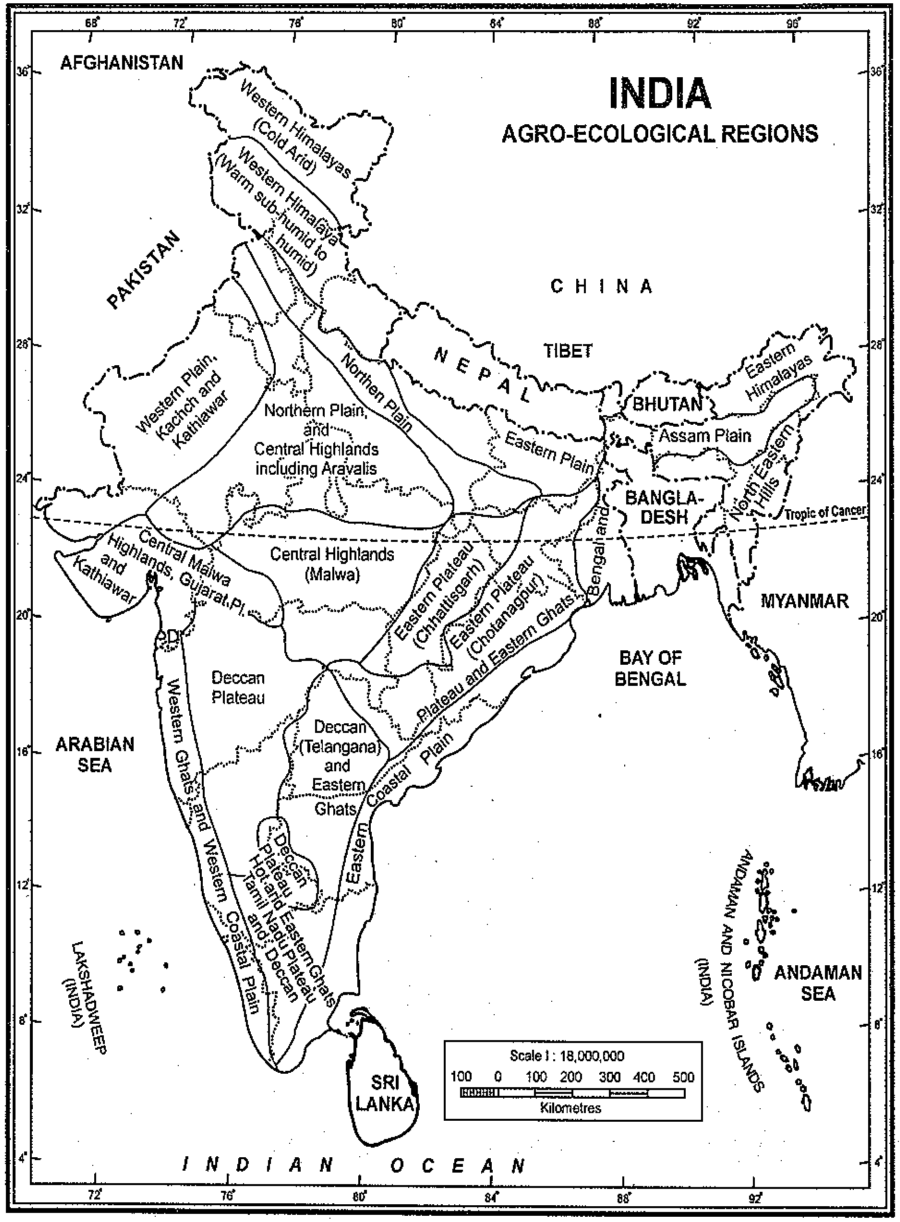

FIG. 20.9. India : Agro-Ecological Region

south-eastern part of Jammu and Kashmir. It is different from the first region because that region is cold and arid whereas this region has warm sub-humid to humid climate. It also includes perhumid ecoregion. Agriculture in this region is not much developed in spite of long growing season of 180-210 days. This is due to rugged topography of the area. However, the ecological conditions of this region are

very congenial to orchards and plantation crops. Consequently, a large variety of temperate fruits are grown here. Brown and podzole soils give natural support to fruit cultivation in this region.

15. The Bengal and Assam Plain. This region includes the entire plain area of West Bengal and the Brahmaputra valley of Assam. The area receives about 150 cm annual rainfall from the south-west monsoons originating in the Bay of Bengal. The climate of this region is termed as hot sub-humid to humid (inclusion of perhumid). These climatic conditions coupled with rich fertile alluvial soils deposited by the rivers provide solid base to rice cultivation in this region. The Ganga-Brahmaputra delta is world famous for jute cultivation. Long growing period of 180-210 days provide ample scope for more than one crop.

16. The Eastern Himalayas. It includes Sikkim, Arunachal Pradesh and hilly areas of Assam. It is warm perhumid ecoregion with brown and red soils. The growing period over 210 days.

17. The North-Eastern Hills (Purvanchal). It spreads over the hills of Nagaland, Manipur, Tripura and Meghalaya. With average annual rainfall of 150-250 cm, this is the region of warm perhumid climate. Although the region has a long growing period of over 210, the red and laterite soils do not support much agriculture. Most of the area is covered by forests.

18. The Eastern Coastal Plain. It spreads over vast area along the east coast of the country from Subarnarekha river in the north to Kanniyakumari in the south. This coastal plain runs parallel to the direction of the south west monsoon originating in the Bay of Bengal and does not receive much rainfall. Therefore, this area has hot sub-humid to semi-arid climate. Big rivers like Mahanadi, Godavari, Krishna and Cauvery have formed large deltas of fertile alluvial soils. These deltas are famous for rice cultivation. There are large variations in agricultural calendar because the growing period varies from 90 to 210 days.

19. The Western Ghats and Western Coastal Plain. The Western Ghats run parallel to the west coast of India in a north-south direction and offers an effective obstruction in the way of the south-west monsoons originating in the Arabian sea. This results in copious rainfall of over 200 cm in the western coastal plains and on the western slopes of the Western Ghats. Thus this is an area of hot humid per-humid climate. It has laterile and alluvium soils. Heavy rains and alluvial soils coupled with long growing season of 90 to 210 days provide suitable conditions for rice cultivation.

20. The Islands of Andaman and Nicobar and Lakshadweep. The islands of Andaman and Nicobar are located in the Bay of Bengal and those of Lakshadweep are in the Arabian sea where hot humid to perhumid climate is found. These islands have red loaming and sandy soils and the growing period is over 210 days.

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CHAPTER 21

Green Revolution

INTRODUCTION

Green Revolution owes its origin in the finding of new dwarf variety of wheat seed by **Dr. Norman Earnest Borlaug**. He was incharge of Wheat Development Programme in Mexico in the 1950s and was the genetic architect of the dwarf wheat. Earlier, he and Dr. Hassar had conducted, in the late 1940s, most relentless breeding programme choosing the best of wheat genes in the world. His efforts at breeding a suitable dwarf variety were crowned with success by 1951 in Mexico and that country became self-sufficient in food by 1956. Later on, the Japanese wheat variety NORIN-10 was crossed with the Mexican improved varieties and the first break through came in 1961 when the Mexican farmers could obtain yields as high as 7,000 kg per hectare which was about $2^1/_2$ times the previous varieties. Green Revolution in rice was triggered off by intense upsurge in rice research resulting from the establishment of International Rice Research Institute (IRRI) at Manila. Some work on rice had been done in Taiwan also.

Although seeds of the Green Revolution were sown in early 1950s in Mexico, the term Green Revolution was first used by the then Administrator of the U.S. AID, **William S. Gadd** on 8 March, 1968 in Washington D.C. when he addressed the Society for International Development on the subject *Green Revolution—Accomplishments and Apprehensions*.

In India, the seeds of Green Revolution were first field tested in the drought year of 1964-65. They were introduced to the Indian scientists by **Dr. Borlaug** in 1963. He had predicted in 1961 that India could double her wheat production in one decade. India received 100 kg seeds each of four dwarf and semi-dwarf varieties. These seeds were planted in different soils in Delhi, Ludhiana, Pusa and Kanpur. The yield was over 4,000 kg per hectare which was about four times the yield of local varieties. These varieties were released for general cultivation after experimentation, multiplication and demonstrations by Indian scientists in about 100 different farmers' fields. In 1966, about 16,000 tonnes of seeds were imported for cultivating about 4 lakh hectares of land. High Yielding Varieties Programme (HYVP) was introduced in the kharif season of 1966. The production of foodgrains in 1967-68 was 25 per cent higher than that of 1966-67. This increase was more than the increase recorded in the preceding 16 years of plan period. This unprecedented increase in production was nothing less than a revolution and it was termed as *Green*

Revolution. In the words of **Dr. Hassar**, *The Green Revolution is the phrase generally used to describe the spectacular increase that took place during 1968 and is continuing in the production of foodgrains in India*. Unfortunately, Green Revolution left its impact only in Punjab, Haryana and Western U.P. in respect of wheat production and Andhra Pradesh and Tamil Nadu in respect of rice production. There seems to be no valid reason why other states cannot follow suit and get the benefit of Green Revolution. Sudhir Sen was quite justified when he said, *The Green Revolution is not a misnomer nor is it a fancy phrase; it is already much a reality. It has not only solved the food problem of India and other developing countries but it has brought the solid assurance that the problem can be solved. It has given them a breathing space in a period of spiralling population, to come to grips with the problem and set their economic house in order*.

INTENSIVE AGRICULTURE DEVELOPMENT PROGRAMME (IADP)

Popularly known as Package Programme, the IADP was taken up in 1961 and it paved the way to an *Adoption Breakthrough* for *Green Revolution* in India. It aimed at diffusing technical know-how, credit and agricultural technology to step up agricultural production in selected districts so that it may have demonstration effect. In the words of **R.N. Chopra**, "It was a historic decision which yielded solid results. The relevance of IADP experiment (1961-64) arises from the fact that it provided a crucial and much needed 'adoption breakthrough"—adoption of modern techniques of agricultural growth which, when coupled with the epoch-making '*biological breakthrough*, gave birth to the Green Revolution in India". The pilot project was launched first in 7 districts of 7 different states. Out of these, four were rice producing, two wheat producing and one millets producing. The districts were Shahabad in Bihar, Thanjavur in Tamil Nadu, Aligarh in U.P., West Godavari in Andhra Pradesh, Ludhiana in Punjab, Raipur in Chhattisgarh and Pali in Rajasthan. Later 8 more districts were selected for this programme. The programme was a grand success and increased new dynamism in the stagnant countryside. It was extended to a total of 114 districts in 1964-65.

According to **C. Subramaniam**, "It is one of the miracle stories of modern development that the allegedly backward tradition-bound Indian farmer has been so responsive to new technology. This has been in a large measure due to the poineering efforts of the IADP through which the package approach to agriculture was introduced." It is worth mentioning that 64 per cent of the growth in the output of foodgrains in the IADP districts was due to capital and knowledge (HYV seeds, fertilizers and pesticides, etc.) — *viz*., factors other than land and labour inputs.

COMPONENTS OF THE GREEN REVOLUTION

Following are the 12 components of the Green Revolution :

1. High Yielding Varieties (HYV) of seeds.
2. Irrigation (*a*) surface and (*b*) ground.
3. Use of fertilizers (chemical).
4. Use of insecticides and pesticides.
5. Command Area Development (CAD).
6. Consolidation of holdings.
7. Land reforms.
8. Supply of agricultural credit.
9. Rural electrification.
10. Rural roads and marketing.
11. Farm mechanisation.
12. Agricultural universities.

Some of the above mentioned components have already been discussed in the earlier chapters and will need little description, while some other components will be discussed in detail here.

It must be noted that majority of the components do not act in isolation, rather they are closely inter-related and heavily dependent upon one another. For example, HYV seeds are highly responsive to use of fertilizers and are equally vulnerable to pest attacks and growth of useless weeds. Their full potential cannot be developed without the requisite supply of water. The shorter maturing period enables the farmers to obtain more than one crop in a year from the same piece of land. This would require hastening of the harvesting operations so that land is quickly prepared for the second crop. This will require mechanisation of farming. In order to make optimum

use of the farm inputs, the farmer must know the *why, where, what, when and how much* of each for which there is ample scope.

1. High Yielding Varieties (HYV) of seeds. According to **R.N. Chopra**, "The high yielding variety seeds are major input of agricultural production under the Green Revolution technology. Their main characteristic is increased responsiveness to chemical fertilizers, their period of maturing is short, it helps double cropping; their short stems can easily carry fertilizer load, resist wind damage, their large leaf surface helps the process of photosynthesis." According to **Sunil Kumar Munsi**, "The HYV seeds were perhaps the single most important input in the Indian Green Revolution. All other inputs were linked with HYV." **M.S. Swaminathan** has remarked that apart from erasing the 'begging bowl' image of our country, the most important gain has been the saving of forests and land, thanks to the productivity improvement associated with high yielding varieties. The development of HYV seeds of wheat in 1960s and those of rice in 1969-70 laid the foundation for Green Revolution in India. Bandhu Das Sen has rightly remarked that they play the role of modernisers of agriculture like engines of change, capable of transforming a traditional farmer into a commercial producer. They act as part of steam engine (for industrial revolution) to ignite an agrarian revolution in poor countries. Thus the HYV programme brought about a major change—a transformation affecting almost every aspect of Indian agriculture. In words of Dantwala, "widespread adoption of HYVs has helped to step up cereal production, stimulated investment and substantially increased the use of modern inputs." The Pearson Commission Report hailed it as *one of the authentic marvels of our time*. Its most important effect was to be seen in the attainment of self-sufficiency in cereals, which enabled us to have a break from the *ship-to-mouth* situation and move forward ahead of population.

Details of seed production, distribution and use have been given in Chapter 20 and need not be repeated here.

2. Irrigation. Irrigation is the second most important component of Green Revolution technology after HYV seeds. Assured and regular supply of sufficient water to crops not only adds to production, it also assures stability in production. Indian rainfall being unreliable, irregular and seasonal, there is urgent need to expand irrigation potential to meet the requirements of the Green Revolution strategy. Irrigation is a pre-condition for successful introduction of HYV seeds even in areas of heavy rainfall. The success in use of HYV seeds lies in availability of water at the right time and in the right quantity for which **B.B. Vohra** had laid more emphasis on ground water rather than on surface water. The ground water gives the advantage of *push-button* irrigation, made possible by a pumpset or a tube well and is completely under farmer's own control. Appreciating the role of ground water in the success of Green Revolution, Vohra has preferred to call it the *Ground Water Revolution*. However, there is serious threat of depletion of ground water due to over-exploitation when the rate of drawl of ground water is higher than the rate at which it is replenished. In many districts of Haryana and Punjab, the ground water exploitation is very high.

The available potential, the growth and utilization of irrigation in India has been discussed at length in earlier chapters and need not be repeated here.

3. Use of Fertilizers (Chemical). The use of chemical fertilizers has been the third most important input of Green Revolution after HYV seeds and irrigation, *rather the three are tied together*. In fact use of HYV seeds needs heavy dose of irrigation and fertilizers to give high yields. Since the entire culturable land has already been brought under plough and there is practically no scope for bringing any new areas under cultivation, further increase in foodgrains production can be achieved only by multiple-cropping which heavily leans on the *trio* of the basic inputs, *viz*. HYV seeds, irrigation and chemical fertilizers.

To encourage balanced fertilizer use and make fertilizers available to farmers at affordable prices, the Central Government determines and notifies the selling price of urea as well as decontrolled P&K fertilizers. The current selling prices of urea and P&K fertilizers are less than the cost of production, the difference between the selling price and the cost of production as assessed by the government is borne as subsidy.

Although the use of fertilizers has considerably increased over the years, this increase is more prominent in areas where Green Revolution has shown its impact. In 1970, southern India was leading in consumption of fertilizers, but later on northern India, particularly, Punjab, Haryana and Uttar Pradesh, became the main consumers.

In spite of the fact that India is the third largest consumer of chemical fertilizers in the world, after the China and U.S.A., per hectare consumption still remains low compared to the world averages. This means that there is still large scope for using chemical fertilizers, increasing the yields and converting the dreams of Green Revolution into reality.

Details of production, distribution, import and utilization have been given in Chapter 20.

4. Use of Insecticides and Pesticides. Though intensive use of irrigation and fertilizers under the Green Revolution technology has increased the farm production, it has also given birth to the problem of pests, insects, weeds, rodents, etc. The monoculture promoted by the Green Revolution technology is more vulnerable to the insects and pests. These pests, weeds and diseases are to be checked by proper doses of insecticides, pesticides and weedicides. Pest surveillance should be an integral part of crop production. The first disease surveillance in this country related to wheat diseases in 1966-67 followed by ad hoc rice survey and surveillance of pests and diseases in 1970, 71 and 72. According to annual report of Ministry of Agriculture (1983-84), over 30 million hectares of cropped area in the country is affected by various pests and diseases, taking an annual toll of 5 to 25 per cent of the agricultural production. There has been a tremendous increase in the use of different types of biocides in the areas under plant protection. The regional distribution makes it clear that areas with Green Revolution technology are the main consumers of pesticides. For example, Punjab, Haryana, Andhra Pradesh and Tamil Nadu consumed over 60 per cent of the country's pesticides in 2013-14.

5. Command Area Development (CAD). Command Area Development Programme is a centrally sponsored scheme which was launched in January 1975. Its aim was to bridge the gap between potential created and utilized in selected major/medium irrigation projects of the country for optimising agricultural production from the irrigated land. The programme covers the following components :

(*i*) *On-farm development (OFD)* works which include soil surveys, land shaping, construction of field channels, field drains, farm roads, re-alignment of field boundaries (where possible consolidation of holdings should also be combined), introduction of *warabandi* to ensure equitable and assured supply of water to each and every farm holding, supply of all inputs and services including credit and strengthening of extension services.

(*ii*) Selection and introduction of suitable cropping pattern.

(*iii*) Development of groundwater to supplement surface water.

(*iv*) Development and maintenance of the main and intermediate drainage system.

(*v*) Modernisation, maintenance and efficient operation of the irrigation system upon the outlet of one cusec capacity.

Initially, 60 major and medium irrigation projects were taken up under CAD programme, covering a Culturable Command Area (CCA) of about 15 million hectares. After inclusion of new projects, deletion of completed projects and clubbing of some projects, there are now 149 projects under implementation. The programme was restructured and renamed as Command Area Development and Water Management (CADWM) programme with effect from 1st April, 2004. The scheme had been implemented as State-Sector Scheme during XI Five Year Plan (2008-09 to 2011-12).

6. Consolidation of Holdings. Small and fragmented land holdings have been one of the main obstacles in the progress of agriculture in India. Consolidation of holdings has been introduced to solve this problem. A detailed discussion on the reducing size of holdings, their fragmentation and consolidation thereof, has been given in Chapter 20.

7. Land Reforms. Immediately after Independence, it was felt that land reforms must be brought in to improve the agricultural situation in the country. Absentee landlordism, tenancy-at-will and share cropping could not help in inculcating interest among the farmers to make investments in farm inputs and adopt new farm technology. In 1947 half of India was under *Zamindari System* in which 80 per cent of the land was in the hands of the absentee landlords. The *Zamindar* used to exploit the farmers who used to till the land. Soon after Independence, the slogan of *land to the tiller* was raised and steps were taken for the abolition of the Zamindari. Consequently, tenants became owners of land. They started taking interest and pains to increase the farm production. *Raitwari* system prevailed in Madras, Bombay, Assam and Punjab. Under this system the peasant was the owner of land and paid rent directly to the Government. The rent was usually half of the net produce. A fixed amount of rent was to be paid irrespective of the condition of the crops. In the event of crop failure the peasant was obliged to pay rent by incurring debt against mortgage. Ultimately the land passed into the hands of the money lender who had no real interest in cultivation. *Mahotwari* was another system in which a chosen peasant (*Lambardar*) was responsible for depositing the rent varying from 40 to 70 per cent of the produce. These systems were to be abolished in the interest of better agricultural performance. Another measure taken by the government was the enforcement of land ceiling act. Under this act a farmer cannot own more land than the ceiling limits. This resulted in the re-distribution of surplus land which proved beneficial to lakhs of landless farmers. After obtaining the ownership rights, farmers worked whole-heartedly on their farms and this led to a tremendous increase in agricultural production. Dr. Randhawa has beautifully summed up the benefits of land reforms. According to him, "A stable and restructured rural base with an equitable tenurial system paved the way to Green Revolution and can be accredited with its blooming to the present stage."

8. Supply of Agricultural Credit. In the words of R.N. Chopra "Credit is the most crucial input in all agricultural developmental programmes. The other inputs *viz.*, technology, HYV seeds, fertilizers, pesticides, irrigation water and machinery—all depend on the availability of credit". A large percentage of Indian farming community consists of small and marginal farmers who do not have their own resources to invest in agriculture. They depend upon agricultural credit to carry on most of their agricultural operations. Earlier they used to get loan from the moneylender who used to charge very high rate of interest. Now Cooperatives, Commercial Banks and Regional Rural Banks extend loans to farmers on easy terms. The role played by diferent agencies in extending loan to farmers has been discussed in Chapter 20.

9. Rural Electrification. Rural electrification is one of the essential inputs in modern agricultural system. Electricity makes a significant contribution to development of agriculture. It is a cheap source of energy which can be used for lifting water by tubewells/pumpsets, processing and preserving agricultural produce, sprinkler irrigation and so many other farm operations. The development of ground water, so vital for Green Revolution, requires uninterruped supply of elctricity at cheaper rates.

Realising the importance of electricity for the proper growth and development of agriculture, a massive programme of rural electrification was taken up immediately after Independence. At the time of Independence only 1,300 villages had been electrified and only 6,400 energised pump sets were working in the entire country. Currently more than 95 per cent of the villages are electrified.

Haryana was the first state to electrify all its 6,759 villages in 1970. Punjab, Kerala, Andhra Pradesh, Karnataka, Gujarat, Himachal Pradesh, Tamil Nadu, J and K, Maharashtra and Nagaland have 97 to 100 per cent villages electrified.

10. Rural Roads and Marketing. Rural roads and marketing have already been discussed in Chapter 20. They constitute an important segment of infrastructure to improve agricultural productivity under the Green Revolution programme. Rural roads are very essential for connecting the villages to the neighbouring markets and villages. Unfortunately, there is still a big gap between the requirement and availability of village roads. Road network upto town level is fairly satisfactory. The weakest point is that of rural roads.

Marketing is essential for progressive agriculture. Regulated markets enable the farmer to sell his agricultural produce and to purchase farm implements and tools, fertilizers, pesticides and other agricultural inputs as well as goods of every day use. The farmer can go to the market with his produce, sell it and on his return journey he can bring the goods required for agriculture or in every day life. In this way the farmer can save on his return transport and avoid unnecessary waste of time, energy and money. Ideally speaking the market place should be within a distance of 5 km from the village. In the words of Leo E. Holman, "Marketing is the part and parcel of a modern productive process, the part at the end that gives point and purpose to all that had gone before. Benefits from mechanisation can be minimised if corresponding improvements are not made in the marketing system."

11. Farm Mechanisation. Much success of the Green Revolution depends upon farm mechanisation. Mechanisation saves a lot of human labour and quickens the farm operations, thereby adding to the farm efficiency and productivity. For a detailed account of farm mechanisation see Chapter 20.

12. Agricultural Universities. Agricultural universities and other agricultural institutes are primarily engaged in agricultural research and passing on the research findings to the farmers. A good deal of research and extension work done by these universities has paid rich dividends in the agricultural field. Success of Green Revolution largely depends upon the work done by these universities. Punjab, Haryana and Uttar Pradesh, are the best examples of such a progress.

IMPACT OF GREEN REVOLUTION

Like other developing countries, Green Revolution has influenced the economy and way of life in India to a great extent as is evident from the following points :

1. Increase in Agricultural Production. The introduction of Green Revolution in 1967-68 has resulted in phenomenal increase in the production of agricultural crops especially in foodgrains. From 1967 onwards, the *Green Revolution* aimed at bringing about a *Grain Revolution*. Among the food grains too, it is the wheat crop which drew maximum benefit from Green Revolution. The production of wheat increased 23.8 million tonnes in 1970-71 to 95.8 million tonnes in 2013-14 thereby recording over four time increase. while the overall increase in the production of foodgrains was about 2.5 times in the corresponding period. On account of this reason, it is said that the Green Revolution in India is largely the *Wheat Revolution*. The area production and yield of foodgrains were 115.10 million hectares, 72.35 million tonnes and 62.9 kg/hectare in 1965-66. The corresponding figures rose to 126.2 million hectares, 264.4 million tonnes and 2095 kg/hectare in 2013-14.

2. Diffusion of Rice and Wheat Cultivation to non-traditional areas. Since the success of the Green Revolution depends on the basic inputs like better seeds, fertilizers and irrigation, it has led to diffusion of crops, particularly two major food-crops *viz.* rice and wheat, to the areas hitherto unknown for their cultivation. For instance, West Bengal and Bihar had been traditional producers of rice and had the distinction of being called as 'rice heartland'. But the virtues of the Green Revolution have helped in spreading rice cultivation to semi-arid areas of Punjab, Haryana and western part of Uttar Pradesh, thereby changing the cropping pattern of these areas. This feat has been achieved primarily due to increase in irrigation facilities supplemented by availability of better seeds and fertilizers. However, contribution of enterprising farmers cannot be under-estimated. Besides, rice cultivation has become popular in vast areas in South India which were producing very little or not rice before 1965-66 (**Fig. 21.1**). The area production and yield of rice were 35.47 million hectares, 30.59 million tonnes and 862 kg/ha in 1965-66 and the corresponding figures increases to 43.9 million hectares, 106.3 million tonnes and 2419 kg/ha in 2013-14.

Similarly wheat cultivation has spread to vast areas in eastern Uttar Pradesh, Madhya Pradesh, Rajasthan, and some parts of Maharashtra, Gujarat and West Bengal. Although diffusion of wheat cultivation started from its heartland right with the beginning of the Green Revolution in the mid 1960s, yet the major part of diffusion in Uttar Pradesh, Madhya Pradesh, Rajasthan, Gujarat, Bihar and West Bengal was observed in 1970s (**Fig. 21.2**).

The area, production and yield of wheat were 12.57 million hectares, 10.40 million tonnes and 827 kg/ha in 1965-66 which rose to 31.3 million hectares, 95.8 million tonnes and 3,059 kg/ha in 2013-14 respectively. Thus, area, total production and yield per hectare recorded 2.4, 9.0 and 3.5 times increase respectively between 1965-66 and 2013-14. This is a great achievement indeed. However, much more has

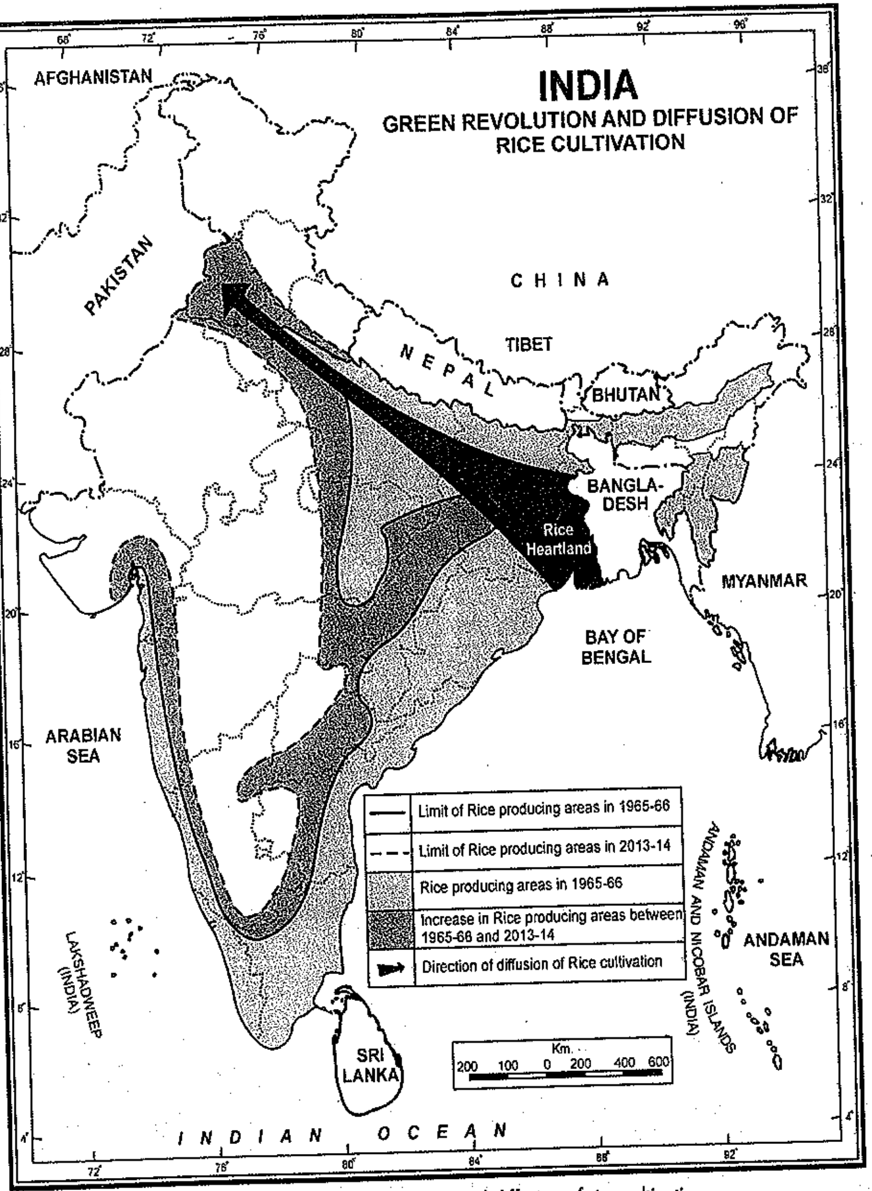

FIG. 21.1. India : Green Revolution and diffusion of rice cultivation.

to be done to meet our growing demand for foodgrains.

3. Prosperity of Farmers. With the increase in farm production the earnings of the farmers also increased and they became prosperous. This has, especially, been the case with big farmers having more than 10 hectares of land.

4. Reduction in import of foodgrains. The main benefit of Green Revolution was the increase in the production of foodgrains, as a result of which there

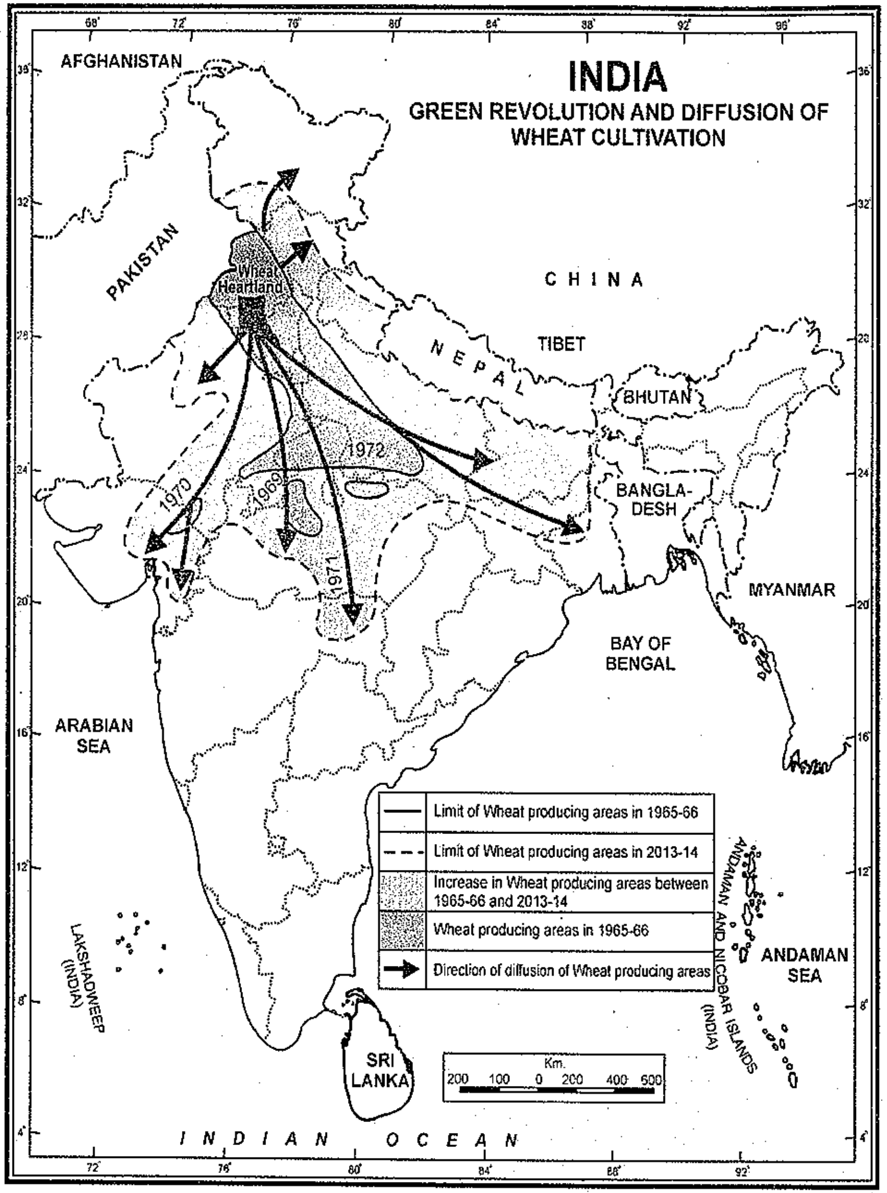

FIG. 21.2. India : Green Revolution and diffusion of wheat cultivation

was a drastic reduction in their imports. We are now self-sufficient in foodgrains and have sufficient stock in the central pool. Sometimes we are in a position to export foodgrains also. The per capita net availability of foodgrains has also increased from 408.1 grams per day in early 1966 to the level of 510.8 grams in 2013, this inspite of the rapid increase in population. In the words of **Dantwala**, *Green Revolution has*

given a breathing time. As a result, there will be relief from anxiety of food shortage and the planners will concentrate more on Indian planning.

5. Capitalistic Farming. Big farmers having more than 10 hectares of land have tended to get the maximum benefit from Green Revolution technology by investing large amount of money in various inputs like HYV seeds, fertilizers, machines, etc. This has encouraged capitalistic farming.

6. Ploughing back of profit. The introduction of Green Revolution helped the farmers in raising their level of income. Wiser farmers ploughed back their surplus income for improving agricultural productivity. This led to further improvement in agriculture. According to a study conducted by Punjab Agriculture University, Ludhiana farmers plough back about 55 per cent of their income for agricultural progress.

7. Industrial Growth. Green Revolution brought about large scale farm mechanisation which created demand for different types of machines like tractors, harvestors, threshers, combines, diesel engines, electric motors, pumping sets, etc. Besides, demand for chemical fertilizers, pesticides, insecticides, weedicides, etc. also increased considerably. Consequently, industries producing these items progressed by leaps and bounds. Moreover, several agricultural products are used as raw materials in various industries. These industries are known as *agro based industries*. Textile, sugar, vanaspati, etc. are some outstanding examples of agro based industries.

8. Rural Employment. While on one hand, large scale unemployment was feared due to mechanization of farming with the introduction of Green Revolution technology in India, there was an appreciable increase in the demand for labour force due to multiple cropping and use of fertilizers. According to Gobind Thukral, "Green Revolution has generated lakhs of new jobs in Punjab. Almost 15 lakh poor people from the impoverished regions of Bihar, eastern Uttar Pradesh and Odisha work here. They not only earn their bread and butter, but take back home new ideas and technology". As per findings of Bhalla and Chadha in respect of Punjab, "The drive towards mechanization was caused mainly by the scarcity of labour and relatively high wage rate especially during peak agricultural operations." During the early years of the Green Revolution, a large number of farm labourers had migrated from Bihar and eastern Uttar Pradesh to Punjab where they found better opportunities of earning a livelihood. However, reverse trend has been observed during 2010s as a large number of labourers from these areas are going back to their home state because they are now finding employment opportunities there caused by overall development including impact of Green Revolution.

9. Change in the Attitude of Farmers. The Indian farmer had remained illiterate, backward and traditional and had been using conventional methods of cultivation since the earliest times. But Green Revolution has brought about a basic change in his attitude towards farming. The way he has readily adopted the Green Revolution technology has exploded the myth that the Indian farmer is basically tradition bound and does not use new methods and techniques. Wolf Ladejinsky has rightly concluded that, "Where the ingredients for new technology are available, no farmer denies their effectiveness. The desire for better farming methods and a better standard of living is growing not only among the relatively small number of affluent farmers using the new technology, but also among countless farmers still from outside looking in."

DEMERITS OR PROBLEMS OF GREEN REVOLUTION

Green Revolution is a unique event in the agricultural history of Independent India. This has saved us from the disasters of hunger and starvation and made our peasants more confident than ever before. But it has its own inherent deficiency segments. Ever since its inception, the income gap between large, marginal and small farmers has increased, gap between irrigated and rainfed areas has widened and some crops have benefited more than the others, sometimes even at the cost of other crops. *It is neither product-neutral nor region-neutral and leaves uneven effects of growth on products, regions and classes of people.* This has given birth to a plethora of socio-economic problems. According to **Radha Krishna Rao**, "The spiraling prices of fertilizers, the tendency to use them frequently and the stagnant wheat and rice yields in Punjab and Haryana have combined to confirm that Green Revolution has reached ripened old age". The fatigue of the Green Revolution is already visible. Still the main lacuna in the Green Revolution is that up till now it is an unfinished task. Some of the demerits or problems of Green Revolution are briefly discussed as under :

1. Inter-Crop Imbalances. The effect of Green Revolution is primarily felt on foodgrains. Although all foodgrains including wheat, rice, jowar, bajra and maize have gained from the Green Revolution, it is wheat which has benefited the most. It has wrested areas from coarse cereals, pulses and oilseeds. The HYV seeds in latter crops have either not been developed so far at all, or they are not good enough for farmers to risk their adoption. Consequently, their cultivation is fast becoming uneconomic and they are often given up in favour of wheat or even rice. The result is that an excess of production in two main foodgrains (wheat and rice) and shortages in most others today prevail side by side. Major commercial crops like cotton, jute, tea and sugarcane are also almost untouched by the Green Revolution. This is not good for a balanced growth of Indian agriculture. Central Government has taken some steps to remove these imbalances.

2. Regional Disparities. Green Revolution technology has given birth to growing disparities in economic development at inter and intra regional levels. It has so far benefited only 40 per cent of the total cropped area and 60 per cent is still untouched by it. The most affected areas are Punjab, Haryana and western Uttar Pradesh in the north and Andhra Pradesh and Tamil Nadu in the south. The major benefit in these two regions has been with respect to increase in wheat and rice cultivation respectively (**Fig. 21.3**). It has hardly touched the Eastern region, including Assam, Bihar, West Bengal and Odisha and arid and semi-arid areas of Western and Southern India. In short, it failed to take care of areas like rainfed, hilly, coastal, dry and arid zones of the country which could be developed for production of exportable items like fruits, honey, mushroom, milk, meat, etc. In short, Green Revolution affected only those areas which were already better placed from agricultural point of view. Thus the problem of regional disparities has further aggravated as a result of Green Revolution. The ratio between the lowest and highest yield-rates among the states for the 1975-78 period amounted to 1 : 3.2 in paddy, 1 : 3.7 in wheat, 1 : 3.4 in cereals, 1 : 3.2 in pulses, 1 : 3.2 in food grains, 1 : 3.0 in oilseeds, 1 : 3.2 in sugarcane, 1 : 4.9 in cotton and 1 : 1.6 in jute. Study of some sample surveys recently conducted by the Indian Agricultural Statistics Research Institute (IASRI) revealed that the single most important factor is the '*input differential*' which alone can explain extreme yield variations even under similar physical and cultural conditions. According to a study by Bhalla and Alagh, 69 districts with a relatively high productivity levels account for 20 per cent of the cultivated area and 36 per cent of output, consume 44 per cent of fertilizers, employ 50 per cent of tractors and 45 per cent of irrigation pumps and have 38 per cent of India's gross irrigated area.

Regional disparities in crop yields can be reduced by evolving suitable disease resistant high-yield strains of paddy for most eastern parts and by developing irrigation facilities and a suitable dry farming technology for the arid and semi-arid western and southern regions.

3. Increase in Inter-Personal Inequalities. It has been observed that it is the big farmer having 10 hectares or more land, who is benefited the most from Green Revolution because he has the financial resources to purchase farm implements, better seeds, fertilizers and can arrange for regular supply of irrigation water to the crops. As against this, the small and marginal farmers do not have the financial resources to purchase these farm inputs and are deprived of the benefits of Green Revolution Technology. There were about 1,37,757 thousand holdings in India in 2010-11 out of which only 0.7 per cent exceeded 10 hectares in size. Francine R. Rankel has concluded from his study of Ludhiana (Punjab), West Godavari (Andhra Pradesh), Thanjavur (Tamil Nadu), Palghat (Kerala) and Bardhaman (West Bengal) that the greater beneficiaries are those farmers who own 10 to 12 hectares of land. Similar conclusion was drawn by **G.R. Saini** from his study of Ferozepur (Punjab) and Muzaffarnagar (U.P.). **G.S. Bhalla** and **G.K. Chadha** have found out that Green Revolution has benefited the farmers in general but one-third of them are small farmers with 2.5 acres (about one hectare) of land and are living below poverty line. Another 24.0 per cent of the farmers own 2.5 to 5.0 acres (1-2 hectares) of land and they are also living below poverty line. The land holdings

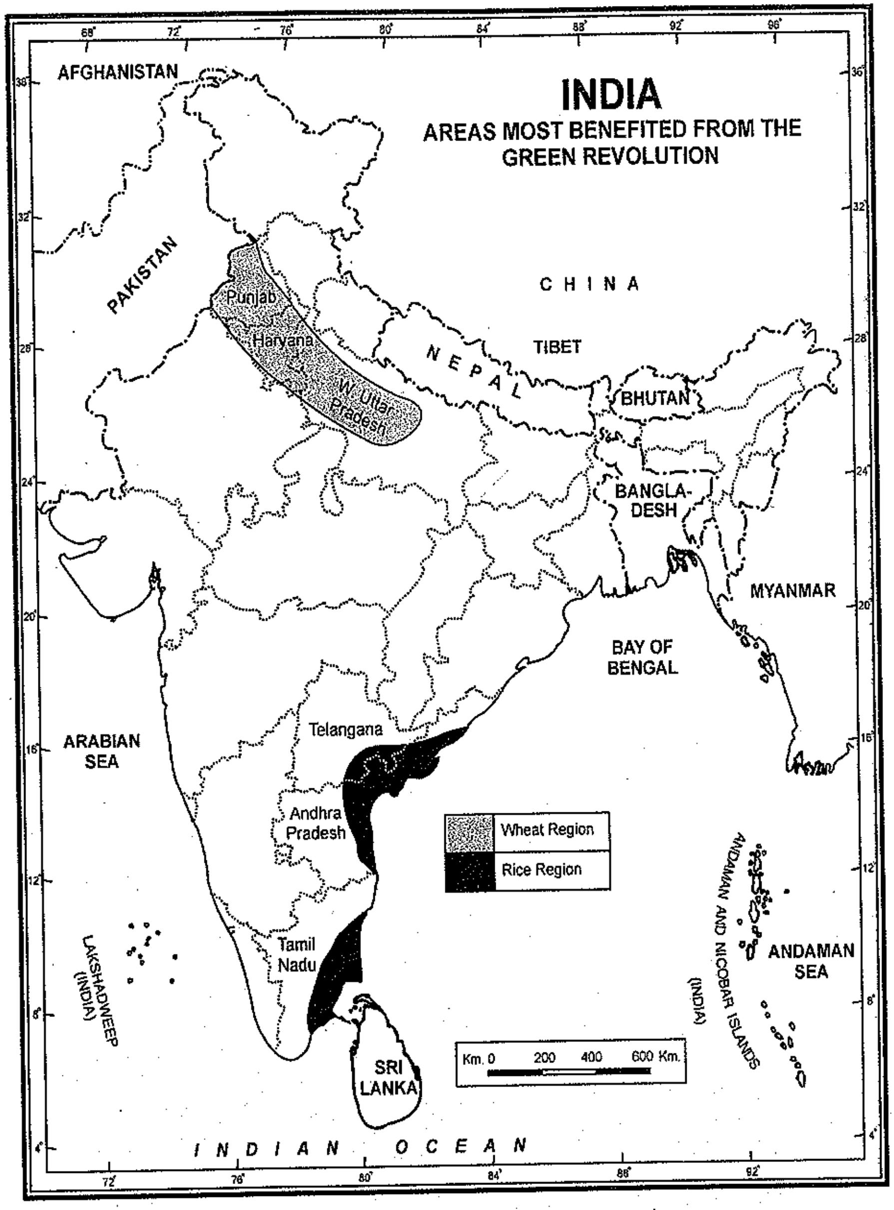

FIG. 21.3. Areas most benefitted from the Green Revolution

are generally small in rice producing areas and the economic position of the farmers living in those areas is extremely miserable. In short, Green Revolution has *made the rich richer and rendered the poor poorer resulting in wide-spread social and economic tensions.*

4. Unemployment. Except in Punjab, and to some extent in Haryana, farm mechanization under

Green Revolution has created widespread unemployment among agricultural labourers in the rural areas. The worst hit are the poor and the landless people.

5. Other Problems. Agriculture under Green Revolution has not grown at a rate which was expected in the beginning. The differential rates of growth of different crops and their regional variations have already been discussed. Some scholars have expressed serious doubts about the capability of HYV seeds itself. Analysing the role played by *miracle seeds* in the Green Revolution, Vandana Shiva says that the term HYV is a *misnomer*. In actuality, these seeds are highly responsive to certain key inputs such as fertilizer and irrigation and as such they should have been called highly *responsive* varieties. Shiva says that there is increasing evidence that the indigenous varieties could also be high yielding given the required doses of inputs. According to Shiva, "the inevitability of the Green Revolution option was built on neglecting the other avenues for increasing production that is more ecological such as improving mixed cropping systems, improving indigenous seeds and improving the efficiency of use of local resources." **Vandana Shiva** further comments that "having destroyed nature's mechanisms for controlling pests through the destruction of diversity, the 'miracle seeds' of the Green Revolution became mechanisms for breeding new pests and creating new diseases". In a case study of Punjab, **M.K. Sekhon** and **Manjeet Kaur** of P.A.U. Ludhiana have warned against the excessive use of groundwater, chemical fertilizers and pesticides. This will lead to large scale depletion of groundwater and will adversely affect the health of soil.

ECOLOGICAL IMPLICATIONS OF GREEN REVOLUTION

Apart from its socio-economic implications, Green Revolution has left a deep impact on various ecological aspects in different parts of the country. Some of the major ecological problems created by Green Revolution are soil salinity and alkalinity, waterlogging, desertification, soil erosion and degradation, deforestation, depletion of underground water, environmental pollution and health hazards. Some of the problems like soil salinity, water-logging desertification and soil erosion and degradation have already been described in Chapter 7 on soil, while some other problems are briefly discussed as under :

Deforestation. More cultivable land is needed to increase agricultural production and forests are the main victims as trees are felled recklessly to make more land available for agriculture. This leads to large scale deforestation which has its own ill effects on environment and ecology. Forests have been destroyed over vast areas in the northern plain of India to make room for agriculture. Punjab and Haryana, the Granary of India' are almost completely devoid of forests. These two states have 3.09 and 3.59 per cent of the total area under forests respectively. Uttar Pradesh is slightly better with just over 5 per cent of its area under forests. This has happened largely due to our quest for a more land to grow more food grains particularly wheat and rice.

Depletion of Underground Water. Success of Green Revolution primarily depends on the intensive use of HYV seeds which requires high input of irrigation. In semi-arid areas of Punjab, Haryana and western part of Uttar Pradesh, wheat cultivation largely depends on irrigation. Since canal irrigation is not sufficient to meet the growing demand, farmers depend heavily on tube well irrigation. Introduction of rice cultivation in these areas as a consequence of Green Revolution has put heavy strain on tube well irrigation. Farmers indulge in over exploitation of ground water resources which leads to depletion of ground water and fall in ground water-table. In some parts of north-west India (Punjab, Haryana and Uttar Pradesh) water table is falling at an alarming rate of one meter per year and it has gone critically low. It is apprehended that ground-water will dry up in due course of time if the present trend is not checked immediately.

Environmental Pollution. Success of Green Revolution is primarily based on use of HYV seeds which perform well only if other inputs like chemical fertilizers (NPK), insecticides and pesticides are also used. Fertilizers help in getting higher yields per hectare while insecticides and pesticides are used to save crops from insects, pests and diseases. Care has to be taken to use fertilizers, insecticides and pesticides upto a permitted limit. Indiscriminate use of these chemicals leads to environmental pollution. When insecticides are sprayed on the crops, some part

of it enters the surrounding air and pollutes it. Some of the chemicals enter the soil and destroy the micro-organisms. These micro-organisms are vital to maintain the fertility of the soil. Some of the chemicals enter water, are dissolved in it, and pollute both surface as well as ground water. Thus, it can be easily said that whereas chemical fertilizers, insecticides and pesticides have saved us from hunger and starvation, it has given birth to serious problems of environmental pollution.

Noise Pollution. Farm mechanisation is one of the important inputs for success of Green Revolution. Increasing use of tractors, harvesters, threshers, crushers etc. make lots of noise and disturb rural peace and tranquillity.

Health Hazards. Indiscriminate use of chemical fertilizers, insecticides and pesticides has resulted in a large number of health hazards. These chemicals pollute air, water and land and cause many ailments. Some of the poisonous chemicals enter our food chain through fruits and vegetables and result in ill health. According to Indian Council of Medical Research, traces of lead, zinc and copper are found in milk and vegetables due to use these chemicals on the crops. In areas of high irrigation intensity by canals and tube wells, in Punjab, Haryana, Rajasthan and western Uttar Pradesh, there are vast tracts of waterlogged areas which provide ideal conditions for mosquito breeding. These mosquitoes cause a large number of ailments including malaria, dengue and chikunguniya.

SECOND GREEN REVOLUTION

As mentioned earlier, the fatigue of the First Green Revolution has become conspicuous and the production as well yields of almost all the crops has reached the plateau stage. Declining productivity of a number of crops due to unsustainable agricultural practices over the years and a galloping rate of population growth have put a severe strain on the food supply situation in the country. The food safety net for our rapidly growing population requires enhanced production and productivity in the form of a Second Green Revolution. In fact, a Second Green Revolution has become imperative keeping in view the tardy growth of food grains in proportion to the population growth. Further, special attention is required for achieving higher production and productivity levels in pulses, oilseeds, fruits and vegetables which remained untouched in the First Green Revolution but are essential for our nutritional security. In this regard, achieving high production of poultry, meat and fisheries is also essential. The First Green Revolution also ignored certain areas like rainfed, hilly, coastal and arid zones which could be developed for producing fruits, milk and meat. Thus, a number of shortcomings have been noticed in the First Green Revolution and it is right time to strive for the Second Green Revolution. Even Norman Barlaug, the chief architect of the First Green Revolution noted upon receiving the 1970 Nobel Peace Prize, that the Green Revolution represented only a **"temporary success."**

The Second Green Revolution differs from the First Green Revolution because in the First Green Revolution the main emphasis was on increasing the production of food grains, often without much caring about environment and ecology. The Second Green Revolution on the other hand, refers to practising sustained agriculture. In order for development to be sustainable it must meet the needs of the present without compromising the ability of future generations to meet their own needs." (Brundtland Commission on Environment and Development, 1987). Thus sustainable agriculture involves protecting natural resources from becoming increasingly degraded and polluted, and using production technologies that conserve and enhance the natural resource base of crops, forests, in land and marine fisheries.

As of now, the outlook for a Second Green Revolution seems uncertain because most of the increase in food supplies has to come from currently cultivated land as all the land fit for cultivation has already been brought under plough using the current level of technology. Therefore raising the level of productivity will require new technologies and better farming practices. Besides green technologies will have to be specially focussed on dry land agriculture and to benefit small and marginal farmers. Improving soil health by taking care of physical, chemical and biological characteristics of soil is equally important. Also of vital concern are water harvesting, water conservation and sustainable and equitable use of water. Besides, there is need to pay more attention to issues such as access to affordable credit and to life and crop insurances reform. Equally important are development and dissemination of appropriate technologies and improved opportunities, infrastructure and regulations for marketing of agricultural products. Thus India is at a juncture where further reforms are urgently required to achieve greater efficiency and productivity in agriculture for sustaining growth.

Strategies for Second Green Revolution

Following strategies have been suggested for success of Second Green Revolution :

(*i*) **Micro-irrigation System.** All ground water and surface schemes having Culturable Command Area (CCA) upto 2,000 hectares individually are known as minor irrigation schemes. These include dug-wells, private shallow tube-wells, deep public tube-wells, boring and deepening of dug-wells and small surface water development works through diversion schemes, storage schemes and lift irrigation. The government has accepted the recommendations of the task force on micro-irrigation and has planned to make heavy investment in this field.

Micro-irrigation technology enables optimal synergies of three components of Green Revolution—improved seeds, water and fertilizers. It helps in direct and concentrated application of water to root zones of crops, through specially designed emitters. Some countries have already started using this technology for optimum use of water resources thereby improve their productivity. In India, the task force on micro-irrigation has recommended an increase of area under micro-irrigation from the current 1.3 million hectares to 69 million hectares.

(*ii*) **Organic Farming.** Ill effects of progress based on synthetic agrochemicals under Green Revolution have been documented several times by a large number of competent authorities. Their adverse effects on environment and public health are almost universally known now. The cost involved in minimising these effects is supposed to be enormous. Increasing consciousness about conservation of environment as well as health hazards caused by agrochemicals has brought major shift in consumer preference towards food quality, particularly in higher strata of society. Consumers are increasingly looking for safe and hazard free organic food. Globally, demand for organic food is increasing at the rate of 20-25 per cent per annum. Worldwide, over 130 countries produce certified organic products in commercial quantities. It is high time that India discards synthetic agrochemicals and opt for organic farming.

(*iii*) **Precision Farming.** As mentioned earlier, agriculture is the backbone of Indian economy and provides food to teeming millions. But the million dollar question is, how long our agriculture will be able to feed the fast growing population at the current level of technology. Agricultural technology available to us at the time of Independence could not have met our food requirements without First Green Revolution. Similarly, the present technology will not be able to produce sufficient food and other agricultural products in the coming future. Thus we will have to develop new technologies which can revolutionize our agricultural productivity and meet the growing demand for agricultural products.

The term "Precision Farming" and "Precision Agriculture" is capturing the imagination of the people concerned with the production of food, feed and fiber. It promises the scenario of increasing productivity, decreasing production costs and minimizing the adverse effects of farming on environment.

Precision farming is able to provide a new solution by using a systems approach for issues of the present day agriculture. The basic issue is to achieve balanced productivity with environmental concerns. The new approach is based on advance information technology which includes describing and modeling variations in soil and plant species, and integrating agricultural practices to meet site specific requirements. Its primary aim is to increase economic returns, reduce energy inputs and decrease adverse effect of agriculture on environment.

(*iv*) **Green Agriculture.** It is a system of cultivation which is based on integrated pest management, integrated nutrient supply, and integrated natural resource management systems. It does not exclude the use of minimum essential quantities of mineral fertilizers and chemical pesticides. It is widely practised and promoted in China and is likely to pick up in India in the near future.

(*v*) **Eco-agriculture.** Eco-agriculture has been defined as an approach that brings together agricultural development and conservation of biodiversity as explicit objectives in the same landscape. Its primary aim is to reinforce the mutual relationship between agricultural productivity and conservation of nature. It is capable of bringing together the most productive elements of modern agriculture, new ecological insights and knowledge of local people who have lived in harmony with nature for thousands of years.

(*vi*) **White Agriculture.** This system of agriculture is based on a substantial use of microorganisms, particularly fungi. The concept of white agriculture originated in China in 1986 and is picking up in India. In this contest, white refers to the white-coated scientists and technicians who perform high tech processes to produce food directly from micro-organisms or use them to improve green agriculture.

IMPORTANT CONSIDERATIONS FOR SECOND GREEN REVOLUTION

- More attention of the government and non-government organisations is needed towards agriculture.
- Benefits of research and development must reach the farmers at the ground level for increasing yields and agricultural production.
- Improvement of marketing by strengthening infrastructure.
- Soil health enhancement.
- Better irrigation and water conservation strategies.
- Access to affordable credit.
- Private public partnership and decentralization of partnership by the poor farmers in the development programmes.
- Food security to people living below poverty line (BPL), small and marginal farmers and landless labourers through the following three pronged strategy.
  - (*a*) Increase in income and agriculture wage by increasing farm productivity.
  - (*b*) Provision of additional off-farm and non-farm employment.
  - (*c*) Effective and strong public distribution system (PDS).
- Assured and remunerative marketing for farm products.

The future of the Indian agriculture largely depends upon our ability to increase the productivity, particularly of small holdings without much damage to environment and ecology so that the object of sustainable development is achieved. *Transforming green revolution into evergreen revolution using one or more than one method described above will usher in a win-win situation both for agriculture and ecosystems.* Extending the benefit of science and technology to areas and farmers that were ignored during the First Green Revolution combined with other facilities can enable us to achieve sustainable food security to all Indians.

Realising the gravity of situation with respect to agricultural production, population growth and food security, and appreciating the limitations of the First Green Revolution, the Government of India has initiated steps to usher in the Second Green Revolution. The Approach Paper to the Eleventh Five Year Plan (2007-12) has highlighted a holistic framework and suggested the following strategies to raise agricultural productivity :

1. Doubling the rate of growth of irrigated area.
2. Improving water management, rainwater harvesting, and watershed development.
3. Making efforts to reclaim degraded land and focusing on soil quality.
4. Bridging the knowledge gap through effective extension of information technology
5. Laying more emphasis on crop diversification and giving importance to high value outputs, *e.g.* fruits, vegetables, flowers, herbs and spices, medicinal plants, bamboo, bio-diesel, but with adequate measures to ensure food security.
6. Providing easy access to credit at affordable rate of interest.
7. Improving the infrastructure and functioning of markets.
8. Refocusing on land reforms issues.
9. Laying emphasis on the cultivation of pulses including hybrid varieties.

10. Focusing on the development of area specific seeds and their application.
11. Paying more attention to rainfed areas, drought-prone crops, and drought resistant, and those amenable to biotechnological application.

Bringing Green Revolution to Eastern India (BGREI). This is a sub-scheme of Rashtriya Krishi Vikas Yojna (RKVY) which was started in 2010-11. Its primary aim is to improve the rice based cropping system in the eastern states with the objective of increasing crop productivity through promotion of recommended agricultural technologies and package of practices. Presently this sub-scheme covers seven states of east India. These states are Assam, Bihar, Chhattisgarh, Jharkhand, Orisha, Eastern Uttar Pradesh and West Bengal. Focused efforts with scientific back-up approach led to record estimated production of 58.5 million tonnes of rice in implementing states during 2012-13 against average of 48.8 million for 2006-07 to 2010-11 (**Table 21.1**).

TABLE 21.1. Production of rice in seven eastern states under BGREI (Lakh tonnes)

State	Normal (2006-07 to 2010-11)	2010-11	2011-12	2012-13
1. Assam	38.63	47.37	45.16	45.81
2. Bihar	43.40	31.20	71.63	73.43
3. Chhattisgarh	56.26	61.59	60.28	66.68
4. Jharkhand	24.27	11.10	31.31	33.33
5. Odisha	69.89	68.28	58.67	74.82
6. Uttar Pradesh	117.60	119.92	140.22	141.26
7. West Bengal	143.29	130.46	146.06	149.72
Total for seven States	488.29	469.74	552.73	584.45
All India	948.61	959.70	1,053.01	1,042.16

Sources : India : A Reference Annual, 2014, p. 72.

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CHAPTER 22

Major Crops

With varied types of relief, soils, climate and with plenty of sun-shine and long growing season, India is capable of growing almost each and every crop. Crops requiring tropical, sub-tropical and temperate climate can easily be grown in one or the other part of India. Indian crops can be divided into following categories.

1. **Food Crops.** Rice, Wheat, Maize, Millets—Jowar, Bajra, Ragi; Pulses—Gram, Tur (Arhar).

2. **Cash Crops.** Cotton, Jute, Sugarcane, Tobacco, Oilseeds, Groundnut, Linseed, Sesamum, Castorseed, Rapeseed, Mustard, etc.

3. **Plantation Crops.** Tea, Coffee, Spices—Cardamom, Chillies, Ginger, Turmeric; Coconut, Arecanut and Rubber.

4. **Horticulture.** Fruits—Apple, Peach, Pear, Apricot, Almond, Strawberry, Walnut, Mango, Banana, Citrus Fruits, Vegetables.

FOOD CROPS

Agriculture forms the back-bone of Indian economy and food crops form the back bone of Indian agriculture. Food crops cover about three-fourths of the total cropped area in the country and contribute to about half of the total value of agricultural production. No part of the country is without food crops. They are grown in all parts of the country either as a sole crop in or combination with other crops. The importance of food crops grows with the growth of population because these crops provide the basic and essential food for man.

RICE

Rice is the most important food crop of India covering about one-fourth of the total cropped area and providing food to about half of the Indian population. This is the staple food of the people living in the eastern and the southern parts of the country, particularly in the areas having over 150 cm annual rainfall. There are about 10,000 varieties of rice in the world out of which about 4,000 are grown in India.

Rice is life for thousands of millions of people. In Asia alone, more than 2,000 million people obtain 60 to 70 per cent of their calories from rice and its products. Recognising the importance of this crop, the United Nations General Assembly declared 2004 as the "International Year of Rice" (IYR). The theme of

IYR—"*Rice is life*" reflects the importance of rice as a primary food source, and is drawn from an understanding that rice-based systems are essential for food security, poverty alleviation and improved livelihood.

Conditions of Growth

Rice is grown under varying conditions in India from 8° to 30° N latitude and from sea level to about 2,500 metre altitude. It is a tropical plant and requires high heat and high humidity for its successful growth. The temperature should be fairly high at mean monthly of 24°C. It should be 20°-22°C at the time of sowing, 23°-25°C during growth and 25°-30°C at the harvesting time. The average annual rainfall required for rice is 150 cm. It is the dominant crop in areas of over 200 cm annual rainfall and is still an important crop in areas of 100-200 cm rainfall. The 100 cm *isohyet* forms the limit of rice in rainfed areas. In areas receiving less than 100 cm annual rainfall, rice can be grown with the help of irrigation, as is done in Punjab, Haryana and western U.P. About 40 per cent of rice crop in India is raised under irrigation. However, it is the temporal distribution of rainfall, rather than the total amount of annual rainfall which is more decisive. The rainfall should be fairly distributed throughout the year and no month should have less than 12 cm of rainfall. Lesser amount of rainfall is required as the harvesting time approaches. The fields must be flooded under 10-12 cm deep water at the time of sowing and during early stages of growth. Therefore, the fields must be level and have low mud walls to retain water. This peculiar requirement of rice makes it primarily a crop of plain areas. Rice grown in well watered lowland plain areas is called ***wet*** or ***lowland rice***. In hilly areas, the hill slopes are cut into terraces for the cultivation of rice. Such a cultivation in which the hill slopes are cut into terraces is called ***terraced cultivation***. The supply of water to the hill terraces is not as much as in the plain areas and the rice grown in hilly areas is called ***dry*** or ***upland rice***.

Rice can be grown on a variety of soils including silts, loams and gravels and can tolerate acidic as well as alkaline soils. However, deep fertile clayey or loamy soils which can be easily puddled into mud and develop cracks on drying are considered ideal for raising this crop. Such soil requirements make *it dominantly a crop of river valleys, flood plains, deltas and coastal plains and a dominant crop there*. High-level loams and lighter soils can be used for quick maturing varieties of rice. Black lava soil is also useful for rice cultivation.

Rice culture is not much suited to mechanisation and is called ***'hoe-culture'***. Most of the work in preparing the seed-bed, in broadcasting seeds, or in transplantation of plants from nurseries to the fields, in harvesting and in winnowing operations is done by human hand. Thus it is a *labour intensive cultivation* and requires large supply of cheap labour for its successful cultivation. It is, therefore, primarily grown in areas of high population density which provide abundant labour and at the same time, offer ready market for its consumption. In most rice producing states, labour is locally available but in Punjab and Haryana, rice cultivation mainly depends upon the migrant labourers from Bihar and eastern U.P.

According to **G.B. Cressey** *rice needs plenty of heat, plenty of rain, plenty of alluvium and plenty of labour to provide plenty of food for plenty of people. There is no other food crop which is so plentiful as rice in India.*

Methods of Rice Cultivation

Following methods of rice cultivation are practised in India.

1. **Broadcasting method.** Seeds are sown broadcast by hand. This method is practised in those areas which are comparatively dry and less fertile and do not have much labour to work in the fields. It is the easiest method requiring minimum input but its yields are also minimum.

2. **Drilling method.** Ploughing of land and sowing of seeds is done by two persons. This method is mostly confined to peninsular India.

3. **Transplantation method.** This method is practised in areas of fertile soil, abundant rainfall and plentiful supply of labour. To begin with, seeds are sown in nursery and seedlings are prepared. After 4-5 weeks the seedlings are uprooted and planted in the field which has already been prepared for the purpose. The entire process is done by hand. It is, therefore, a very difficult method and requires heavy inputs. But at the same time it gives some of the highest yields.

TABLE 22.1. Rice Cropping Seasons in India

Crop	Local name	Sowing	Harvesting	Percentage of area	Percentage of Production
Autumn (Kharif)	Aus or Kar	May-June	Sept-Oct.	39.4	43.97
Winter (Rabi)	Aman, Sali or Karthika	June-July	Nov.-Dec.	54.2	48.79
Summer (Spring)	Boro or Dalua	Nov.-Dec.	March-April	6·4	7·24

4. Japanese method. This method includes the use of high yielding varieties of seeds, sowing the seeds in a raised nursery-bed and transplanting the seedlings in rows so as to make weeding and fertilizing easy. It also involves the use of a heavy dose of fertilizers so that very high yields are obtained. The Japanese method of rice cultivation has been successfully adopted in the main rice producing regions of India.

Rice Cropping Seasons

Rice is grown almost throughout the year in hot and humid regions of eastern and southern parts of India where two to three crops in a year are not uncommon. But in the northern and hilly parts of the country, the winters are too cold for rice cultivation and only one crop is grown in those areas. **Table 22.1** gives the period of sowing and harvesting the rice crop.

Production

India is the second largest producer and consumer of rice in the world after China and accounts for 17.95 per cent of the world's total rice production. **Table 22.2** gives the trends in production of rice for selected years. A look at this table shows that there has been considerable increase in production, area and yield of rice in India.

In a span of about six decades from 1950-51 to 2013-14, the area, production and yield have increased by about one and a half times, five and three and a half times respectively. It is interesting to note that the rate of increase in production is much higher than the rate of increase in area under rice cultivation. This is due to the increase in yields as a result of better inputs and farm practices. Thus, there has been a modest gain in extent of cultivated area but a substantial gain in yield and production. Increased irrigation facilities in drier areas, reclamation of waterlogged soils and introduction of new high-yielding strain crops (particularly in Punjab, Haryana and Tamil Nadu) made this possible. There was a record production of 106.3 million tonnes in 2013-14. Yield also reached at a high level of 2,419 kg/hectare.

In spite of the spectacular progress, our yield of 2,419 kg per hectare (2013-14) is much lower compared to 6,548 kg in China, 7,537 kg in U.S.A., 6,511 kg in Japan and 6,878 kg in Republic of Korea. This means that there is still vast scope for increasing production. This will have to be done by increasing yields because scope for increasing area under rice crop is negligibly small.

TABLE 22.2. Area Production and Yield of Rice in India

Year	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
Area (Million hectares)	30.81	34.13	37.59	40.15	42.69	44.71	43.91	45.54	41.92	42.86	44.01	42.41	43.9
Production (Million tonnes)	20.58	34.58	42.22	53.63	74.29	84.98	96.69	99.18	89.09	95.98	105.4	104.40	106.3
Yield (kg/hectare)	668	1013	1123	1336	1740	1901	2102	2178	2125	2239	2393	2462	2419

Source : (*i*) Agricultural Statistics at a glance, 2013, pp. 66-67.
(*ii*) Economic Survey 2013-14, Statistical Appendix, pp. 17, 18, 19

Distribution

Rice is grown in varying degrees in almost all parts of the country excepting higher parts of the Himalayan ranges exceeding 2,500 metres in altitude, Marusthali part of Rajasthan, Kachchh-Saurashtra, Malwa and Marathwada regions due to various geographical constraints. The premier rice producing areas include the lower and the middle Ganga Plains, the east and the west Coastal Plains, the Brahmaputra valley and parts of the Peninsular plateau. Punjab, Haryana and Uttar Pradesh have assumed considerable importance after the introduction of the Green Revolution. **Table 22.3** gives vital data about the statewise distribution of rice among the major producers.

It is clear that about half of rice production in India is contributed by four states namely W. Bengal, Uttar Pradesh, Punjab and Andhra Pradesh. The other major producers are Odisha, Bihar, Chhattisgarh, Assam, Tamil Nadu, Haryana, Karnataka, Jharkhand, Madhya Pradesh, Maharashtra, Gujarat and Kerala in order of importance.

1. West Bengal. West Bengal is the largest producer of rice in India contributing about 14.33 per cent of the total rice production from 12.8 per cent of the rice producing area of the country. Rice occupies three-fourths of the total cropped area in the lower Ganga Plains. Suitable climatic conditions and large scale alluvial deposits have helped in the cultivation of rice on such a scale. Over two-thirds of the production comes from Medinipur, Bardhaman, North and South Twenty Four Parganas, Bankura, Birbhum and West Dinajpur districts. The other producing districts are Haora, Hugli, Jalpaiguri, Coochbehar and Malda. As many as three crops called ***aman***, ***aus*** and ***boro*** are grown in a year. They account for about 78 per cent, 20 per cent and 2 per cent of the total production respectively.

TABLE 22.3. State-wise Area, Production and Yield of Rice in India (2012-13)

Sl. No.	State	Area		Production		Yield (kg/ hectare)
		Million hectares	%age of all India	Million tonnes	%age of all India	
1.	West Bengal	5.43	12.80	14.96	14.33	2,755
2.	Uttar Pradesh	5.86	13.82	14.41	13.80	2,459
3.	Punjab	2.85	6.72	11.37	10.89	3,989
4.	Andhra Pradesh including Telangana	3.49	8.23	10.91	10.45	3,126
5.	Odisha	4.03	9.50	7.64	7.32	1,896
6.	Bihar	3.25	7.66	7.34	7.03	2,258
7.	Chhattisgarh	3.78	8.91	6.61	6.33	1,749
8.	Assam	2.24	5.28	4.56	4.37	2,036
9.	Tamil Nadu	1.58	3.73	4.40	4.21	2,785
10.	Haryana	1.22	2.88	3.98	3.81	3,262
11.	Karnataka	1.27	2.99	3.28	3.14	2,583
12.	Maharashtra	1.55	3.65	3.04	2.91	1,961
13.	Jharkhand	1.35	3.18	3.03	2.90	2,244
14.	Madhya Pradesh	1.88	4.43	2.78	2.66	1,479
15.	Gujarat	0.70	1.65	1.50	1.44	2,143
16.	Kerala	0.20	0.47	0.53	0.51	2,650
	Others	1.73	4.08	4.06	3.89	@
	All India	**42.41**	**100.00**	**104.40**	**100.00**	**2,462**

@—Since area/production is low in individual states, yield rate is not worked out.
Source : Agricultural Statistics at a glance, 2013, p. 68.

2. Uttar Pradesh and Uttarakhand. Uttar Pradesh has recorded unprecedented progress in the production of rice during the last five decades. Earlier this state used to produce only 6 to 8 per cent of the country's rice but according to 2012-13 figures, Uttar Pradesh had 13.82 per cent of the country's rice producing area and accounted for 13.80 per cent of the total rice production of the country, thus occupying the second place among the top rice producing states. About one-fourth of the total cultivated area of the state is devoted to rice cultivation. The unusual interest shown by the farmers in the rice culture; supported by the easy availability of HYV seeds, fertilizers and uninterrupted supply of irrigation are the chief factors responsible for this progress. As many as 50 districts of the state are producing rice out of which 7 are major producers. The main producing districts are Dehra Dun, Gorakhpur, Bareilly, Muzaffarnagar, Kheri, Faizabad, Barabanki, Banda, Varanasi, Nainital, Pilibhit, etc.

3. Punjab. Punjab is traditionally a wheat producing state but the enterprising farmers of Punjab have made full use of package technology including perennial irrigation water by canals and tube wells, HYV seeds and fertilizers. This has resulted in widespread change in the cropping pattern of Punjab and the state has become the third important producer of rice in spite of its small size. Punjab now gives over 3,989 kg/hectare which is the highest yield for any state of India. It is far above the other traditional rice producing states and more than one and a half times the average yield of the country. Since 1953-54, Punjab has recorded an annual growth rate of over 12 per cent as against only 2.8 per cent for the country as a whole. As many as 12 districts of Punjab are producing rice but major part of production comes from Patiala, Firozepur, Ludhiana, Sangrur, Amritsar, Faridkot and Jalandhar.

4. Andhra Pradesh and Telangana. With over 10 per cent of the rice production and about 8.23 per cent of the rice area of the country, Andhra Pradesh is the fourth largest producer of rice in India. About one-fourth of the total cropped area of the state is under rice cultivation. The Godavari-Krishna Delta and the adjoining coastal plains form one of the most outstanding rice producing tracts of the country. The yields and production have increased considerably with the introduction of *Package Technology* (Green Revolution). In 2012-13, Andhra Pradesh recorded yield of 3,126 kg/hectare against India's average of 2462 kg/hectare. This is the third highest yield in India after that of Punjab (3,989 kg/ha) and Haryana (3,262 kg/ha). About 20 districts of Andhra Pradesh and Telangana are producing rice out of which West Godavari, East Godavari, Krishna, Guntur, Srikakulam, Nellore, Prakasam, Anantapur, Warangal and Chittoor are the major producers. In fact West Godavari, East Godavari and Krishna are three most important rice producing districts not only of Andhra Pradesh but of the whole of India and account for over 7 per cent of the total rice production of the country. In the neighbouring state of Telangana, Karimnagar, Nizamabad, Mehbubnagar, Nalgonda and Medak are important rice producing districts.

5. Odisha. Odisha produces over 7 per cent rice of India. Although about two-thirds of the total cropped area of Odisha is devoted to rice, the total production is low due to low yield of only 1,896 kg/hectare. Over 90 per cent of the state's rice comes from Sambalpur, Koraput, Ganjam, Cuttack, Puri, Bolangir and Mayurbhanja.

6. Bihar. Bihar has slipped from fourth position in 1990-91 to sixth position in 2012-13 among the rice producing states of India. This is partly due to increase in production in other states and partly due to carving of new state of Jharkhand out of Bihar. Although Bihar has 7.66 per cent of the rice area of the country and about two-thirds of the cultivated area of the state is under rice cultivation, the state produces only 7.03 per cent of the total rice of India. This is due to low average yield of only 2,258 kg per hectare against 2,462 quintals per hectare for the country as a whole. About 25 districts of Bihar are producing rice but the main producing districts are Rohtas, Bhojpur, Purnea, Paschim Champaran, Purab Champaran, Aurangabad, Gaya, Bhagalpur, Patna and Gopalganj.

7. Chhattisgarh. Chhattisgarh basin drained by the Mahanadi and its tributaries is the main rice producing region in this state. Although Chhattisgarh accounts for about 9 per cent of the rice area of the country, this state produces only 6.3 per cent of the country's total rice. This is primarily due to low yields of rice in this state. In fact the average yield of rice in Chhattisgarh is 1,749 kg/hectare only which

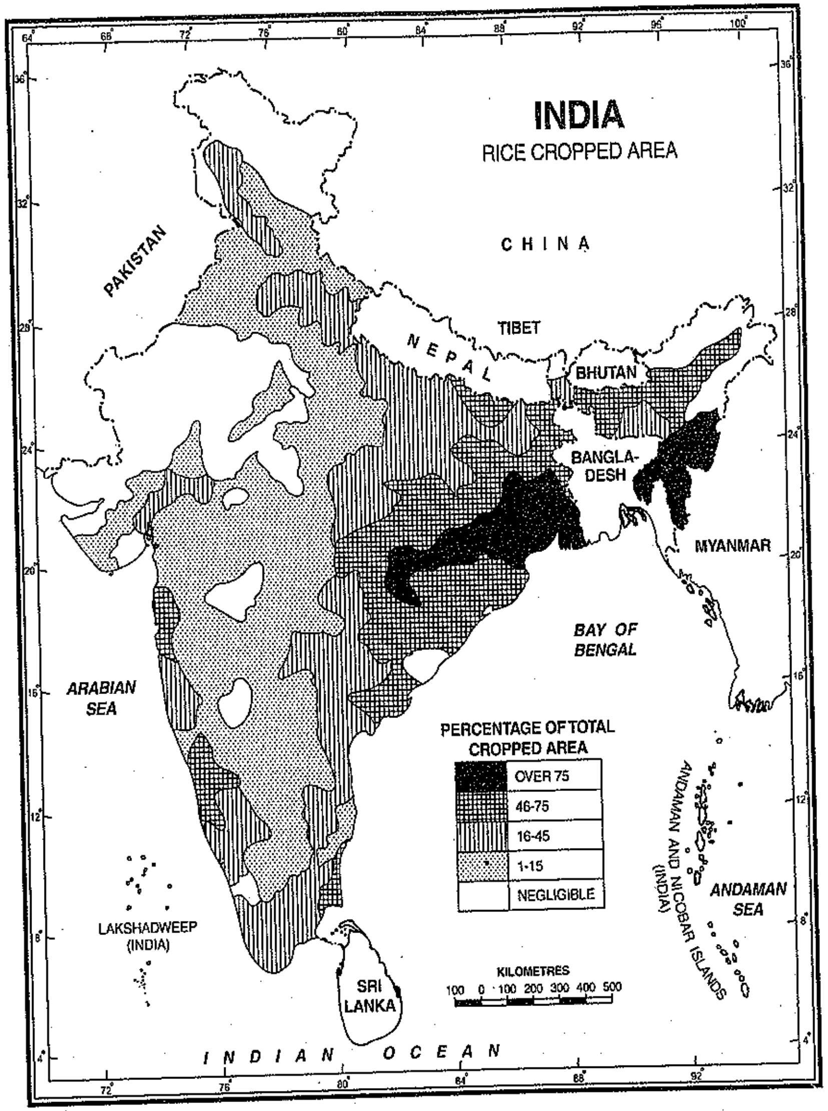

FIG. 22.1. India : Rice cropped area

happens to be one of the lowest in the country. Bastar, Durg, Raigarh, Sarguja, Rajnandgaon, Kankar, Dantewara, Bilaspur, Janjgir, etc. are the main rice producing districts.

8. Assam. Rice is grown on three-fourth of the cropped area of Assam. Most of the rice is produced in the Brahmaputra, Surma, and Barak valleys. Some rice is produced on the hill slopes by terraced cultivation. Kamrup, Sibsagar, Goalpara, Darrang, Nowgong and Cachar are the main producing districts.

9. Tamil Nadu. Although Tamil Nadu produces only 4 per cent rice of India, the state has the distinction of giving high yield of 2,785 kg/hectare. This is mainly due to the effect of Green Revolution under which HYV seeds, fertilizers and irrigation facilities have been made available to the farmers. About 37 per cent of the cropped area of this state is under rice cultivation. Thanjavur in the Cauvery delta is the second largest rice producing district of the country which produces about 2.8 per cent rice of India and accounts for about 25 per cent rice produced by the state. South Arcot Vallalar, North Arcot Ambedkar, Nellai Kattabomman (Tirunelveli), Tiruchirapalli, Perumpidugu, Muthuraiyar, Coimbatore, Ramnathpuram and Salem are the other important rice producers.

10. Haryana. Like Punjab, Haryana is traditionally a wheat producing state. But the cropping pattern has undergone an unprecedented change due to large scale extension of irrigation and provision of HYV seeds and chemical fertilizers, coupled with the progressive outlook of the Haryana farmers. Only a few years ago Haryana was not on the rice map of India but rapid progress during the last five decades has enabled Haryana to occupy an important place among the rice producing states of India. Haryana has a high yield of 3262 kg per hectare which is the second highest after that of Punjab. Kurukshetra, Karnal, Ambala, Kaithal, Panipat and Yamunanagar are the important rice producing districts.

11. Karnataka. Karnataka has made rapid progress in rice cultivation during the last few years. In Karnataka, rice is mainly grown in the valleys of the Wainganga, the Tungabhadra and the Cauvery and in the northern red soil areas. Tumkur, Dakshina Kannada, Shimoga, Mandya, Uttar Kannada, Mysore, Raichur and Kodagu are the main producers.

12. Maharashtra. Rice is grown in the Konkan coastal area, on the Ghats and in some eastern parts. Chandrapur, Raigad, Thane, Bhandara, Kolhapur, etc. are important rice producing districts.

13. Jharkhand. This state produces about three per cent rice of India. Ranchi, Paschim Singhbum, Purb Singhbum, Lohardaga and Gumla are the chief rice producing districts.

The other producers include Madhya Pradesh, Gujarat, Kerala, North Eastern hill states (Tripura, Manipur, Arunachal Pradesh, Mizoram, Sikkim), Himachal Pradesh, Jammu & Kashmir and Goa.

Trade

Large producers of rice are its large consumers also and there is little surplus for trade. However some interstate trade is carried on and about ten per cent of the total production enters trade. Punjab, Haryana, Tamil Nadu, Andhra Pradesh and Uttar Pradesh are surplus states and supply rice to deficit states like West Bengal, Maharashtra, Gujarat, Kerala and Delhi.

Even in the face of huge home consumption of rice, it is amusing to note that rice exports from India have grown steadily during the last decade (**Table 22.4**). India now occupies second position in rice exports, next only to Thailand, among the rice trading countries of the world. However, the surplus production scenario has no room for the complacency,

TABLE 22.4. Export of Rice from India

Year	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Basmati											
Quantity ('000 tonnes)	708.79	771.49	1163	1166.57	1045.73	1183.36	1556.41	2016.87	2370.68	3178.18	3456.52
Value ₹ crore	2058.47	1993.05	2823.90	3043.10	2792.81	4344.58	9477.03	10889.60	11354.77	15449.60	19391.31
Other than Basmati											
Quantity ('000 tonnes)	4255.08	2640.57	274.94	2921.60	3702.22	5286.08	931.89	139.54	100.68	3997.72	6663.66
Value ₹ crore	3772.77	4093.08	3615.1	31.78.17	4243.10	7410.03	1687.37	365.3	231.29	8669.13	14416.90

Source : Agricultural Statistics at a glance, 2013, pp. 244-45.

keeping in view the rapid growth of population, per capita availability of 188.8 grams/day as on 17-02-2012 and the vagaries of monsoon. It is estimated that the rice demand will be a whooping 140 million tonnes in 2025. This projected demand can only be met by maintaining steady increase in production over the years. In the post WTO (World Trade Organisation, 1995) era, adequate rice is be produced not only for self-sufficiency but also for export purposes. The exportable surplus of good quality rice is to be produced at the competitive price. Since India has got the comparative advantage in Basmati rices, all efforts are being made to increase the production and productivity.

Table 22.4 shows that export of Basmati rice has steadily increased both in terms of quantity and value of exports. Punjab, Haryana and western Uttar Pradesh produce some of the best qualities of Basmati rice for which there is great demand in the international market. However, exports of rice other than Basmati are not lagging behind.

WHEAT

Next to rice, wheat is the most important foodgrain of India and is the staple food of millions of Indians, particularly in the northern and north-western parts of the country. It is rich in proteins, vitamins and carbohydrates and provides balanced food.

Conditions of Growth

Conditions of growth for wheat are more flexible than those of rice. In contrast to rice, wheat is a rabi crop which is sown in the beginning of winter and is harvested in the beginning of summer. The time of sowing and harvesting differs in different regions due to climatic variations. The sowing of wheat crop normally begins in the September-October in Karnataka, Maharashtra, Andhra Pradesh, Madhya Pradesh and West Bengal; October-November in Bihar, Uttar Pradesh, Punjab, Haryana and Rajasthan and November-December in Himachal Pradesh and Jammu & Kashmir. The harvesting is done in January-February in Karnataka, Andhra Pradesh, M.P., and in West Bengal; March-April in Punjab, Haryana, U.P. and Rajasthan and in April-May in Himachal Pradesh and J&K. The growing period is variable from one agro climatic zone to other that effects the vegetative and reproductive period leading to differences in potential yield. The important factors affecting the productivity are seeding time and methodology, crop establishment and climatic conditions during the growing season.

Wheat is primarily a crop of mid-latitude grasslands and requires a cool climate with moderate rainfall. The ideal wheat climate has winter temperature 10° to 15°C and summer temperature varying from 21°C to 26°C. The temperature should be low at the time of sowing but as the harvesting time approaches higher temperatures are required for proper ripening of the crop. But sudden rise in temperature at the time of maturity is harmful.

Wheat thrives well in areas receiving an annual rainfall of about 75 cm. Annual rainfall of 100 cm is the highest limit of wheat cultivation. The isohyet of 100 cm marks the boundary between wheat growing areas on one hand and rice growing areas on the other. In areas of less than 50 cm annual rainfall, irrigation is necessary for its successful growth. In fact, wheat can be grown in areas with as little as 20-25 cm annual rainfall provided proper irrigation facilties are available. About 5 to 7 waterings are required in irrigated areas depending upon the amount of rainfall. While prolonged drought, especially in rainfed areas, at the time of maturity is harmfull, light drizzles and cloudiness at the time of ripening help in increasing the yield. Frost at flowering time and hail storm at the time of ripening can cause heavy damage to the wheat crop.

Although wheat can be grown in a variety of soils, well drained fertile, friable loams and clay loams are the best suited soils for wheat cultivation. It also grows well in the black soil of the Deccan plateau.

Wheat cultivation is an extensive type of farming which is highly mechanized and requires comparatively less labour. It is mainly grown in the flat alluvial plains of north India.

To sum up wheat requires a combination of factors including *cool climate with moderate rainfall, flat and well drained plain areas, fertile friable loam and heavy inputs in the form of irrigation, HYV seeds, fertilizers and mechanization.*

Production

India is the second largest producer of wheat in

TABLE 22.5. Area, Production and Yield of Wheat in India

Year	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Area (Million hectares)	9.75	12.93	18.24	22.28	24.17	25.73	26.48	27.99	28.04	27.75	28.46	29.07	29.86	29.65
Production (Million tonnes)	6.46	11.00	23.83	36.31	55.14	69.68	69.35	75.81	78.57	80.68	80.80	86.87	93.90	92.46
Yield (kg/hectare)	663	851	1307	1630	2281	2708	2619	2708	2802	2907	2839	2988	3140	3118

Source : Agricultural Statistics at a glance, 2013, pp. 69-70.

the world next only to China, and accounts for 12.39 per cent of the total production of wheat in the world.

Wheat is grown on 13 per cent of the cropped area of India. **Table 22.5** shows the production trends of wheat in India.

It is clear from the table that all the three aspects of the crop *i.e.* production, area and yield have recorded rapid growth particularly after the introduction of the Green Revolution strategy in 1967. The production had more than doubled from 11 million tonnes in 1960-61 to 23.83 million lakh tonnes in 1970-71. During the same period the area under wheat had increased by over 41 per cent and yield had increased by 53.6 per cent. The development of new varieties of seeds has brought about a real revolution in wheat production. The phenomena of overall development in wheat farming is still continuing although the pace of progress has slowed down with Green Revolution reaching its mature stage. In spite phenomenal improvement in wheat culture in India, our yield of 3,140 kg/hectare (2003-04) is still very low as compared to that of some other wheat producing countries China, France, Germany, Kazakhstan, Egypt and Italy. It is estimated that yield can be raised upto 4,000 kg/hectare in irrigated areas and upto 2,000 kg/hectare in unirrigated areas by using appropriate location specific technology including better quality seeds, proper fertilizers and control of weeds, pests and diseases. Further, there is vast scope for extending wheat cultivation to non-traditional areas like Assam valley and in Odisha. This can be done by timely harvest of the kharif crops and by reducing the extent of fallow land. West Bengal has already started growing wheat in sufficient quantity.

Distribution

Wheat production is mainly confined to North-Western parts of the country. Table 22.6 gives the distribution pattern of wheat in India.

Uttar Pradesh, Punjab and Madhya Pradesh and Haryana are the four prominent wheat producing states. These states account for over three-fourths of the wheat area and produce about three-fourths of the total wheat production in India. In fact, Punjab, Haryana and the contiguous western parts of U.P. have earned the distinction of being called the '*Granary of India*'. The other major wheat producing states are Rajasthan, Bihar and Gujarat.

1. Uttar Pradesh. Uttar Pradesh is the largest wheat producing state of India accounting for about one-third of area and production of wheat of the country. In 2012-13, this state produced 30.3 million tonnes of wheat. Fine alluvial soil deposited by the mighty Ganga and its several big and small tributaries and a close network of canals, supplemented by large number of tube wells have helped U.P. to occupy the top position. More than half of the wheat area lies in the Ganga-Ghagra doab. Next in importance is the Ganga-Yamuna doab. These two doabs account for about 75 per cent wheat of U.P. About 55 districts of Uttar Pradesh produce wheat out of which 43 are the important producers. Saharanpur, Muzaffarnagar, Meerut, Moradabad, Rampur, Budaun, Etawah, Hardoi, Bahraich, Kheri, Gonda, Basti, etc. are the main producing districts. However, wheat production to the east of Varanasi declines due to high rainfall and heavy soils.

2. Punjab. Although very small state as compared to Uttar Pradesh, Punjab has emerged as a very important producer of wheat in India. The Green Revolution strategy has helped Punjab in making rapid strides in wheat production. In fact, *Punjab has drawn maximum benefit from Green Revolution and in Punjab too it is the wheat crop which has been benefited the most.* The excellent irrigation system

TABLE 22.6. Area, Production and Yield of Wheat in India (2012-13)

State	Area		Production		Yield
	Million hectares	%age of all India	Million tonnes	%age of all India	(kg/ hectare)
1. Uttar Pradesh	9.73	32.82	30.30	32.77	3114
2. Punjab	3.52	11.87	16.11	17.42	4577
3. Madhya Pradesh	5.30	17.88	13.13	14.20	2477
4. Haryana	2.50	8.43	11.12	12.03	4448
5. Rjasthan	2.82	9.51	8.95	9.68	3174
6. Bihar	2.22	7.49	5.38	5.82	2423
7. Gujarat	1.05	3.54	3.14	3.40	2990
8. West Bengal	0.32	1.08	0.91	0.98	2844
9. Maharashtra	0.59	1.99	0.88	0.95	1492
10. Uttarakhand	0.36	1.21	0.84	0.91	2333
11. Himachal Pradesh	0.36	1.21	0.54	0.58	1500
12. Jammu and Kashmir	0.30	1.01	0.42	0.45	1400
13. Jharkhand	0.16	0.54	0.27	0.29	1688
14. Karnataka	0.23	0.78	0.17	0.18	739
15. Assam	0.05	0.17	0.06	0.06	1200
Others	0.14	0.47	0.24	0.26	@
All India	**29.7**	**100.0**	**92.5**	**100.0**	**3118**

@ Since area/production is low in individual states, yield rate is not worked out.

Source : Agricultural Statistics at a glance, 2013, p. 71.

provided by a close network of canals and the tube wells is supplemented by light rainfall associated with the *western disturbances*. The fertile alluvial soil brought by the rivers of the Indus system is ideal for wheat production. Over and above, the Punjab farmer is very enterprising and is always willing to adopt the new farm technologies. Punjab accounts for about 17.42 per cent of the wheat production and 11.88 per cent of wheat area of India.

This state gives the highest yield of 4577 kg/ha. In 2012-13, Punjab produced 16.11 million tonnes of wheat, thus occupying second position among the major wheat producing states of India. Punjab has 12 leading wheat producing districts. Jalandhar, Ludhiana, Sangrur, Bhatinda, Amritsar, Firozepur, Faridkot, Mansa, Kapurthala, Fatehgarh Sahib, Rupnagar and Patiala are the main producing districts. The state has a large surplus and contributes a lot of wheat to the central pool.

3. Madhya Pradesh. Madhya Pradesh is the third largest wheat producing state and accounts for over 14 per cent of the total production of India. The state has nearly 5.3 million hectares of land under wheat cultivation. This is an indication of low yield which is only 2477 kg/hectare. Steps have to be taken to increase the yield so that the state occupies a prestigious position among the wheat producing states of India. Sagar, Vidisha, Tikamgarh, Morena, Sehore, Gwalior, Guna, Satna, Bhind and Chhatarpur are important wheat producing districts.

4. Haryana. The physical and human conditions for wheat cultivation in Haryana are the same as those prevailing in Punjab, although to a lesser degree. The impact of Green Revolution is clearly visible in Haryana also. Presently, Haryana accounts for about 8.43 per cent of the wheat area of India and produces over 12 per cent of the total wheat of the country after that of Punjab. The yield 4448 kg/hectare is the

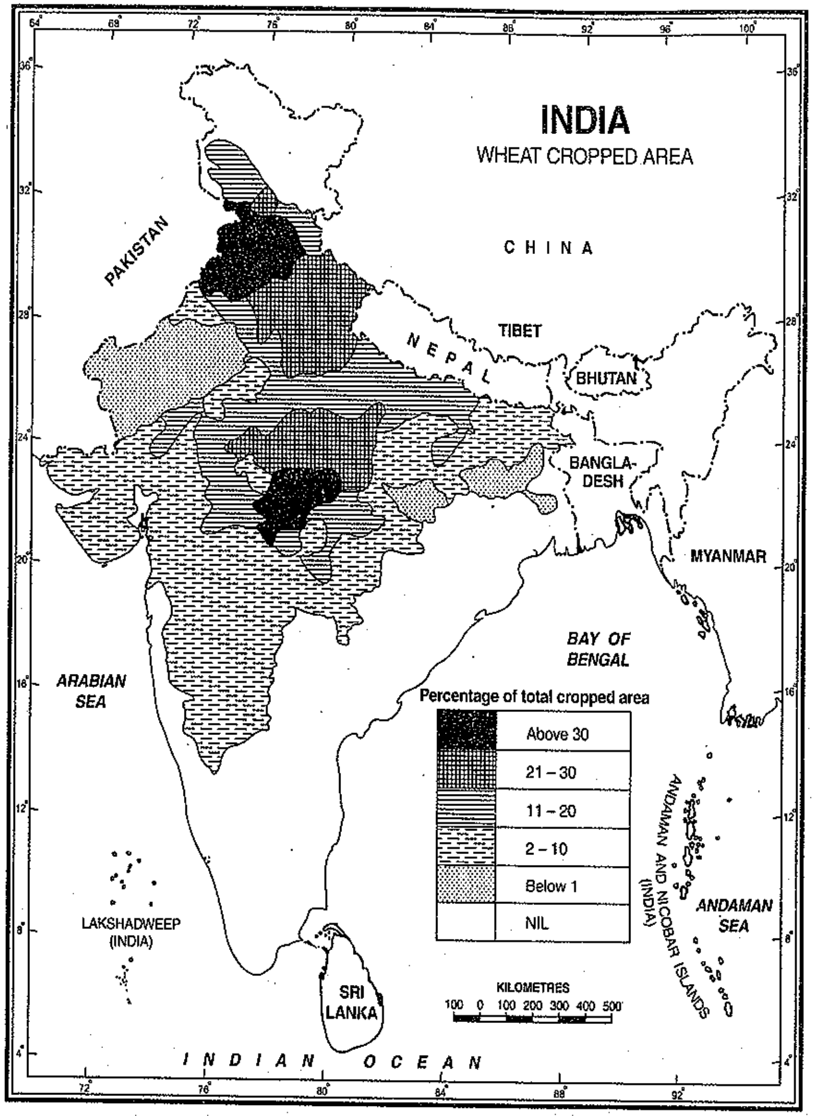

FIG. 22.2. India : Wheat cropped area

second highest in the country after that of Punjab. Karnal, Kurukshetra, Ambala, Kaithal, Panipat, Sonipat, Rohtak, Jind, Hisar, Sirsa, Fetehbad and Gurgaon are important producing districts.

5. Rajasthan. Vast stretches of sandy desert, scarcity of rainfall and paucity of irrigation facilities have been restricting wheat cultivation in Rajasthan since long. But some of the irrigation projects initiated after Independence, especially the Indira Gandhi Canal, have brought about considerable improvement in the cropping pattern of the state. Currently, Rajasthan accounts for 9.68 per cent of the total wheat production and 9.51 per cent of wheat area of India. Over 20 districts are producing wheat and 11

are major producers. Ganganagar, Hanumangarh, Bharatpur, Kota, Alwar, Jaipur, Chittaurgarh, Tonk, Sawai Mandhopur, Udaipur and Pali are important wheat producing districts of Rajasthan.

6. Bihar. Bihar accounts for 5.8 per cent of wheat production and about 7.5. per cent of wheat area of India with a low yield of 2423 kg/hectare. This means that there is need to improve the situation with respect to yields. Most of the wheat is produced in the *North Bihar Plain*. Rohtas, Bhojpur, Saran, Nalanda, Paschim and Purba Champaran, Siwan and Begusarai are the main districts.

Others. Gujarat, West Bengal, Maharashtra, Uttarakhand and Himachal Pradesh are the other important producers of wheat in India. In *Gujarat*, wheat is mainly produced in Mahi and Sabarmati valleys. Mahesana, Junagadh, Bhavnagar, Amreli, Bharuch, Rajkot and Kheda are important wheat producing districts. In *Maharashtra*, wheat is produced in the valleys of the Wardha, Tapi, Godavari, Bhima, Purna and Krishna. *West Bengal* has made significant progress both in area and production of wheat with the introduction of new technology. Most of the production comes from Birbhum, Burdwan, Murshidabad and Nadia districts. In Uttarakhand, most of the wheat production comes from river valleys. In *Himachal Pradesh* wheat is produced mainly in Kangra, Mandi, Sirmaur and Una districts. Srinagar, Baramula, Doda Anantnag, Jammu and Punch are the main producers in *Jammu* and *Kashmir*. Some wheat is also produced in Bijapur, Raichur, Belgaum and Dharwar districts of *Karnataka*.

Trade

About one-third of the total production of wheat enters trade. Punjab, Haryana, Uttar Pradesh, Rajasthan and Madhya Pradesh are surplus states and supply wheat to deficit states like Maharashtra, West Bengal, Bihar and the Union Territory of Delhi. India is both an importer and an exporter of wheat depending on the domestic production and requirement.

MAIZE

Maize is an inferior grain which is used both as food and fodder. Its grain provides food and is used for obtaining starch and glucose. Its stalk is fed to cattle.

Conditions of Growth

Maize can be grown under varied climatic and soil conditions. Maize is mainly a rainfed kharif crop which is sown just before the onset of monsoon and is harvested after retreat of the monsoon. In Tamil Nadu it is a rabi crop and is sown a few weeks before the onset of winter rainy season in Sept. and Oct. It requires 50-100 cm of rainfall and it cannot be grown in areas of more than 100 cm rainfall. In areas of lesser rainfall, the crop is irrigated. For example, more than half of the maize area in Punjab and Karnataka is irrigated. Long dry spell during the rainy season is harmful for maize. Sunshine after showers is very useful for maize. Cool and dry weather helps in ripening of the grain. This crop usually grows well under temperatures varying from 21°C to 27°C, although it can tolerate temperatures as high as 35°C. Frost is injurious to maize and this crop is grown only in those areas where there are about four and a half frost free months in a year. Fertile well-drained alluvial or red loams free from coarse materials and rich in nitrogen are the best soils for its successful growth. Well drained plains are best suited for its cultivation, although it grows in some hilly areas also. The cultivation of maize in India is characterised by *inter-culture i.e.* along with and in pulses, vegetables and oil seeds.

Production

Maize is an important cereal of India and is grown over 4 per cent of the net area sown of the country. There have been large variations in the production of maize in India since Independence. It was only 1.7 million tonnes in 1950-51 which rose to 4.1 million tonnes in 1960-61 and 7.5 million tonnes in 1970-71. Thereafter, variable trends in maize production had been observed till 1995-96. However, production of maize increased rapidly from 9.53 million tonnes in 1995-96 to 22.23 in 2012-13. Thus production of maize in India more than doubled within a short span on nearly one and a half decade. **Table 22.7** gives production figures for maize with respect to some selected years.

Distribution

Table 22.8 shows that two-third of the maize is produced in states of Andhra Pradesh (including Telangana), Karnataka, Bihar, Maharashtra and

TABLE 22.7. Area, Production and Yield of Maize in India

Year	1950 -51	1960 -61	1970 -71	1980 -81	1990 -91	1995 -96	2000 -01	2005 -06	2006 -07	2007 -08	2008 -09	2009 -10	2010 -11	2011 -12	2012 -13
Area (Million hectares)	3.16	4.41	5.85	6.01	5.90	5.98	6.61	7.59	7.89	8.12	8.17	8.26	8.55	8.78	8.71
Production (Million tonnes)	1.73	4.08	7.49	6.96	8.96	9.53	12.04	14.71	15.10	18.96	19.73	16.72	21.73	21.76	22.23
Yield (kg/hectare)	547	926	1279	1159	1518	1595	1822	1938	1912	2335	2414	2024	2542	2478	2552

Source : Agricultural Statistics at a glance, 2013 pp. 81-82.

Rajasthan. In **Andhra Pradesh** and **Telangana**, the plateau region of Telangana and some parts of Seemandhra are well known for maize cultivation. Nizamabad, Medak and Karimnagar are important maize producing districts. More than one-third of the crop is raised irrigated and almost entirely with HYV seeds. **Karnataka** is the second largest producer contributing about 15 per cent of the total maize production of India. This is followed by Maharashtra (10.48). In fact Karnataka, Telengana and Andhra Pradesh have recently emerged as important producers of maize. Belgaum, Chitradurga, Bijapur, Kolar, Bengaluru and Mysore are the important maize producing districts in Karnataka. In In **Maharashtra**, districts of Solapur, Dhule and Osmanabad are important producers. The arid lands of **Rajasthan** are

TABLE 22.8. Distribution of Area, Production and Yield of Maize in India (2012-13)

States	Area		Production		Yield
	Million hectares	%age of all India	Million tonnes	%age of all India	kg/hectare
1. Andhra Pradesh	0.97	11.14	4.81	21.64	4959
2. Karnataka	1.31	15.04	3.43	15.43	2618
3. Bihar	0.69	7.92	2.33	10.48	3377
4. Maharashtra	0.84	9.64	1.82	8.19	2167
5. Rajasthan	0.99	11.37	1.76	7.92	1778
6. Madhya Pradesh	0.85	9.76	1.51	6.79	1776
7. Uttar Pradesh	0.74	8.5	1.23	5.53	1662
8. Tamil Nadu	0.33	3.79	1.19	5.35	3606
9. Gujarat	0.48	5.51	0.84	3.78	1750
10. Himachal Pradesh	0.28	3.21	0.63	2.83	2250
11. Jammu & Kashmir	0.31	3.56	0.51	2.29	1645
12. West Bengal	0.11	1.26	0.42	1.89	3818
13. Jharkhand	0.23	2.64	0.39	1.75	1696
14. Punjab	0.13	1.49	0.23	1.03	1769
Others	0.45	5.17	1.13	5.08	@
India	**8.71**	**100.00**	**22.23**	**100.00**	**2552**

@ Since area/production is low in individual states, yield rate is not worked out.

Source : Agricultural Statistics at a glance, 2013, p. 83.

specially suited to maize cultivation where it is grown in Udaipur, Bhilwara, Dungurpur, Chittaurgarh and Banswara districts. This state gives one of the lowest yields among all the major maize producing states of India. At one stage, **Bihar** was the largest producer of maize but this state has lost much of its importance as a major maize producer in the country. Almost all the districts of the north Ganga plain produce maize but the major production comes from Samastipur, Begusarai, Bhagalpur, Purnea, Purbi Champaran and Siwan districts. The Upper Ganga Plain of **Uttar Pradesh** is an important producer of maize in the state. In Uttar Pradesh, maize is grown in as many as 25 districts but Bulandshahar, Jaunpur, Ghaziabad, Bahraich, Farrukhabad and Gonda are the main producing districts. Tamil Nadu accounts for a bulk over five per cent maize of India. In **Madhya Pradesh,** most of the production comes from Madhya Bharat Pathar, with Indore, Ratlam, Dhar, Mandspur, Dewas, Ujjain and Jhubia as the main producing districts. The geographical conditions are not much favourable for the cultivation of maize and the state gives one of the lowest yield of 1776 kg/ha in India. In **Gujarat**, Mahsana, Banaskantha, Rajkot and Kheda districts in the valleys of the Sabarmati and Mahi rivers are the main producers and together contribute over 55 per cent of the state's production.

The hilly areas of **Himachal Pradesh** are also well suited to maize cultivation. Kangra, Mandi, Sirmaur and Chamba districts occupy an important position in the production of maize.

Among the other producers Odisha, Jammu and Kashmir, Punjab, Chhattisgarh, Jharkhand and West Bengal. In Punjab, cultivation of maize has given place to other kharif crops and its production has drastically fallen from 7 lakh tonnes in 1977-78 to 4.1 lakh tonnes in 2011-12. Still Jalandhar, Kapurthala, Rupnagar, Ludhiana, Amritsar, Faridkot and Patiala are important maize producing districts.

MILLETS

Millets are short duration (3-4 months) warm weather grasses grown in those inferior areas where main food crops like rice and wheat cannot be successfully grown. They provide food for the poor people and fodder for cattle. *Jowar, bajra, ragi, korra, kodon, kutki, sanwa, haraka, varagu, bauti*, and *rajgira* are some of the important millets grown in India.

JOWAR (SORGHUM)

Jowar plays a significant role in feeding the teeming poor millions in the rural areas of India. **Dr. Voelkar** has spoken very highly of nutritive value of jowar as a fodder.

Conditions of Growth

Jowar is grown both as *kharif* as well as a *rabi* crop. As a *kharif* crop, it grows well in areas having mean monthly temperature of 26°C to 33°C. However, the *rabi* crop can be grown in areas where the mean monthly temperature does not fall below 16°C. It requires more than 30 cm rainfall during the growing period and does not grow where the rainfall exceeds 100 cm. Jowar is *par excellence a rainfed crop of dry farming areas where irrigation is not used.* Both excessive moisture and prolonged droughts are harmful for its proper growth. Though it can be grown in a variety of soils including loamy and sandy soils, clayey deep regur and alluvium are the best suited soils for jowar. Most of the crop is grown in plain areas but it can also be raised on gentle slopes upto 1,200 metres height.

Production and Distribution

Jowar has suffered severely at the hands of other favoured crops. The area under jowar increased slightly from 15.57 million hectares in 1950-51 to 18.41 million hectare in 1960-61. Thereafter, it has been fluctuating but the general trend has been towards its reduction. Trends of production area and yields of jowar are shown in **Table 22.9.** India produced 6.18 million tonnes of jowar from 5.33 million hectares of land with an average yield of 862 kg/hectare in 2012-13. Table 22.9 shows the distribution of jowar in India.

It is clear from **Table 22.10** that **Maharashtra** far excels all other states and produces more about 37 per cent of the total jowar production of India. As many as 22 districts of Mahrashtra produce jowar but Osmanabad, Nanded, Yavatmal, Buldhana, Parbhani, Kolhapur, Amravati, and Ahmednagar are important producing districts. In the Maharashtra plateau region, jowar is the staple food of the people and two crops in a year are raised here. First is sown just before the onset of the monsoon and the second is sown after the retreat of the monsoon. In some

TABLE 22.9. Production, Area and Yield of Jowar in India

Year	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Area (Million hectares)	15.57	18.41	17.37	15.81	14.36	9.86	8.67	8.47	7.76	7.53	7.79	7.38	6.25	6.18
Production (Million tonnes)	5.50	9.81	8.11	10.43	11.68	7.53	7.63	7.15	7.93	7.25	6.70	7.00	5.98	5.33
Yield (kg/hectare)	353	533	466	660	814	764	880	844	1021	962	860	949	957	862

Source : Agricultural Statistics at a glance, 2013, pp. 75-76.

of Pune, as much as 80 per cent of the cultivated area is devoted to jowar. The stalks are usually more than 2 metres long and are used as fodder for the cattle. **Karnataka** with 26.64 per cent of India's jowar production is the second largest producer. Jowar is widely grown in the north-eastern parts of the Karnataka plateau. About 80 per cent of Karnataka's production comes from Dharwar, Bijapur, Raichur, Gulbarga, Belgaum, Chitradurga and Bidar districts. **Madhya Pradesh** is the third largest producer but lags far behind Maharashtra in production contributing only 9 per cent of the total production of India. However, this state has the destination of giving highest yield of 1690 kg/hectare in 2012-13. Ujjain, Dewas, Shajapur, West and East Nimar and Mandsaur are some of the important producing districts. **Andhra Pradesh** along with Telangana has experienced a decrease in area and production of jowar during the last few years. Kurnool, Mahbubnagar, Khammam, Adilabad, Cuddapah, Nalgonda, Medak, Anantapur, Guntur, etc. are the important jowar producing districts in these two states. **Rajasthan's** dry climate

TABLE 22.10. Distribution of Jowar in India (2012-13)

States	Area		Production		Yield
	Million hectares	%age of all India	Million Tonnes	%age of all India	(kg/hectare)
1. Maharashtra	3.04	49.19	1.97	36.96	648
2. Karnataka	1.32	21.36	1.42	26.64	1076
3. Madhya Pradesh	0.29	4.69	0.49	9.19	1690
4. Andhra Pradesh	0.29	4.69	0.43	8.07	1483
5. Rajasthan	0.68	11.00	0.42	7.88	618
6. Uttar Pradesh	0.18	2.91	0.25	4.69	1389
7. Tamil Nadu	0.21	3.40	0.18	3.38	857
8. Gujarat	0.09	1.46	0.12	2.25	1333
9. Haryana	0.06	0.97	0.03	0.56	500
10. Odisha	0.01	0.16	0.00	0.09	490
Others	0.01	0.16	0.02	0.28	@
All India	**6.18**	**100.00**	**5.33**	**100.00**	**862**

@ Since area/production is low in individual states, yield rate is not worked out.

Source : Agricultural Statistics at a glance, 2013, p. 77.

and sandy soil provide favourable conditions for the cultivation of jowar. Kota, Sawai Madhopur, Jaipur, Tonk, etc. are the important jowar producing districts. However Rajasthan suffers from the problem of extremely low yields of 618 kg/hectare. In **Tamil Nadu** jowar is the second most important food crop after rice. Most of the production comes from Coimbatore, Tiruchirapalli, Madurai and Dharmapuri districts. Jowar is grown as a fodder crop in some of the south western parts of **Uttar Pradesh**. In **Gujarat** also, it is grown as fodder in the districts of Surat, Bharuch, Mahsana, and Vadodara.

BAJRA (BULL RUSH MILLET)

Bajra is the second most important millet which is used as food in drier parts of the country. It is also widely used as fodder as its stalks are fed to cattle. In certain areas the stalk is used for thatching purposes.

Conditions of Growth

Bajra is a crop of dry and warm climate and is grown in areas of 40-50 cm of annual rainfall. It seldom grows in those areas where the annual rainfall exceeds 100 cm. The ideal temperature for its growth is 25°-30°C. Bright sunshine after light showers is very useful in early stages of its growth. Bajra can be grown on poor light sandy soils, black and red soils and on upland gravely soils. It is a kharif crop which is sown between May and September and harvested between October and Feb./March. It is sown either as a pure or mixed crop with cotton, jowar and ragi. It is a rainfed crop and is seldom irrigated.

Production and Distribution

There had been wide fluctuations in the production of bajra from a minimum of 2.6 million tonnes in 1950-51 to a maximum of 12.11 million tonnes in 2003-04. The yields have also varied widely from a minimum of 288 kg/hectare in 1951-52 to a maximum of 1,141 kg/hectare in 2003-04. Large scale variations in area under bajra cultivation have also been observed (**Table 22.11**).

More than 85 per cent of India's bajra comes from four states of Rajasthan, Uttar Pradesh, Gujarat and Haryana. These four states also account for about 80 per cent of area under bajra. Rajasthan is the largest producer which accounts for 44.39 per cent of the production and 55.42% of the area under bajra. The leading bajra producing districts are Barmer, Nagaur, Jalore, Jodhpur, Pali, Sikar, Churu, Ganganagar, Hanumangarh, Bikaner, Alwar, Bharatpur, Jaipur, Jaisalmer, Jhunjhunu and Sawai Madhopur. **Uttar Pradesh** produced 1.76 million tonnes (12.5 per cent of India) in 2012-13. The main production comes from Mathura, Agra, Aligarh, Badaun, Moradabad, Etah, Etawah, Bulandshahar, Shahjahanpur, Mainpuri, Pratapgarh, Ghazipur, Farrukhabad, Allahabad and Kanpur. **Gujarat** is the third important producer, where 1.07 million tonnes (12.24 per cent of India's total) of bajra was produced in 2012-13. Most of the crop is grown in sandy tracts with maximum concentration in semi-arid parts of the state. Kachchh, Mehsana, Kheda, Bhavanagar, Amreli, Banaskantha, Surendranagar, Sabarkantha, Jamnagar, Rajkot, Junagadh districts are important producers. **Haryana** produced 0.79 million tonnes (9.04 per cent of total for India) in 2012-13. Most of the production comes from the drier south-western part of the state contiguous to Rajasthan. Mahendergarh, Rewari, Gurgaon, Rohtak and Hissar are important bajra producing districts. **Maharashtra** has shifted from first position in 2002-03 to fifth position in 2012-13 partly due to

TABLE 22.11. Area, Production and Yield of Bajra in India

Year	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Area (Million hectares)	9.02	11.47	12.49	11.66	10.48	9.83	9.58	9.57	9.51	8.75	8.90	9.61	8.78	7.20
Production (Million tonnes)	2.60	3.28	5.53	5.34	6.89	6.76	7.68	8.42	9.97	8.89	6.51	10.37	10.05	8.74
Yield (kg/hectare)	288	286	426	458	658	688	802	886	1042	1015	731	1079	1156	1214

Source : Agricultural Statistics at a glance, 2013, pp. 78-79.

TABLE 22.12. Distribution of Bajra in India (2012-13)

States	Area		Production		Yield
	Million hectares	%age of all India	Million Tonnes	%age of all India	(kg/hectare)
1. Rajasthan	3.99	55.42	3.88	44.39	972
2. Uttar Pradesh	0.90	12.50	1.76	20.14	1956
3. Gujarat	0.62	8.61	1.07	12.24	1726
4. Haryana	0.41	5.69	0.79	9.04	1927
5. Maharashtra	0.62	8.61	0.42	4.81	677
6. Karnataka	0.31	4.31	0.32	3.66	1032
7. Madhya Pradesh	0.19	2.64	0.30	3.43	1579
8. Andhra Pradesh	0.07	0.97	0.11	1.26	1571
9. Tamil Nadu	0.05	0.69	0.07	0.8	1400
10. Jammu & Kashmir	0.02	0.28	0.01	0.11	500
Others	0.02	0.28	0.01	0.11	@
All India	**7.20**	**100.00**	**8.74**	**100.00**	**1214**

@ Since area/production is low in individual states, yield rate is not worked out.
Source : Agricultural Statistics at a glance, 2013 p. 80.

decrease in production in this state and partly due to increase in production in other states. In Maharashtra, bajra is mainly grown in the central plateau having poor soils and dry climate. Nashik, Dhule, Satara, Pune, Sangli, Aurangabad, Solapur, Jalgaon and Ahmednagar are the main producing districts. Among the other producers are Madhya Pradesh, Karnataka, Tamil Nadu, Andhra Pradesh, Telangana and Jammu and Kashmir.

RAGI

Ragi is another important millet mainly grown in drier parts of south India with some parts of north India also contributing a small quantity. It requires 20°-30°C temperature and 50-100 cm rainfall. It is raised on red, light black and sandy loams as well as on well drained alluvial loams. It is a rainfed kharif crop which is sown between May and August and harvested between September and January.

Table 22.13 shows that there had been varying trends in area, production and yield of ragi in India. These variations are the result of varying weather conditions and choicer of farmers regarding selection of crops.

The total production of Ragi was 23.54 lakh tonnes in 2005. **Karnataka** is the largest producer accounting for 17.24 lakh tonnes (73.23 per cent) from 9.38 lakh hectares (61 per cent). Bengaluru, Kolar, Hassan, Tumkur, Chitradurga and Mysore districts account for over 80 per cent production of Karnataka. **Uttarakhand** is the second largest producer but lags far behind Karnataka with only 1.74 lakh tonnes (7.4 per cent). Tamil Nadu is the third largest producer with 1.33 lakh tonnes of ragi production in 2005-06. Dharmpuri, Salem, Coimbatore, Ramnathpuram, Madurai, and Nilgiri districts are the main producers. **Maharashtra** (1.32 lakh tonnes), Andhra Pradesh (0.79 lakh tonnes) are some other important producers.

TABLE 22.13. Area, Production and Yield of Ragi in India

Year	1990-91	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
Area (thousand hectares)	2171	1759	1647	1405	1666	1553	1534
Production (thousand tonnes)	8962	2732	2375	1316	1966	2432	2354
Yield (quintals per hectare)	10.8	15.5	14.4	9.3	11.8	15.7	15.3

Source : Statistical Abstract of India 2007, pp. 110, 116, 122.

BARLEY

Barley, like millets, is considered as an inferior grain. Besides food, it is used for manufacturing beer and whisky.

Conditions of Growth

It does not tolerate high heat and high humidity and thrives well in areas where the temperature is 10°-15°C for about three months in a year and the rainfall varies from 75 cm to 100 cm. Light clay and alluvial soils are best suited for its cultivation. It is grown as a rabi crop in the Great Plains and valleys of the western Himalayas. It can be grown upto an altitude of 1,300 metres as in Uttarakhand.

Production and Distribution

Over the years, fluctuating trends have been observed in the production of barley but the production has definitely declined by over 56 per cent in four and a half decades from 28.19 lakh tonnes in 1960-61 to 12.21 lakh tonnes in 2005-06. More conspicuous is the decline in area under barley which had come down from 32.05 lakh hectares in 1960-61 to a meagre 6.46 lakh hectares in 2005-06. However, the yield has recorded two and a half times increase during the same period. It was just 8.8 quintals/hectare in 1960-61 and rose to 19.7 quintals/hectare in 2005-06. The probable cause of decline in area and production is more importance being given to main food crops, particularly to wheat. This is not good for balanced growth of agriculture and must be checked.

Rajasthan is the largest producer accounting for over 40 per cent production of the country. The major part of the production comes from Pali, Tonk, Sawai Madhopur, Alwar, Bharatpur, Sikar, Jaipur, Udaipur, Ajmer, Bhilwara, Ganganagar and Hanumangarh districts. **Uttar Pradesh** is the second largest producer contributing 33.8 per cent of the total India. Aligarh, Agra, Bulandshahar, Mathura, Fatehpur, Allahabad, Varanasi, Mirzapur, Jaunpur, Ghazipur, Gorakhpur, Ballia, Partapgarh, Azamgarh etc. are the main producing districts.

Thus nearly three fourth barley comes from just two states. Some barley is also produced in **Madhya Pradesh** (100 thousand tonnes). Haryana (76 thousand tonnes) Punjab (63 thousand tonnes), **Chhattisgarh** (19 thousand tonnes), Uttarakhand (18 thousand tonnes), Himachal Pradesh (18 thousand tonnes), Bihar (18 thousand tonnes) and West Bengal.

PULSES

Pulses include a number of crops which are mostly leguminous and provide much needed vegetable proteins to a largely vegetarian population of India. They serve as an excellent forage and grain concentrates in the feed of cattle. Pulses have the capacity to fix atmospheric nitrogen in the soil and are normally rotated with other crops to maintain or restore soil fertility. Though gram and *tur* (arhar) are the more important pulses, several other pulses such as *urd* (black gram), *mung* (green gram), *masur* (lentil), *kulthi* (horse gram), *matar* (peas), *khesri* and *moth* are also grown.

GRAM

Gram is the most important of all the pulses and accounts for 37 per cent of the production and 28.28 per cent of the total area of pulses in India. It can be grown in a wide range of climatic conditions but it prefers mild cool and comparatively dry climate with 20°-25°C temperature and 40-50 cm rainfall. It grows well on loamy soils. It is a rabi crop, which is sown between September and November and is harvested between February and April. It is cultivated as pure or mixed with wheat, barley, linseed or mustard. Mixed cropping helps to check the gram blight to some extent.

Production

Like other food crops of second order, gram has also suffered a lot at the hands of wheat. The area under gram cultivation fell from a peak of 10.33 million hectares in 1959-60 to an extremely low of 5.19 million hectares in 2000-01. Similarly production of gram fell from 7.62 million tonnes in 1958-59 to a very low of 3.63 million tonnes in 1987-88. However, some recovery has been made both with respect to area and production of gram during the last one decade although varying trends have been observed in area as well as production of gram. But the yield per hectare has recorded a significant increase from 482 kg in 1950-51 to 744 kg in 2000-01 and 6021 kg in 2012-13 (**Table 22.14**).

Distribution

Although gram is cultivated in several parts of India, most of the gram comes from Madhya Pradesh, Rajasthan and Maharashtra. These three states account for more than two-thirds of the total gram production of the country (**Table 22.15**).

Madhya Pradesh is the largest producer with 3.55 million tonnes (40%) to its credit. Vidisha, Bhind, Morena, Chhatarpur, Jabalpur, Narsingpur, Dhar, Hoshangabad, Raisen, Gwalior, Patlam, Ujjain, Guna, Sagar, Shivpuri and Dalia are significant producers. Next to Madhya Pradesh is **Rajasthan** producing 1.27 million tonnes accounting for over 14 per cent of India's production. Gananagar, Alwar, Bharatpur, Jaipur, Sawai Madhopur, Udaipur, Banswara, Jaiselmer, Kota, Tonk, Churu, Jhunjhuna

TABLE 22.14. Area, Production and Yield of Gram in India

Year	1950-51	1960-61	1970-71	1980-81	1987-88	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Area (Million hectares)	7.57	9.28	7.84	6.58	5.77	5.19	6.93	7.49	7.54	7.89	8.17	9.19	8.30	8.70
Production (Million tonnes)	3.65	6.25	5.20	4.33	3.63	3.86	5.60	6.33	5.75	7.06	7.48	8.22	7.58	8.88
Yield (kg/hectare)	482	674	663	657	629	744	808	845	762	895	915	895	912	1021

***Source*:** Agricultural Statistics at a glance 2013, pp. 87-88.

TABLE 22.15. Distribution of Gram in India (2012-13)

States	Area		Production		Yield (kg/hectare)
	Million hectares	%age of all India	Million Tonnes	%age of all India	
1. Madhya Pradesh	3.13	35.98	3.55	39.98	1134
2. Rajasthan	1.25	14.37	1.27	14.30	1016
3. Maharashtra	1.25	14.37	1.06	11.94	848
4. Andhra Pradesh	0.68	7.82	0.76	8.56	1118
5. Uttar Pradesh	0.60	6.90	0.73	8.22	1217
6. Karnataka	0.03	0.34	0.65	7.32	2166
7. Chattisgarh	0.27	3.10	0.29	3.27	1074
8. Gujarat	0.17	1.95	0.20	2.25	1176
9. Bihar	0.06	0.69	0.09	1.01	1500
10. Haryana	0.05	0.57	0.05	0.56	1000
11. Odisha	0.04	0.46	0.03	0.34	750
12. West Bengal	0.03	0.34	0.03	0.34	1000
Others	1.14	13.10	0.17	1.91	@
All India	**8.70**	**100**	**8.88**	**100**	**1021**

@ Since area/production is low in individual states, yield rate is not worked out.

***Source*:** Agricultural Statistics at a glance, 2013, p. 89.

and Ajmer are the main producing districts. **Maharashtra** is the third largest producer and produces about one million tonnes amounting to about twelve per cent of India's production. The bulk of gram comes from Usmanabad, Aurangabad, Solapur, Parbhani, Ahmednagar, Beed, Nandel and Nasik districts. In **Andhra Pradesh**, most of the production comes from the Rayalseema region. **Uttar Pradesh** is the fifth largest producer of gram in the country. The main producing districts are Banda, Hamirpur, Jalaun, Jhansi, Kanpur, Allahabad, Fatehpur, Sitapur, Barabanki, Agra, Lalitpur and Sultanpur. The other important producing states are Karnataka, Gujarat, Bihar and Chhattisgarh. Gram in small quantities is also produced in Haryana, Odisha and West Bengal.

TUR or ARHAR (Pigeon Pea or Red Gram)

Tur is the second most important pulse of India next to gram. It is chiefly grown as a kharif crop but in areas of mild winters it is grown as a rabi crop also. It is grown as a dry crop mixed with other kharif crops like jowar, bajra, ragi, maize, cotton, groundnut, etc. and is seldom grown as a single crop. Its conditions of growth are more or less similar to those of other pulses and millets.

Production

Table 22.16 shows that there have been large scale temporal variations with respect to area, production and yields of tur.

TABLE 22.16. Area, Production and Yield of Tur in India

Year	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Area (Million hectares)	2.18	2.43	2.66	2.84	3.59	3.63	3.58	3.56	3.73	3.38	3.47	4.37	4.01	3.81
Production (Million tonnes)	1.72	2.07	1.88	1.96	2.41	2.25	2.74	2.31	3.08	2.27	2.46	2.86	2.65	3.07
Yield (kg/hectare)	788	849	709	689	673	618	765	650	826	671	711	655	656	806

***Source*:** Agricultural Statistics at a glance, 2013, p. 90, 91.

TABLE 22.17. Production of Tur in India (2012-13)

States	Area		Production		Yield (kg/hectare)
	Million hectares	%age of all India	Million Tonnes	%age of all India	
1. Maharashtra	1.08	28.35	0.91	29.64	843
2. Madhya Pradesh	0.53	13.91	0.4	13.03	755
3. Karnataka	0.67	17.59	0.37	12.05	552
4. Uttar Pradesh	0.31	8.14	0.37	12.05	1194
5. Gujarat	0.23	6.04	0.27	8.79	1174
6. Andhra Pradesh	0.48	12.60	0.25	8.14	521
7. Jharkhand	0.19	4.99	0.20	6.51	1053
8. Odisha	0.14	3.67	0.13	4.23	929
9. Bihar	0.03	0.79	0.05	1.63	1667
10. Tamil Nadu	0.05	1.31	0.04	1.30	800
Others	0.10	2.62	0.08	2.61	@
All India	**3.81**	**100.00**	**3.07**	**100.00**	**806**

@ Since area/production is low in individual states, yield rate is not worked out.

***Source*:** Agricultural Statistics at a glance, 2013, p. 92.

Distribution

A look at **table 22.17** reveals that **Maharashtra** is the largest producer of tur in India with over 29 per cent production from over 28 per cent area under tur. Most of production comes from Amrawati, Wardha, Akola, Yavatmal, Beed, Nagpur, Usmanabad, and Parbani districts. **Madhya Pradesh** is the second largest producer where major part of production comes from Hoshangabad, Chhindwara, Bebul, East Nimar, Dewas, Sidhi, Narsimhapur, and Bhind districts. *Karnataka* with about 12 per cent of the production is the third largest producer. Gulbarga, Bellary and Bidar districts of the North Moidan are the main producers. In **Uttar Pradesh**, Varanasi, Jhansi, Allahabad and Lucknow are the main producing districts. The other tur producing states include Gujarat, Andhra Pradesh, Jharkhand, Odisha, Bihar and Tamil Nadu. Bihar has the distinction of giving highest yield of 1667 kg/hectare which is over two times the national average of 806 kg/hectare.

CASH CROPS

Cash crops are those crops which are grown for sale in the market either in raw form or in semi-processed form. Thus cash crops have special characteristic of earning cash for the farmer. Prominent among the cash crops are cotton, jute, sugarcane, tobacco and oilseeds. These crops play a significant role in the economy of the country. This is evident from the fact that they occupy only 15 per cent of the total cropped area of the country but account for over 40 per cent of the agricultural production by value. Besides they provide raw materials to a large number of industries.

COTTON

Cotton is the most important fibre crop not only of India but of the entire world. It provides the basic raw material (*cotton fibre*) to cotton textile industry. Its seed (*binola*) is used in vanaspati industry and can also be used as part of fodder for milch cattle to get better milk.

Conditions of Growth

Cotton is the crop of tropical and sub-tropical areas and requires uniformly high temperature varying between 21°C and 30°C. The growth of cotton is retarded when the temperature falls below 20°C. Frost is *enemy number one of the cotton plant* and it is grown in areas having at least 210 frost free days in a year. The modest requirement of water can be met by an average annual rainfall of 50-100 cm. However, it is successfully grown in areas of lesser rainfall with the help of irrigation. About one-third of the total area under cotton cultivation is irrigated. About 80 per cent of the total irrigated area under cotton is in Punjab, Haryana, Gujarat and Rajasthan. Moist weather and heavy rainfall at the time of boll-opening and picking are detrimental to cotton as the plant becomes vulnerable to pests and diseases. High amount of rainfall in beginning and sunny and dry weather at ripening time are very useful for a good crop.

Cotton is a kharif crop which requires 6 to 8 months to mature. Its time of sowing and harvesting differs in different parts of the country depending upon the climatic conditions. In Punjab and Haryana, it is sown in April-May and is harvested in December-January, that is before the winter frost can damage the crop. In the peninsular part of India, it is sown upto October and harvested between January and May because there is no danger of winter frost in these areas. In Tamil Nadu, it is grown both as a kharif and as a rabi crop. Here the rainfall occurs after September and cotton is sown in October. The irrigated crop is sown in January-February. Most of the crop is grown mixed with other kharif crops such as maize, jowar, ragi, sesamum, castor, groundnut and some vegetables.

Cotton cultivation is closely related to deep black soils (*regur*) of the Deccan Plateau and the Malwa Plateau and those of Gujarat. It also grows well in alluvial soils of the Satluj-Ganga Plain and red and laterite soils of the peninsular region. Cotton quickly exhausts the fertility of soil. Therefore, regular application of manures and fertilizers to the soils is very necessary.

Picking is a crucial period from the labour point of view. Since picking of cotton is not yet mechanized, a lot of cheap and efficient labour is required at this time. Normally the picking season is spread over a period of about three months.

Types of Cotton

Three broad types of cotton are generally recognised on the basis of the length, strength and structure of its fibre.

TABLE 22.18. Area, Production and Yield of Cotton in India

Year	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Area (Million hectares)	5.88	7.61	7.61	7.82	7.44	8.53	8.68	9.14	9.41	9.41	10.13	11.24	12.18	11.98
Production (Million bales*)	3.04	5.60	4.56	7.01	9.84	9.52	18.50	22.63	25.88	22.28	24.02	33.00	35.20	34.00
Yield (kg/hectare)	88	125	122	152	225	190	362	421	467	403	403	499	491	482

*1 bale = 170 kg.

Source : Agricultural Statistics at a glance, 2013, pp. 111-12.

1. Long staple cotton. It has the longest fibre whose length varies from 24 to 27 mm. The fibre is long, fine and lustrous. It is used for making fine and superior quality cloth. Obviously, it fetches the best price. There has been rapid progress in the production of long staple cotton since Independence. About half of the total cotton produced in India is long staple. It is largely grown in Punjab, Haryana, Maharashtra, Tamil Nadu, Madhya Pradesh, Gujarat and Andhra Pradesh.

2. Medium staple cotton. The length of its fibre is between 20 mm and 24 mm. About 44 per cent of the total cotton production in India is of medium staple. Rajasthan, Punjab, Tamil Nadu, Madhya Pradesh, Uttar Pradesh, Karnataka and Maharashtra are its main producers.

3. Short staple cotton. This is inferior cotton with fibre less than 20 mm long. It is used for manufacturing inferior cloth and fetches less price. About 6 per cent of the total production is of short staple cotton. U.P., Andhra Pradesh, Rajasthan, Haryana and Punjab are its main producers.

Production

India has the largest area under cotton cultivation in the world though she is the world's third largest producer of cotton after China and the U.S.A. Currently it is grown over 8.6 per cent of the net sown area. **Table 22.18** shows the trends in the production of cotton in India.

Bt Cotton

Bt stands for *Bacillus thuringiensis*, the bacterium whose toxin is produced by Bt cotton after genetic alteration. The first Bt protected cotton crops were tested in the fields of U.S.A. and it entered in U.S. cultivation in 1995. China welcomed Bt cotton in 1997. Later 13 countries, including India, followed the cultivation of Bt cotton. In India, it was released for commercial cultivation in 2002. The initial field trials of Bt cotton showed extremely encouraging results as the yield of Bt cotton was *80 per cent more than that of non-Bt variety although it required three times less spraying and 70 per cent less insecticide.* The area under cotton crop increased sharply by about 50 per cent from 8.53 million hectares in 2000-01 to 12.18 million hectares in 2011-12 and the production also registered more than three times increase from 9.52 million bales (1 bale = 170 kg) in 2000-01 to 35.20 million bales in 2011-12. A number of studies conducted on Bt cotton before and after commercialization have shown the following benefits :

(*i*) Higher cotton yield owing to effective control of bollworms.

(*ii*) Drastic reduction in application of chemical insecticides for bollworm control.

(*iii*) Higher profit to farmers.

(*iv*) Conservation of biological control agents and other beneficial organisms.

The area under Bt cotton raised from a minimal of 1 per cent in 2003-04 to a staggering 90 per cent in 2011-12 (**Table 22.19**). In spite of large area under Bt cotton, the yields have not registered any increase worth the name. This shows that the new Bt cotton is loosing its sheen. According to K.R. Kranthi, Director, Central Cotton Research Institute (CICR), "Although the GM variety, officially allowed in 2002, sharply raised yields initially, productivity is now projected to decline and signs of diminishing returns

TABLE 22.19. Area under Bt Cotton

Year	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Percentage of area under Bt	0	1	6	18	41	62	84	85	85	90

Source : Cotton Corporation of India.

are visible now." In fact Bt toxin is a narrow spectrum bio-insecticide as it controls only bollworm. Cotton attracts over 130 different species of pests. The biodiversity of cotton pests varies from insects like ball weevil, grey weevil, cotton jassid, cotton aphids, cotton thrip to Nematodes like root-rust.

The above mentioned situation needs to be improved for which better technology (seeds, fertilizers, pesticides, insecticides and irrigation) is required. Maharashtra has the largest area of 20 lakh hectares under Bt cotton, followed by Andhra Pradesh (7.6 lakh hectares), Gujarat (3.3 lakh hectares) and Madhya Pradesh (3.1 lakh hectares). All these states are in South India : In North India Punjab and Haryana have 2.8 lakh hectares and 0.42 lakh hectares respectively under Bt cotton. The biggest concern about large scale adoption of Bt cotton in India is that the bollworm (a serious pest disease of cotton) may develop resistance to this transgenic crop as has happened in some parts of China. It is worth noting that almost 65 per cent of the area under cotton is rainfed with erratic and poorly distributed rains during the cropping season. It is subjected to severe attack of pests and diseases.

Distribution

India has the sole distinction of growing all the three cultivated species of cotton and their intra- and inter-specific hybrids. In India, cotton is grown in three distinct agro-ecological zones, *viz*., Northern (Punjab, Haryana and Rajasthan), Central (Gujarat, Maharashtra and Madhya Pradesh) and Southern zone (Andhra Pradesh, Tamil Nadu and Karnataka).

Table 22.20 shows the statewise distribution of cotton in India.

1. Gujarat. Accounting for over 25 per cent of the total production and nearly 21 per cent of the cotton area of the country, Gujarat is the largest cotton producing state of India. The average yield is 594 kg/hectare. With 'black cotton soil' 1.5 metre deep in some parts and with 80-100 cm annual rainfall Gujarat provides favourable conditions for cotton cultivation. Two-thirds of the production comes from the Gujarat plains including Bharuch, Surendernagar, Vadodra and Ahmedabad districts. Mahesana, Kheda, Sabarkantha, Surat, Amreli and Panchmahals are other major producers.

2. Maharashtra. Maharashtra is the second largest producer and produces over 22 per cent of the total cotton production of India. Maharashtra is a traditional producer of cotton. The lava soil of deccan plateau is world renowned for cotton production and is popularly known as the *black cotton soil*. Over 80 per cent of the production comes from Khandesh, Vidarbha and Marathwada regions comprising the districts of Yavatmal, Nanded, Amravati, Parbhani, Wardha, Jalgaon, Akola, Buldhana, Nagpur, Dhule, etc. However, Maharashtra suffers from low productivity as this state gives the lowest yield of 313 bales/hectare among the cotton producing states of India.

3. Andhra Pradesh. Andhra Pradesh accounts for about 21 per cent of production and over 20 per cent of hectarage of India. Two-thirds of the production of Andhra Pradesh comes from two districts,

DESI BT COTTON

The Genetic Engineering Approval Committee (GEAC) has approved a new Bt cotton variety for commercial planting, making it India's first genetically modified (GM) to be developed by the public sector. The new cotton variety called *Bikaneri Narma* was developed by the Central Institute of Cotton Research (CICR), Nagpur and the University of Agricultural Sciences in Dharwar (Karnataka). The variety contains the gene for the Bt cry 1 AC protein and has been approved by GEAC for release in the North, Central and South Cotton Growing Zones of the country. Farmers have been using it since 2009. It is too early to draw any conclusion about the impact of desi Bt cotton.

TABLE 22.20. Statewise Distribution of Cotton in India (2012-13)

States	Area		Production		Yield (kg/hectare)
	Million hectares	%age of all India	Million balls	%age of all India	
1. Gujarat	2.50	20.87	8.73	25.68	594
2. Maharashtra	4.15	34.64	7.65	22.50	313
3. Andhra Pradesh	2.40	20.03	7.35	21.62	521
4. Haryana	0.61	5.09	2.50	7.35	697
5. Madhya Pradesh	0.61	5.09	2.20	6.47	613
6. Punjab	0.48	4.01	2.00	5.88	708
7. Rajasthan	0.45	3.76	1.30	3.82	491
8. Karnataka	0.49	4.09	1.20	3.53	416
9. Tamil Nadu	0.13	1.09	0.50	1.47	654
Others	0.16	1.34	0.57	1.68	@
All India	**11.98**	**100.00**	**34.00**	**100.00**	**482**

@ Since area/production is low in individual states, yield rate is not worked out.

* 1 cotton bale = 170 kg.

Source : Agricultural Statistics at a glance, 2013, p. 113.

namely Guntur and Prakasam. Kurnool and Anantapur contribute the rest.

4. Haryana. Accounting for 7.35 per cent production and 5.09 per cent of hectarage, Haryana is the fourth largest producer of cotton in India. In the year 2012-13, Haryana produced 2.5 million bales. About 80 per cent of the production comes from Hissar, Sirsa and Fatehabad districts which are contiguous to the major cotton producing districts of Punjab. Like Punjab, most of the production is in the form of the American long staple varieties. Bhiwani, Jind and Rohtak and Ambala are other producing districts.

5. Madhya Pradesh. More than 80 per cent of the production comes from Malwa where there are vast tracts of lava soil. East Nimar, West Nimar, Ujjain, Shajapur, Dewas, Dhar, Ratlam, Rajgarh, Indore, and Bhopal are the main producers.

6. Punjab. Punjab has slipped from first position in 1990-91 to sixth position in 2012-13 as a producer of cotton in India. This state has the distinction of giving the highest yield of 708 kg/hectare (2012-13). Punjab has also the distinction of producing some of the best qualities of cotton in India. All this has been made possible due to fertile alluvial soils, a close network of irrigation facilities, heavy dose of fertilizers and pesticides and above all the enterprising spirit of the farmers. Most of the cotton production comes from the Malwa region of the state. This region contributes nearly 95 per cent of Punjab's cotton. Cotton is known as "white gold" in this region. Bhatinda, Faridkot, Firozepur and Sangrur are the major producing districts and account for over three fourths of Punjab's total production of cotton. Ludhiana, Muktsar, Moga, Mansa and Fatehgarh Sahib are other cotton producing districts.

7. Rajasthan. Rajasthan accounts for about 3.82 per cent of the production and 3.76 per cent of the area of the country. The state has the low yield of only 491 kg/hectare. Ganganagar is the most important cotton producing district of Rajasthan and accounts for over 80 per cent of the state's production. This district is contiguous to the cotton producing areas of Punjab and Haryana and enjoys the same advantages. The remaining cotton of Rajasthan comes from Bhilwara, Ajmer, Chittaurgarh, Jhalawar, Pali and Hanumangarh.

8. Karnataka. This state produces 3.53 per cent cotton of India from 4.09 per cent of India's area under cotton cultivation. The North Karnataka plateau

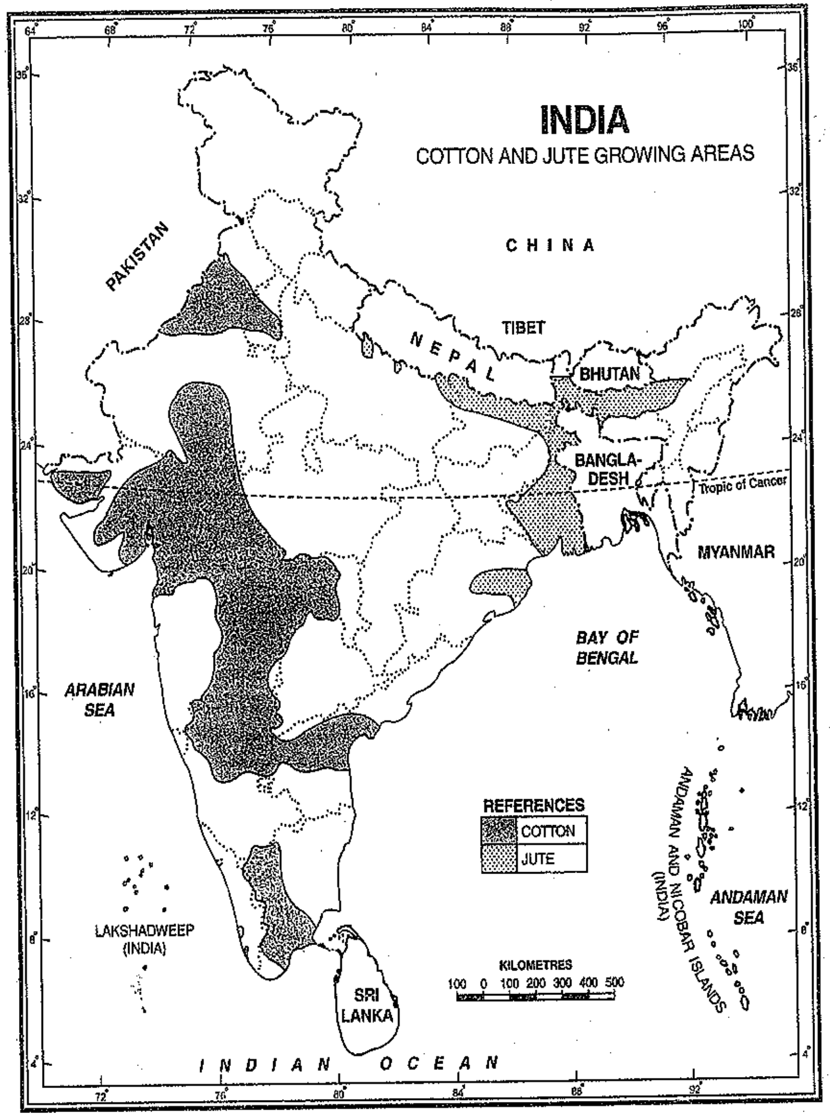

FIG. 22.3. India : Fibre Crops (Cotton & Jute)

is the main area of cotton cultivation. Dharwad, Raichur, Bellary and Gulbarga are the main producing districts.

9. Tamil Nadu. Tamil Nadu contributes about 1.47 per cent of the total production with about 1.09 percent of the total area of the country. Coimbatore, Salem, Madurai, Tiruchirapalli, Ramnathapuram, Vellore, Chengalpattu and Tirunelveli are the main producing districts.

Uttar Pradesh, Kerala, Odisha, Meghalaya and Mizoram also produce cotton in small quantities.

Trade

India is an exporter as well as importer of cotton.

TABLE 22.21. India : Imports and exports of Cotton, Raw including waste ('000 tonnes)

Year	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Imports	233.85	252.90	192.18	98.75	81.48	136.48	211.69	171.42	58.41	77.42	231.01
Exports	11.75	179.61	86.64	614.80	1162.22	1557.59	457.56	1357.99	1885.77	2003.58	2014.82

Source : Agricultural Statistics at a glance, 2012, pp. 245-49 and 2013, pp. 243-47.

India exports inferior quality cotton mainly to U.K., where it is mixed with superior quality cotton. India has been a big importer of superior quality long staple cotton mainly from the USA, Russia, UAR, Sudan and Kenya. With the increase in domestic production of superior quality cotton, our imports have come down and exports have increased considerably (Table 22.21) India has achieved near self-sufficiency in the production of superior quality cotton.

Considering the major provisions of World Trade Organisation (WTO) *vis-a-vis* India's position, the points that emerge to be of immediate concern in enhancing the productivity and quality of Indian cotton and making it competitive globally are : (*i*) bringing down the cost of cultivation and enhancing its productivity and quality, (*ii*) rendering our cotton globally attractive, (*iii*) keeping Indian cotton free of trash content.

JUTE

Next to cotton, jute is the second important fibre crop of India. Jute is in great demand because of the cheapness, softness, strength, length, lustre and uniformity of its fibre. It is used for manufacturing a large variety of articles such as gunny bags, hessian, ropes, strings, carpets, rugs and clothes, tarpaulins, upholstery and decoration pieces.

Conditions of Growth

Jute is the crop of hot and humid climate. It requires high temperature varying from 24°C to 35°C and heavy rainfall of 120 to 150 cm with 80 to 90 per cent relative humidity during the period of its growth. Small amount of pre-monsoon rainfall varying from 25 cm to 55 cm is very useful because it helps in the proper growth of the plant till the arrival of the proper monsoon. Incessant and untimely rainfall as well as prolonged droughts are detrimental to this crop. Rainfall between 2.5 to 7.5 cm in a month, during the sowing period, is considered to be sufficient. Occasional showers varying from 2 to 3 cm at intervals of a week's time during the growing period are very useful. Large quantity of water is required not only for growing the jute crop but also for processing the fibre after the crop is harvested. Light sandy or clayey loams are considered to be best suited soils for jute. Since jute rapidly exhausts the fertility of soil, it is necessary that the soil is replenished annually by the silt-laden flood water of the rivers. Large supply of cheap labour is also necessary for growing and processing the jute fibre.

Method of Cultivating and Processing of Jute

Jute is generally sown in February on lowlands and in March-May on uplands. The crop takes 8-10 months to mature but different varieties take different time to mature. The harvesting period generally starts in July and continues till October. The plants are cut to the ground and tied into bundles. Sheafs of jute stocks are then immersed in flood water or ponds or stagnant water for about 2 to 3 weeks for retting. High temperature of water quickens the process of retting. After retting is complete, the bark is peeled from the plant and fibre is removed. After this, stripping, rinsing, washing and cleaning is done and the fibre is dried in the sun and pressed into bales. All this process is to be done by human hand for which availability of plenty of labour at cheap rates is very essential. Luckily, this labour is readily available because jute is cultivated in areas of high population density.

Production

India suffered a great setback in the production of jute as a result of partition of the country in 1947 because about 75 per cent of the jute producing areas went to Bangla Desh (East Pakistan at that time). Fortunately, most of the jute mills remained in India. Strenuous efforts were made to increase production and area of jute, immediately after partition to feed our starving jute mills in the wake of short supply of raw jute.

Table 22.22 shows that there had been rapid increase in area, production and yield of jute during three decades between 1950-51 and 1980-81 after which varying trends in almost all the three aspects (area, production and yield) have been observed. This is perhaps due to changes in weather conditions and pressure on land for other crops like rice. In fact there is tough competition for land in the delta region.

The significant role played by jute in the country's economy can be assessed from the fact that more than 4 million farm families are involved in jute farming and majority of them belong to small and marginal categories. Cultivation of jute generates employment (seasonal) of more than 10 million mandays per season. Besides 0.5 million people are involved in raw jute and finished goods trading and ancillary activities. Currently India accounts for about 56 per cent of world jute production as compared to only 25 per cent produced by Bangladesh. Research and development work carried by the agricultural scientists during the last few years has not only resulted in increasing yield of the fibre but also in improvement of the fibre quality and shortening of cultivation period. Investigations reveal that the crop pattern jute-paddy-potato is more profitable for the farmers than say paddy-potato-sesame.

Distribution

Table 22.23 shows that over 99 per cent of the total jute of India is produced in just fives states of West Bengal, Bihar, Assam, Andhra Pradesh and Odisha.

1. West Bengal. West Bengal is the undisputed king of jute production in India accounting for about three-fourth of the production and nearly two-thirds of the area under jute. Here hot and humid climate and alluvial, loamy soil coupled with cheap abundant labour provide conditions *par excellence* for the growth of jute. Almost all parts of the state are producing some jute but its cultivation decreases in the north sub-Himalayan region, towards the south in the Ganga delta where land is too low for jute and towards the west where the rocky ground of the Deccan plateau is more marked than the Ganga alluvium. However, major part of the production comes from Nadia, Murshidabad, 24 Parganas, Koch Bihar, Jalpaiguri, Hugli, Dakshin Dinajpur, Bardhaman, Maldah, Paschim Medinapur and Purba Medinapur districts. The entire jute production is consumed in the jute mills located in the Hugli basin. In 2012-13, West Bengal produced 8.31 million bales (73.54% of India) of jute from 0.58 million hectares (66.67%) of India giving highest yield of 2579 kg/ha.

2. Bihar. Bihar is the second largest producer but lagging far behind West Bengal in the production of jute accounting only for about 18.5 per cent of the production and over 17 per cent of the area of the country under jute. Purnea is the largest producing district accounting for 60 per cent of Bihar's production. Katihar, Saharsa and Darbhanga are the other producing districts.

3. Assam. With about 5.13 per cent of the production and 8.05 per cent of the area of the country, Assam is the third largest jute producing state of India. The main concentration is in the

TABLE 22.22. All India, Area, Production and Field of Jute and Meslin

Year	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Area (Million hectares)	0.57	0.90	1.08	1.30	0.91	1.02	0.90	0.94	0.96	0.90	0.91	0.87	0.90	0.87
Production (Million bales*)	3.31	5.26	6.19	8.16	8.29	9.23	10.84	11.27	11.21	10.37	11.82	10.62	11.40	11.30
Yield (kg/hectare)	1043	1049	1032	1130	1646	1634	2173	2170	2101	2071	2349	2192	2283	2338

*1 bale = 180 kg.

Source : Agricultural Statistics at a glance, 2013, pp. 114-15.

TABLE 22.23. Distribution of Jute and Meslin in India (2012-13)

States	Area		Production		Yield (kg/hectare)
	Million hectares	%age of all India	Million bales*	%age of all India	
1. West Bengal	0.58	66.67	8.31	73.54	2579
2. Bihar	0.15	17.24	2.09	18.50	2508
3. Assam	0.07	8.05	0.58	5.13	1491
4. Andhra Pradesh	0.02	2.30	0.13	1.15	1170
5. Odisha	0.02	2.30	0.08	0.71	270
6. Maharashtra	0.02	2.30	0.03	0.27	270
7. Meghalaya $	—	0.00	—	0.00	
Others	0.01	1.15	0.08	0.71	@
All India	**0.87**	**100.00**	**11.30**	**100.00**	**2338**

@ Since area/production is low in individual states, yield rate is not worked out.

$ Area and Production figures for 2012-13 are included in others category.

Source : Agricultural Statistics at a glance, 2013, p. 116.

Brahmaputra and Surma valleys. Goalpara, Kamrup, Nowgong, Darrang and Sibsagar are the main producing districts.

Others. Among the other producers, is **Andhra Pradesh** were delta area is the main producer. In **Odisha**, Cuttack, Puri and Bolangir are the main producers. In **Uttar Pradesh**, areas along the Himalayan foothills including Kheri, Bahraich and Sitapur districts are the main producers. Some jute is also produced in Maharashtra, Kerala, Madhya Pradesh, Tripura and Meghalaya.

Trade

India's production of jute always falls short of her requirements and it is imported to feed our jute mills. Bangladesh is the chief supplier of jute to India. India imports raw jute and exports jute hessian. There are large temporal variations in the imports of row jute and exports of jute hessian (**Table 22.24**).

Being a natural fibre, jute is biodegradable and as such "environment friendly". The principal products can be reused and, as a result, many have a secondary value for other users. Despite such positive features, the world market for jute has remained depressed. The primary cause of such a situation is the development of substitutes like plastic products, synthetic fibres, paper package, etc.

SUGARCANE

Sugarcane belongs to bamboo family of plants and is *indigenous to India*. It is the main source of sugar, *gur* and *khandsari*. About two-thirds of the total sugarcane produced in India is consumed for making *gur* and *khandsari* and only one-third of it goes to sugar factories. It also provides raw material for manufacturing alcohol. Bagasse, the crushed cane residue, can be more beneficially used for manufacturing paper instead of using it as fuel in the

TABLE 22.24. India : Imports of Raw Jute and Exports of Jute Hessian

Year	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Imports of raw jute ('000 tonnes)	143.23	111.97	20.74	61.34	83.05	135.75	52.24	62.66	83.31	181.18	148.73
Value of exports of jute hessian (₹ crore)	349.31	410.11	427.20	490.90	375.81	464.44	415.59	307.63	722.87	945.83	868.46

Source : Agricultural Statistics at a glance, 2012, pp. 245-249 and 2013 pp. 243-47.

mills. It is also an efficient substitute for petroleum products and a host of other chemical products. A part of it is also used as fodder. Sugarcane accounts for the largest value of production and holds an enviable position among all the commercial crops in India. Obviously, it is the first choice of the farmers, wherever geographical conditions favour its growth.

Conditions of Growth

It is a long duration crop and requires 10 to 15 and even 18 months to mature, depending upon the geographical conditions. It requires hot and humid climate with average temperature of 21°-27°C and 75-150 cm rainfall. In the latter half, temperature above 20°C combined with open sky helps in acquiring juice and its thickening. Too heavy rainfall results in low sugar content and deficiency in rainfall produces fibrous crop. Irrigation is required in areas receiving lesser rainfall than the prescribed limit. Short cool dry winter season during ripening and harvesting is ideal. Frost is detrimental to sugarcane. Therefore, it must be harvested before frost season, if it is grown in northern parts of the country where winters are very cold and frost is a common phenomenon. On the other hand, hot dry winds are also inimical to sugarcane.

It can grow on a variety of soils including loams, clayey loams, black cotton soils, brown or reddish loams and even laterites. In fact, sugarcane can tolerate any kind of soil that can retain moisture. But deep rich loamy soils are ideal for its growth. The soil should be rich in nitrogen, calcium and phosphorus but it should not be either too acidic or too alkaline.

Sugarcane exhausts the fertility of the soil quickly and extensively and its cultivation requires heavy dose of manures and fertilizers. Flat plain or level plateau is an advantage for sugarcane cultivation because it facilitates irrigation and transportation of cane to the sugar mills.

It is a labour intensive crop requiring ample human hands at every stage *i.e.* sowing, hoeing, weeding, irrigating, cutting and carrying sugarcane to the factories. Therefore, cheap abundant labour is a prerequisite for its successful cultivation.

Production

India has the largest area under sugarcane cultivation in the world and she is the world's second largest producer of sugarcane next only to Brazil. The cane production registered a dramatic increase of 93 per cent in the decade 1951-61 as a result of diversification of agriculture but this spurt slackened to 14.9 per cent growth between 1960-61 and 1970-71 mainly as a result of the farmers' withdrawal of land under cane owing to internal market fluctuations. However, production began looking up again with the establishment of a number sugar mills during the decade 1971-81 and growth rate was 22 per cent. The production of sugarcane reached a high level of 355.52 million tonnes in 2006-07 after which varying trends have been observed. In the year 2012-13, production of sugarcane in India stood at 338.96 million tonnes.

As in case of production, area under sugarcane cultivation registered a rapid increase from 1.7 million hectares in 1950-51 to 4.32 million hectares in

TABLE 22.25. Area, Production and Yield of Sugarcane in India

Year	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Area (Million hectares)	1.71	2.62	2.62	2.67	3.69	4.32	4.20	5.15	5.06	4.42	4.17	4.88	5.04	5.06
Production (Million tonnes)	57.05	110.00	126.37	154.25	241.05	295.96	286.17	355.52	348.19	285.03	292.30	342.38	357.67	338.96
Yield (kg/hectare)	33422	45549	48322	57844	65395	68578	66919	69022	68877	64553	74020	70091	70317	66988

Source: Agricultural Statistics at a glance, 2012, pp. 115-16.

2000-01 after which the area under sugarcane cultivation increased at a slow rate. In fact, large variations in area under sugarcane have been observed since 2006-07 onwards.

The yield of sugarcane doubled in four decades increasing from just 33422 kg/hectare in 1950-51 to 65395 kg/hectare in 1990-91. The process of increase in yields continued till 2000-01 when it stood at 68578 kg/hectare. The yield remained at this high level for three consecutive years from 1997-98 to 1999-2000. Again the yield recorded a rapid increase from 64553 kg/ha in 2008-09 to 70713 kg/ha in 2011-12. Our yields stand nowhere when compared with some of the best in the world. For example, countries like Indonesia, Egypt and Mexico are producing about 50 per cent more sugarcane/hectare as compared to India. As against India's 66.9 tons/ha in 2012-13, the yields of Brazil (79.0 tonnes/ha), Columbia (101.3 tonnes/ha), Australia (71.4 tonnes/ha), Egypt (116.7 tonnes/ha) and Peru (125.5 tonnes/ha) are much higher. Three new breeds of sugarcane namely Co238, Co239 and Co118 have been developed by at Coimbatore based Sugarcane Breeding Institute which are likely to give 10 tonnes more cane per hectare and bringing India at par with Brazil, a country which produces largest quantity of sugarcane. Lack of fertilizers, uncertain weather conditions, inadequate irrigation, poor varieties of cane, small and fragmented holdings and backward methods of cultivation are some of the major causes of low yields in India.

Sugarcane Research Institute set up at Coimbatore in Tamil Nadu started functioning in 1912. It evolved better varieties of cane, particularly for northern India. One of the important achievements of this institute was introduction of *ratooning* which became very popular in India. In this system the sugarcane is cut leaving the root intact in the soil. Ratoon crop is the second or any other successive crop obtained from the roots left over in the field from the first crop. This is widely practised in different parts of the country due to its low cost of production and relatively shorter maturation period, because cost inputs and time are saved as there is no need for fresh sowing and growing of roots. However, productivity decreases with each passing year and ratooning becomes uncommercial after one or two years.

Distribution

On the basis of study of conditions of growth for sugarcane as mentioned in the above paragraphs, following three distinct belts of sugarcane cultivation can be identified.

(*i*) The Satluj-Ganga plain from Punjab to Bihar containing 51 per cent of the total area and 60 per cent of the country's total production.

(*ii*) The black soil belt from Maharashtra to Tamil Nadu along the eastern slopes of the Western Ghats.

(*iii*) Coastal Andhra and the Krishna Valley.

Here, it is worth drawing a comparison between sugarcane cultivation in the northern and the southern parts of India. In northern plain of India, the summer temperatures ranging from 30° to 35°C and dry scorching winds called '*loo*' in May and June hamper the normal growth of the cane. In the winter months of December and January the sugarcane crop is likely to be damaged by excessively cold weather accompanied by frost. Consequently the yield/hectare is low. In south India, on the other hand, the absence of '*loo*' during the summer and reasonably high temperature during the frost free winter, coupled with the maritime winds in the coastal areas are some of the climatic factors which are extremely beneficial to this crop. The paradoxical character of sugarcane cultivation in India is that whereas south India offers more favourable climatic conditions for the growth of sugarcane, the most important sugarcane belt lies in north India. There are two reasons for such a contradictory situation. Before the World War I, this area was mainly used for growing indigo which was the most favourite cash crop with the farmers at that time. But with the introduction of cheap aniline dyes, indigo lost its market and its cultivation had to be discontinued after the First World War. Consequently, its place was taken by sugarcane cultivation. Another reason is that sugarcane has to face tough competition for land from a number of other cash crops such as cotton, tobacco, groundnut, coconut, etc. in the south.

1. Uttar Pradesh. Table 22.26 clearly shows that Uttar Pradesh far excels all other states with regard to production and area under sugarcane. The state accounts for about 36 per cent of the production and about 42.86 per cent of the area under sugarcane cultivation of India. In fact, all parts of the state

TABLE 22.26. Distribution of Sugarcane in India (2012-13)

States	Area		Production		Yield
	Million hectares	%age of all India	Million bales*	%age of all India	(kg/hectare)
1. Uttar Pradesh	2.16	42.86	128.82	35.68	59639
2. Maharashtra	1.02	20.24	86.73	24.02	85029
3. Karnataka	0.43	8.53	38.81	10.75	90256
4. Tamil Nadu	0.35	6.94	38.58	10.69	110229
5. Andhra Pradesh	0.20	3.97	16.69	4.62	83450
6. Bihar	0.22	4.37	11.29	3.13	51318
7. Gujarat	0.20	3.97	12.75	3.53	63750
8. Haryana	0.10	1.98	6.96	1.93	69600
9. Uttarakhand	0.11	2.18	6.31	1.75	57364
10. Punjab	0.08	1.59	5.65	1.56	70625
11. Madhya Pradesh	0.07	1.39	2.68	0.74	38286
12. West Bengal	0.02	0.40	1.68	0.47	84000
13. Assam	0.03	0.60	0.99	0.27	33000
14. Odisha	0.01	0.20	0.88	0.24	88000
Others	0.04	0.79	2.22	0.61	@
All India	**5.04**	**100.00**	**361.04**	**100.00**	**71668**

@ Since area/production is low in individual states, yield rate is not worked out.
Source : Agricultural Statistics at a glance, 2013, p. 119.

except a few dry areas in the west and south-west produce sugarcane to some extent. Vast alluvial plains, congenial climate and large scale use of irrigation and fertilizers are some of the important factors which have helped U.P. to acquire this status. The largest concentration is in the upper Ganga-Yamuna Doab, Rohilkhand and trans-Saryu areas which together produce about 70 per cent of sugarcane produced in this state. Western part of the state forms the core of sugarcane production in the country. As many as 30 districts of U.P. produce sugarcane. However, Muzaffarnagar, Meerut, Bijnor, Moradabad, Saharanpur, Kheri, Deoria, Bulandshahr, Ghaziabad, Bareilly and Sitapur are the important sugarcane producing districts.

2. Maharashtra. Though Maharashtra is the second largest producer of sugarcane in India, this state lags far behind U.P. with respect to area and the production accounting for about 24 per cent of the production and 20 per cent of the area of the country. But Maharashtra is in a superior position with respect to recovery of sugar and duration of crushing period. Maharashtra's yields are about 33 per cent higher than those of Uttar Pradesh. Most of the sugarcane is grown on black lava soil with the help of irrigation. Most of the production comes from Ahmednagar, Kolhapur, Pune, Nashik, Solapur, Sangli, Satara, Osmanabad and Aurangabad.

3. Karnataka. With over 10.7 per cent of the production and over 8 per cent of the area, Karnataka is the third largest sugarcane producing state of India. Most of the sugarcane is grown with the help of irrigation. Belgaum, Mandya, Mysore, Bijapur, Shimoga and Chitradurga are important producing districts.

4. Tamil Nadu. Though Tamil Nadu accounts only for about 10.69 per cent of the production and nearly 7 per cent of the area under sugarcane of the

country, this state has unique distinction of giving highest yield of 1,10,229 kg/hectare. Over 80 per cent of the production comes from Tirupur, Salem, Tiruchirapalli, Dharampuri and Coimbatore districts. The rest is contributed by Dharampuri, Madurai, Thanjavur and Ramnathpuram districts.

5. Andhra Pradesh. Most of the cultivation is done in the coastal areas having fertile soil and suitable climate. West Godavari, East Godavari, Vishakhapatnam, Krishna, and Srikakulam are important producers.

6. Bihar. Bihar's main sugarcane producing areas comprise a continuation of the main sugarcane producing belt of U.P. In the recent years, area under sugarcane has decreased because much of the sugarcane area has been shifted to wheat cultivation.

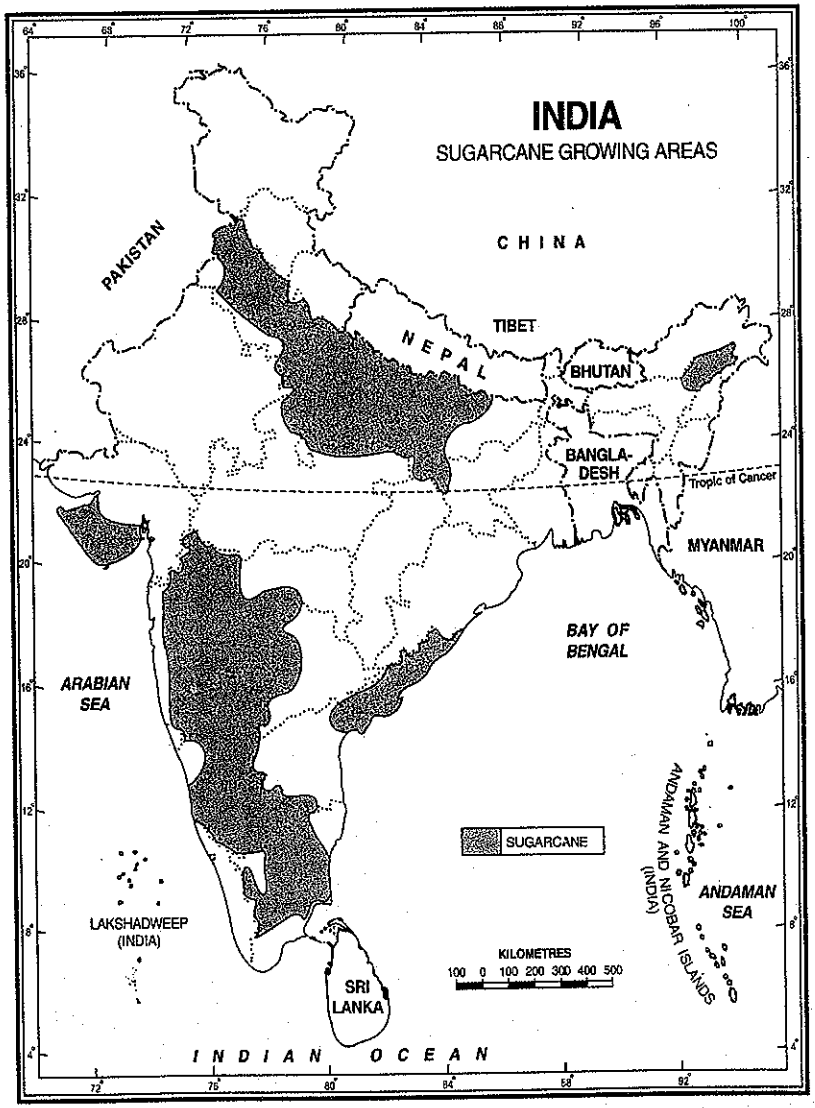

FIG. 22.4. India : Sugarcane Growing Areas

Champaran, Gaya, Saran, Muzaffarpur, Darbhanga and Patna are the main producing districts.

7. Gujarat. Gujarat produces only 3.53 per cent sugarcane from nearly 4 per cent area of India. Its recovery of 10.31 per cent of sugar is one of the highest among the major sugar cane producing states of India. Surat, Bhavnagar, Rajkot, Junagadh and Jamnagar are the important sugarcane producing districts.

8. Haryana. Haryana has progressed a lot in sugarcane cultivation during the last few years mainly due to the extension of irrigation facilities. It is an important cash crop in the fertile areas of Karnal, Kaithal, Ambala, Kurukshetra, Rohtak, Hisar, Panipat, Sonepat, Gurgaon and Faridabad districts. However, it avoids western dry districts.

9. Uttarakhand. Most of Uttarakhand is a hilly and mountainous area and is not suitable for sugarcane cultivation. However, parts of Udham Singh Nagar, Haridwar, Nainital and Dehra Dun districts are plain areas or areas located at the foothills. As such these districts help the state to produce about 1.75 per cent sugarcane of India. Udham Singh Nagar is basically a tarai area which is very rich from agriculture point of view. This district contributes major part of sugarcane production of the state.

10. Punjab. Sugarcane cultivation in Punjab has suffered a lot on account of shift in favour of wheat after the introduction of Green Revolution strategy. Still Gurdaspur, Jalandhar, Sangrur, Rupnagar, Patiala, Ludhiana, Firozepur, Amritsar districts are important producers of sugarcane in Punjab.

Others. Koraput, Cuttack, Puri and Sambalpur in *Odisha*; Gwalior, Morena, Ratlam in *M.P.*, Brahamputra valley in *Assam*, Burdwan, Birbhum, Hugly, Malda, North 24 Parganas, Nadia and Murshidabad in *West Bengal* and Ganganagar, Kota, Chittaurgarh, Bundi, Bhilwara and Udaipur districts in *Rajasthan* are other important producers of sugarcane in India.

TOBACCO

Tobacco is another important cash crop of India. This was brought to India by the Portuguese in 1508. Since then its cultivation has spread to different parts of the country and at present India is an important producer of tobacco in the world. Tobacco is mainly used for smoking in the form of cigarette, *bidi*, cigar, cheroot and *hookah* and is chewed also. It is also used for manufacturing insecticides. Normally speaking, tobacco is to be grown in rotation with other crops but the cash returns from this crop are so high that it is grown year after year on the same land in many parts of India. Surprisingly, it is the common opinion in many parts of Andhra Pradesh and Maharashtra that the quality of tobacco is much improved if it is continuously grown for many years on the same piece of land.

Conditions of Growth

It is a plant of tropical and sub-tropical climates and can withstand a wide range of temperature varying from 16° to 35°C. It normally requires 100 cm of annual rainfall but it can also be successfully grown in areas of 50 cm annual rainfall provided the rainfall is fairly distributed. Irrigation is required in areas of lower and erratic rainfall. Frost is injurious to its growth. Bright rainless weather is helpful at the curing stage. Well drained friable sandy loams, not too rich in organic matter but rich in mineral salts allowing full development of roots are best suited for tobacco. Soil is more important than climate. In fact, *soil rather than climate is the determining factor for its geographical distribution*. Further it can be grown from low lying flat plains upto a height of 1,800 metres. Cheap and abundant labour is required at all stages of its cultivation, starting from field preparation, transplantation, weeding, harvesting, processing and preparing it for the market.

Types of Tobacco

Broadly speaking, two types of tobacco are grown in India.

(*i*) *Nicotiana Tobacum* is of better quality and is used for cigarette, cigar, cherroot, *bidi*, chewing, snuff, *hookah* and pipe. The plant is tall and has long broad leaves with pink flowers. About 90 per cent of the total tobacco production in India is of this type.

(*ii*) *Nicotiana Rustica* needs cool climate and is mainly grown in northern and north-eastern parts of the country. Its plant is comparatively shorter and has round and puckered leaves and yellow flowers. It is grown mainly for *hookah*, chewing and snuff. It accounts for about 10 per cent of the total tobacco production of India.

Production

With a production of 8.2 lakh tonnes in 2011-12, India is the third largest tobacco producing country of the world after China (31.59 lakh tonnes) and Brazil (9.52 lakh tonnes) and accounts for 11.25 per cent of the world's total tobacco production. India is followed by USA, Malawi, Indonesia and Argentina in descending order with respect to production of tobacco. The production of tobacco had been slowly increasing and had more than doubled from 0.26 million tonnes in 1950-51 to 0.56 million tonnes in 1990-91. Varying trends in production have been observed between 1990-91, and 2007-08 after which there has been rapid increase in production. Similarly, the area under tobacco cultivation had increased from 0.36 million hectares in 1950-51 to 0.41 million hectares in 1990-91. The area suddenly fell to 0.26 million hectares in 2000-01 but picked up very fast to reach the highest level of 0.49 million hectares in 2010-11. The yield per hectare had also increased by about 2.5 times from 731 kg in 1950-51 to 1,772 kg in 2011-12. Trends of production, area and yield of tobacco in India from 1950-51 to 2011-12 are shown in **Table 22.27**.

Distribution

Although tobacco is grown in as many as 15 states of India, only two states *viz*. Gujarat and Andhra Pradesh account for about 65.3 per cent of the production and 62.42 per cent of the hectarage under tobacco in the country.

TABLE 22.27. Area, Production and Yield of Tobacco in India

Year	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Area (Million hectares)	0.36	0.40	0.45	0.45	0.41	0.26	0.37	0.37	0.35	0.39	0.44	0.49	0.46
Production (Million tonnes)	0.26	0.31	0.36	0.48	0.56	0.34	0.50	0.47	0.44	0.57	0.69	0.83	0.82
Yield (kg/hectare)	731	766	810	1065	1353	1318	1351	1274	1255	1456	1559	1687	1772

Source : Agricultural Statistics at a glance, 2013, pp. 120-21.

TABLE 22.28. Production of Tobacco in India (2011-12)

States	Area		Production		Yield
	'000 hectares	%age of all India	'000 tonnes	%age of all India	(kg/hectare)
1. Gujarat	158.00	34.01	279.00	33.89	1,766
2. Andhra Pradesh	132.00	28.41	259.00	31.46	1,962
3. Uttar Pradesh	24.05	5.18	124.70	15.15	5,185
4. Karnataka	115.00	24.75	106.00	12.87	922
5. Bihar	9.94	2.14	18.74	2.28	1,885
6. Tamil Nadu	2.87	0.62	4.38	0.53	1,526
7. Maharashtra	0.95	0.20	1.10	0.13	1,158
Others	21.76	4.68	25.74	3.13	1,183
All India	**464.57**	**100.00**	**823.33**	**100.00**	**1,772**

@ Since area/production is low in individual states, yield rate is not worked out.

Source : Agricultural Statistics at a glance, 2013, p. 122.

1. Gujarat. According to 2011-12 figures, Gujarat produced 279 thousand tonnes (33.89% of India) of tobacco from 158 thousand hectares (34% of India) of land giving the yield of 1,766 kg/hectare. About 90 per cent of Gujarat's tobacco comes from Kheda and Vadodara districts.

2. Andhra Pradesh. Andhra Pradesh has been the traditional producer of tobacco in India. In the year 2011-12, Andhra Pradesh accounted for 259 thousand tonnes (31.46% of all India) of tobacco from 132 thousand hectares (28.41% of all India) of land with an average yield of 1962 kg/hectare. This is higher than the yield of Gujarat and much lower than that of Uttar Pradesh, Prakasam, West Godawari, East Godavari, Krishna, Kurnool and Nellore are the main producing districts.

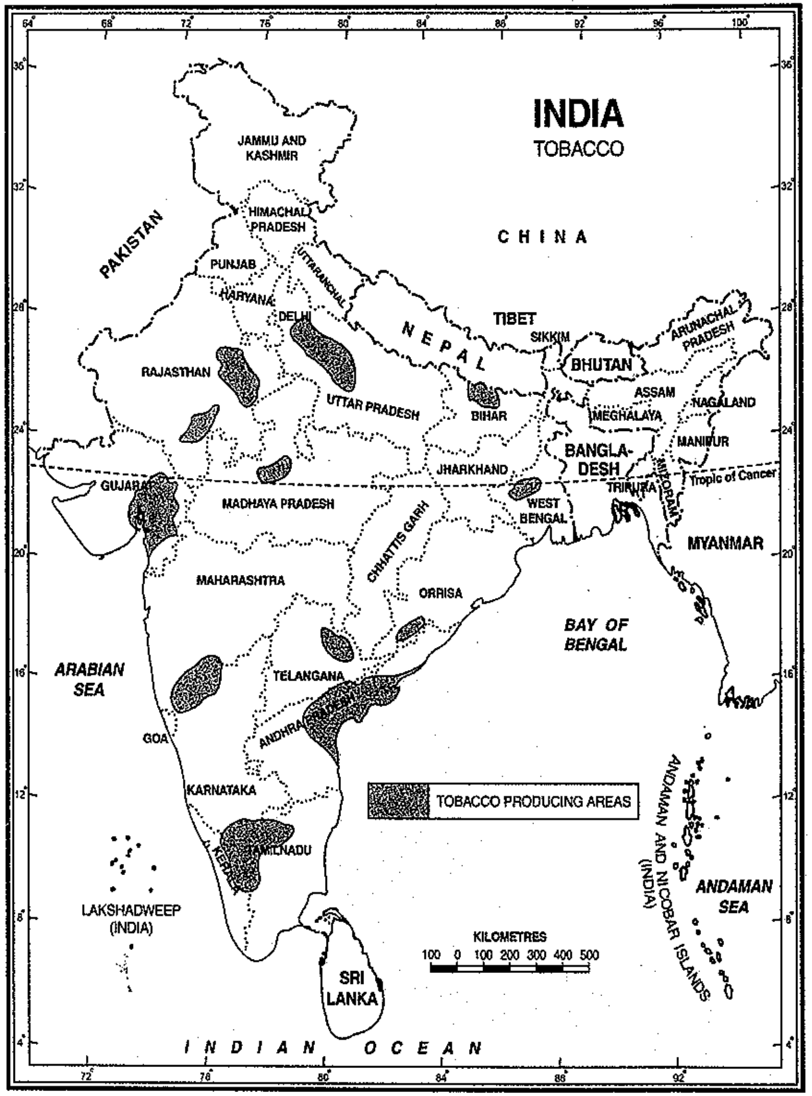

FIG. 22.5. India : Tobacco

TABLE 22.29. Value of Tobacco Exports (₹ crore)

Year	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Unmanufactured Tobacco	733.52	801.41	940.07	1021.32	1251.28	1432.80	2766.27	3621.44	3151.65	2898.56	3814.98
Manufactured Tobacco	289.37	295.06	314.54	309.34	433.89	499.09	294.78	722.96	833.74	1106.96	1221.03

Source : Agricultural Statistics at a glance, 2012, pp. 247-48.

Others. The other tobacco producing states in India are Uttar Pradesh (15.1%), Karnataka (12.9%) Bihar (2.3%), Tamil Nadu (0.53%), and Maharashtra (0.13%). It is worth noting that Uttar Pradesh gives the highest yield of 5,185 kg/ha against the national average of 1,772 kg/ha, although this state contributes a little over 15 per cent of the total tobacco production of India.

Trade

About 80 per cent of the total production of tobacco is used within the country and the remaining 20 per cent is exported. India is world's fourth largest exporter of tobacco. In 2012-13, the value of tobacco exports from India was ₹ 5036 crore. **Table 22.29** shows that bulk of India's tobacco export consists of unmanufactured tobacco and less than half to one-third of the foreign exchange is earned from the export of manufactured tobacco. Presently India exports tobacco to about 60 countries. Russia and U.K. purchase about two-third of our total tobacco exports. The other important buyers of Indian tobacco are Japan, Egypt, Sri Lanka, Nepal, Indonesia, Germany and Singapore. About 90 per cent of the tobacco export trade is handled by Chennai alone, the rest being handled by Kolkata, Mumbai and Vishakhapatnam. To make Indian tobacco more competitive in the world market in terms of price and quality, varieties with enhanced productivity and desirable quality traits should be developed.

OILSEEDS

Oilseeds constitute a very important group of commercial crops in India. The oil extracted from oilseeds form an important item of our diet and are used as raw materials for manufacturing large number of items like paints, varnishes, hydrogenated oil, soaps, perfumery, lubricants, etc. Oil-cake which is the residue after the oil is extracted from the oilseeds, forms an important cattle-feed and manure.

India has the largest area and production of oilseeds in the world. Nine major oil seeds *viz.*, groundnut, sesamum, rapeseed and mustard, linseed, safflower, castor seed, sunflower, and soyabean occupied 26.53 million hectares (2012-13) which is over 18 per cent of the net area sown. **Table 22.30** shows that there had been gradual increase in area, production and yield of oilseeds, with the passage of time, some short lived variations notwithstanding.

It must, however, be noted that the production of oilseeds has always fallen short of our demand and there has always been a need to import oilseeds or their products for meeting the demand of our evergrowing population.

TABLE 22.30. Area, Production and Yield of Nine Oilseeds in India

Year	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Area (Million hectares)	10.73	13.77	16.64	17.60	24.15	22.77	27.86	26.51	26.69	27.56	25.96	27.22	26.31	26.53
Production (Million tonnes)	5.16	6.98	9.63	9.37	18.61	18.77	27.98	24.29	29.76	27.72	24.88	32.48	29.80	31.01
Yield (kg/hectare)	481	507	579	532	771	810	1014	916	1115	1006	958	1193	1133	1169

Source : Agricultural Statistics at a glance, 2013, pp. 96-97.

TABLE 22.31. Distribution of nine oilseeds in India (2012-13)

States	Area		Production		Yield
	Million hectares	%age of all India	Million tonnes	%age of all India	(kg/hectare)
1. Madhya Pradesh	7.54	28.42	9.28	29.93	1,231
2. Rajasthan	4.92	18.55	6.2	19.99	1,260
3. Maharashtra	3.7	13.95	5.02	16.19	1,357
4. Gujarat	2.54	9.57	2.89	9.32	1,138
5. Andhra Pradesh	1.94	7.31	1.64	5.29	845
6. Uttar Pradesh	1.16	4.37	1.04	3.35	897
7. Haryana	0.58	2.19	0.99	3.19	1,707
8. Karnataka	1.46	5.5	0.95	3.06	651
9. Tamil Nadu	0.43	1.62	0.9	2.9	2,093
10. West Bengal	0.74	2.79	0.83	2.68	1,122
11. Odisha	0.24	0.9	0.17	0.55	708
12. Assam	0.28	1.06	0.17	0.55	607
13. Bihar	0.14	0.53	0.16	0.52	1,143
14. Punjab	0.05	0.19	0.07	0.23	1,400
Others	0.81	3.05	0.7	2.26	@
All India	**26.53**	**100**	**31.01**	**100**	**1,169**

@ Since area/production is low in individual states, yield rate is not worked out.
Source : Agricultural Statistics at a glance, 2013, p. 98.

With limited scope of bringing additional area under oilseeds, increase in oilseed production will have to come primarily from land saving technologies highlighting a combination of high yield plant type, standard crop management practices and balanced crop nutrition.

There have been large scale regional variations in area, production and productivity changes in oilseeds. Only a few states like Haryana, Madhya Pradesh, Rajasthan and West Bengal increased their oilseed production both through area expansion and productivity improvement. States like Maharashtra, Tamil Nadu and Himachal Pradesh increased their oilseed output mainly through productivity improvement. In some states like Odisha, area productivity and production declined sharply.

Table 22.31 shows that Madhya Pradesh, Rajasthan, Maharashtra and Gujarat are the main producers of nine oilseeds and account for over two-third of the area and more than three-fourths of the production of India. Tamil Nadu gives maximum yield of 2,093 kg/hectares. Other producers include Andhra Pradesh, Uttar Pradesh, Haryana, Karnataka, Tamil Nadu, West Bengal, Odisha, Assam, Bihar and Punjab.

GROUNDNUT

Groundnut is the most important oilseed of India and accounts for a little less than half of the major oilseeds produced in the country. Groundnut kernels are rich in proteins and vitamins and have high calorific value. It contains 40-50 per cent oil which is mainly used as edible oil in its pure form or in hydrogenated vanaspati form. The groundnut oil is also used for manufacturing margarine, medical emulsions, soap and toilet requisites. Groundnut is eaten raw, roasted, sweetened or salted. Its oil cake is used as an important rich cattle feed. It serves as an important rotation crop because it syntehsizes atmospheric nitrogen and increases the fertility of soil.

TABLE 22.32. Area, Production and Yield of Groundnut in India

Year	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Area (Million hectares)	4.49	6.46	7.33	6.80	8.31	6.56	6.74	5.62	6.29	6.16	5.48	5.86	5.26	4.77
Production (Million tonnes)	3.48	4.81	6.11	5.01	7.51	6.41	7.99	4.86	9.18	7.17	5.43	8.26	6.96	4.75
Yield (kg/hectare)	775	745	834	736	904	977	1187	886	1459	1163	991	1411	1323	996

Source : Agricultural Statistics at a glance, 2012, pp. 97-98.

Conditions of Growth

It thrives best in the tropical climate and requires 20°-30°C temperature and 50-75 cm rainfall. Isohyet of 100 cm marks the upper limit of groundnut cultivation. It is highly susceptible to frost, prolonged drought, continuous rain and stagnant water. Dry winter is needed at the time of ripening. It can be grown both as a *kharif* and as a *rabi* crop but 91 per cent of the total area under groundnut is devoted to *kharif* crop. Well drained light sandy loams, loams, red, yellow and black cotton soils are well suited for its cultivation.

Production and Distribution

India is the second largest producer of groundnut contributing about 17.4% of the world's total production but is way behind China's 40.27 per cent. **Table 22.32** shows that there had been large scale temporal variations in area production and yields of groundnut depending on the farmer's choice of crops and weather conditions. It must be noted that groundnut is primarily a rainfed crop and there are bound to be fluctuations in its production, area and yield depending upon the amount of rainfall and its temporal distribution.

Table 22.33 shows that Andhra Pradesh, Tamil Nadu, Gujarat and Rajasthan are the four main producers. These four states together account for over 70% of total production of India. ***Andhra Pradesh*** is the largest producer of groundnut in India and accounts for over 23 per cent of India's total production. About 50 per cent of the state's production comes from Chittoor, Kurnool and Anantpur districts, though other districts also produce sufficient groundnut. ***Tamil Nadu*** is the second largest producer accounting for over 18 per cent of the total groundnut produced in India. Salem, Tiruchirapalli and Coimbatore districts produce half of the state's total output. ***Gujarat*** is the third largest producer contributing 16 per cent of India's total production. About 60 per cent of the state's total production comes from Junagadh, Jamnagar, Amreli, Bhavnagar, Rajkot, Sabarkantha, Panchmahals and Surat districts. ***Rajasthan*** produces over 13 per cent of India's groundnut. Chittaurgah, Bhilwara, Tonk, Jhalawar, and Jaipur are the main producing districts. ***Karnataka*** produces over 8 per cent of India's groundnut. Dharwar, Gulbarga, Belgaum, Bellary, Kolar, Tumkur, Raichur and Mysore districts supply about three-fourths of the state's total production. ***Maharashtra*** produces about 5 per cent of India's groundnut. Jalgaon, Dhule, Kolhapur, Satara, Osmanabad, Yavatmal, Nashik and Amravati districts produce about two-thirds of the state's production.

The other producers in order of importance are Odisha, Madhya Pradesh and Uttar Pradesh. West Bengal, Kerala, Punjab, Haryana and Bihar also produce small quantities of groundnut.

Trade

About 75 per cent of the total production enters the interestate trade—the main traders being Andhra Pradesh, Tamil Nadu, Gujarat, Maharashtra, Karnataka and Punjab. India's capacity to export groundnut and its products has drastically been reduced due to increased domestic consumption resulting from rapid population growth. However, groundnut cake is still exported to U.K. and other European countries and to Russia.

TABLE 22.33. Distribution of Groundnut in India (2012-13)

States	Area		Production		Yield
	Million hectares	%age of all India	Million tonnes	%age of all India	(kg/hectare)
1. Andhra Pradesh	1.35	28.30	1.11	23.37	822
2. Tamil Nadu	0.36	7.55	0.86	18.11	2,389
3. Gujarat	1.29	27.04	0.76	16.00	589
4. Rajasthan	0.40	8.39	0.62	13.05	1,550
5. Karnataka	0.65	13.63	0.41	8.63	631
6. Madhya Pradesh	0.21	4.40	0.31	6.53	1,476
7. Maharashtra	0.22	4.61	0.25	5.26	1,136
8. Uttar Pradesh	0.09	1.89	0.09	1.89	1,000
9. Odisha	0.07	1.47	0.08	1.68	1,143
Others	0.13	2.73	0.26	5.47	@
All India	**4.77**	**100.00**	**4.75**	**100.00**	**996**

@ Since area/production is low in individual states, yield rate is not worked out.

Source : Agricultural Statistics at a glance, 2013, p. 101.

SESAMUM (*Til*)

Sesamum contains 45 to 50 per cent oil which is used for cooking purposes and for manufacturing perfumery and medicines. Sesamum seeds are eaten in fried form mixed with sugar or gur. Its oil-cake is fed to milch cattle.

Conditions of Growth

Sesamum is a rainfed crop and requires 45-50 cm rainfall. It thrives well in areas having 21°-23°C temperature. Frost, prolonged drought and heavy rains for a longer duration are harmful to this crop. Well-drained light loamy soils are best suited to sesamum. It is cultivated in plains as well as on elevations upto 1,300 metres. It is grown as a *kharif* crop in the north and as a *rabi* crop in the south.

Production and Distribution

India has the world's largest area under sesamum and is also the largest producer of this crop accounting for one-third of the world production. Since it is a rainfed crop, the production figures show fluctuating trends. But there has been an overall 87 per cent increase in its production from 4.5 lakh tonnes in 1950-51 to a record 8.4 lakh tonnes in 1990-91. After that, the production had fluctuated but the general trend had been on the decline. Signs of recovery had been seen in 1996-97 and 2001-02 but generally the country fails to maintain a higher level of production. The overall production declined from 698 thousand tonnes in 2001-02 to 618 thousand tonnes in 2006-07. The decline is still continuing.

Sesamum is produced in almost all parts of the country but West Bengal is the largest producing state and accounts for about one-third of the total production of India. The other major producers are Gujarat, Rajasthan, Maharashtra, Tamil Nadu, Karnataka, Madhya Pradesh, Andhra Pradesh and Uttar Pradesh.

RAPESEED AND MUSTARD

Next to groundnut, rapeseed and mustard are two most important oilseeds of India. The oil content of these seeds is 25-45% which is used as a cooking medium, preservative for pickles, lubricants and toiletteries. Oil cake forms an important cattlefeed and is also used as manure.

TABLE 22.34. Area, Production and Yield of Rapeseed and Mustard in India

Year	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Area (Million hectares)	2.07	2.88	3.32	4.11	5.78	4.48	7.28	6.79	5.83	6.30	5.59	6.90	5.89	6.34
Production (Million tonnes)	0.76	1.35	1.98	2.30	5.23	4.19	8.13	7.44	5.83	7.20	6.61	8.18	6.60	7.82
Yield (kg/hectare)	368	467	594	560	904	936	1117	1095	1001	1143	1183	1185	1121	1234

Source : Agricultural Statistics at a glance, 2013, pp. 102-03.

Conditions of Growth

Like wheat and gram, they thrive only in cool climate of the Satluj-Ganga plain and very small quantity is grown in the peninsular India. They are mainly grown as rabi crop in pure or mixed form with wheat, gram and barley.

Production and Distribution

India and is world's third largest producer after Canada and China, accounting for about 10% of world's production. There has been nearly four-fold increase in their production in three decades from 1960-61 to 1991 after which varying trends of production have been noticed.

But considerable increase in production and yield has been recorded from 2000-01 to 12-13 (**Table 22.34**).

Rajasthan excells all other states with respect to production of mustard and rapeseed and produces over 46 per cent from over 44 per cent of area under these crops in India. Bharatpur, Kota, Alwar, Jaipur, Chittaurgarh, Tonk, Sawai Medhopur, Udaipur, Pali districts contribute the major part of production and cover large area. *Haryana* is the second largest producer and has the distinction of giving the highest yield of 1,714 kg/hectare. Hisar, Sirsa, Fatehabad, Mahandergarh, Rewari, Gurgaon, Mewat, Bhiwani are the chief producers. *Madhya Pradesh* is the third

TABLE 22.35. Distribution of Rapeseed and Mustard in India (2012-13)

States	Area		Production		Yield
	Million hectares	%age of all India	Million tonnes	%age of all India	(kg/hectare)
1. Rajasthan	2.83	44.64	3.65	46.68	1,290
2. Haryana	0.56	8.83	0.96	12.28	1,714
3. Madhya Pradesh	0.78	12.3	0.92	11.76	1,179
4. Uttar Pradesh	0.66	10.41	0.84	10.74	1,273
5. West Bengal	0.47	7.41	0.46	5.88	979
6. Gujarat	0.21	3.31	0.34	4.35	1,619
7. Assam	0.25	3.94	0.16	2.05	640
8. Bihar	0.09	1.42	0.11	1.41	1,222
9. Punjab	0.03	0.47	0.04	0.51	1,333
Others	0.46	7.26	0.34	4.35	@
All India	**6.34**	**100.00**	**7.82**	**100.00**	**1,233**

@ Since area/production is low in individual states, yield rate is not worked out.

Source : Agricultural Statistics at a glance, 2013, p. 104.

largest producer. Bhind, Morena and Gwalior are the main producing districts in this state. *Uttar Pradesh* is the triditional producer but has surrendered its top position during the last few years, partly due to fall in its own production and partly due to increase in production in other states. Agra, Faizabad, Meerut, Kanpur, Saharanpur, Etah and Etawah are the chief producing districts. *West Bengal* has also emerged as a major producer. West Dinajpur, Birbhum, Nadia and Murshidabad districts contribute the bulk of production. Gujarat, Assam, Bihar, Punjab, Odisha etc. are some of the other producing states.

LINSEED

Linseed has 35 to 47 per cent oil content. This oil has a unique drying property and is used for manufacturing paints, varnishes, printing ink, oil-cloth, and water-proof fabrics. It is also used as an edible oil in some parts of the country.

Conditions of Growth

Although this crop can be grown under varied geographical conditions, it prefers cool, moist climate with about 20°C temperature and 75 cm rainfall. Clay loams, deep black soils and alluvial soils are best suited for its cultivation. It can be cultivated upto a height of 800 metres above sea level. It is a *rabi* which is sown in Oct-Nov. and harvested in March-April.

Production and Distribution

India produces about 10 per cent of world's linseed and is world's third largest producer after Russia and Canada. However, there had been almost consistent decline in production during the last few years and the production had fallen from 322 thousand tonnes in 1990-91 to 168 thousand tonnes in 2006-07.

Madhya Pradesh, Bihar, Uttar Pradesh, Chhattisgarh and Maharashtra are the main producers accounting for about four-fifths of the total production of India. *Madhya Pradesh* is the largest producer accounting for 49 thousand tonnes (29%) of linseed. Balaghat, Satna, Rewa, Hoshangabad, Vidisha, Jhabua, Sagar, Guna and Panna contribute a major part of the production. *Bihar* is the second largest producer of linseed in India. In 2006-07, this state produced 24 thousand tonnes of linseed which was over 14 per cent of the all India production. Darbhanga, Purnea, Muzaffarpur, Bhagalpur, Rohtas and Champaran are the chief producing districts. *Uttar Pradesh* is the third largest producer with 19 thousand tonnes (11.3%) of linseed to its credit. Almost every district in Uttar Pradesh produces some linseed as a mixed crop but Agra, Etawah, Kanpur, Mirzapur, Allahabad, Gonda, Bahraich and Hamirpur are the main contributors. *Chhattisgarh* produced 17 lakh tonnes (10%) linseed in 2006-07. Durg, Raipur and Bilaspur are the main producing districts. *Maharashtra* produced 13 thousand tonnes accounting for over 9.5 per cent of the total production of India. Chandrapur, Osmanabad, Bhandara, Nagpur, Aurangabad, and Parbhani are the main producers. The other producers include Rajasthan, Odisha and Karnataka.

CASTOR SEED

Castor seed contains 50 per cent oil which is used for various purposes such as lubricant in various machines, hair oil, lighting and for manufacturing soap and leather tanning. Oil-cake is used as manure and leaves of the plant are fed to silk worms.

Conditions of Growth

Castor seed plant grows into a small tree and is generally raised as a mixed crop in tropical and sub-tropical climates. It thrives well in areas of 20°-25°C temperature and 50-75 cm rainfall. It is grown on red sandy loams in the peninsular India and on light alluvial soils of the Satluj-Ganga plain. Almost the whole area of castor seed production is rainfed. It is a *kharif* crop in the north and a *rabi* crop in the south.

Production and Distribution

India is the second largest producer of castor seed after Brazil and produces about one-fifth of the total world production. The production increased from a meagre one lakh tonnes in 1950-51 to all time record of over nine lakh tonnes in 1996-97. Thereafter, the production fell and stood at 7.6 lakh tonnes only in 2006-07. Gujarat, Rajasthan and Andhra Pradesh are the main producers. **Gujarat** is the largest producer of castor seed in India and accounts for more than two- thirds of the total production. Mehsana, Kheda, Sabarkantha, and Banaskantha are the main producing districts. **Rajasthan** is the second largest producer contributing about 13.6 per cent of India's castor seed. About half the production of this state comes from Sirohi district and the rest is produced by Jalore and Barmer districts. **Telangana** is also an important producer where major production comes from Nalgonda, Mahbubnagar, Warangal, Hyderabad and Rangareddi. The remaining castor seed is produced by Rajasthan, Odisha, Karnataka and Tamil Nadu.

PLANTATION CROPS

Plantation crops are those crops which are grown on plantations covering large estates. Unlike other crops, they are not annual crops and usually take 3-5 years to bear returns after they are sown. But once they start bearing fruit, they continue to do so for 35-40 years. They require heavy initial capital investment and high level technology for their growth and processing. They cover small area in India but are of high economic value. Tea, coffee and rubber are the principal plantation crops but spices are also included in this category. Tea and coffee crops are also famous as *beverage crops*. There are over 30,000 plantations in India giving full or part time employment to over 20 lakh persons. Most of the plantations are under tea, coffee and rubber.

TEA

Tea is the dried leaf of a bush. It contains theine and when added to boiling water along with sugar and milk, it gives a very cheap and stimulating drink. Thus it is the most important **beverage crop** of India.

Tea bush is supposed to be indigenous to China but it was reported by Major Robert Bruce in 1823 that indigenous tea bushes grew wild on the hill slopes of upper Assam. In the year 1840, tea seeds were imported from China and commercial tea plantations were set up in the Brahmaputra valley. To begin with, tea plantations were confined to Upper Assam only but later on, new areas such as lower Assam and Darjeeling were also opened up to tea plantations and by 1859, there were 30 tea plantations in Assam alone. Later on, tea plantations were also set up in Nilgiri Hills of South India, Tarai along the foothills of the Himalayas and in some places in Himachal Pradesh.

Conditions of Growth

Tea bush is a tropical and sub-tropical plant and thrives well in hot and humid climate. *There is a very close relation between climate, the yield and the quality of tea.* The ideal temperature for its growth is 20°-30°C and temperatures above 35°C and below 10°C are harmful for the bush. It requires 150-300 cm annual rainfall which should be well distributed throughout the year. While prolonged dry spell is harmful for tea, high humidity, heavy dew and morning fog favour rapid development of young leaves. Alternate waves of warm and cool winds are very helpful for tea leaves. Tea is a shade-loving plant and develops more vigorously when planted along with shady trees.

Tea bush grows well in well drained, deep, friable loams. However, virgin forest soils rich in humus and iron content are considered to be the best soils for tea plantations. Relatively large proportion of phosphorus and potash in the soil gives special flavour to tea as is the case in Darjeeling. In order to increase the yield, proper dose of nitrogenous fertilizers such as ammonium sulphate should be given to soil.

Although tea requires heavy rainfall for its growth, stagnant water is injurious to its roots. It is, therefore, grown on hill slopes where water drains away easily and waterlogging does not take place. However, it grows equally well in the valleys if the drainage is good. Most of the tea plantations in India are found at elevations ranging from 600 to 1,800 metres above sea level.

Tea is a labour intensive crop and requires abundant supply of cheap and skilled labour, especially at the time of plucking the tea leaves. This is a tedious process which requires skilled manipulation of fingers for plucking two leaves and a bud at a time. For this purpose, women labourers are employed in large numbers. Currently, tea industry provides employment to one million workers. Through its forward and backward linkages another 10 million people derive their livelihood from tea. It is one of the largest employers of women among organised industries of India. Women constitute over 50 per cent of the total workforce.

Method of Cultivation

Tea gardens are set up on the cleared hill slopes

TABLE 22.36. Area, Production and Yield of Tea in India

Year	1970-71	1980-81	1990-91	2000-01	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
Area (Million hectares)	0.4	0.4	04	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Production (Million tonnes)	0.4	0.6	0.7	0.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Yield kg/hectare	1182	1491	1784	1673	1705	1695	1695	1695	1695	1,730	1,730

Source : Economic Survey 2012-13, pp. A.17-19 and 2013-14 Statistical Appendix pp. 17-19.

where shade trees are planted in advance. Seeds are sown in the germination beds and the saplings transplanted to the garden. The garden is regularly hoed and weeded so that tea bush grows without any hindrance. Use of manures and fertilizers is a common practice in the gardens. Oil cakes and green manures are widely used. Pruning of the plant is an essential part of tea cultivation. It helps in maintaining the proper shape of tea bush to a height of about one metre with about the same diameter. The aim of pruning is to have new shoots bearing soft leaves in plenty and to facilitate the plucking of leaves by women labourers from the ground.

Production

Tea cultivation does not have long tradition in India as it started in the middle of nineteenth century only, when first tea plantations were established in Assam. However, tea cultivation has shown steady progress right from the beginning. At the time of Independence, tea gardens covered 3,011 lakh hectares producing 2.61 lakh tonnes of tea. The progress of tea cultivation in India from 1970-71 to 2013-14 is shown in **Table 22.36.**

This table shows that production and area of tea in India has increased by 2.5 times and 1.5 times respectively between 1970-71 and 2013-14 and its yield has increased by almost 1.5 times during the same period. At present, India is the third largest producer of tea in the world, next to China and Turkey and contributes 17.1 per cent of the world's tea production.

Distribution

Tea cultivation in India is highly concentrated in a few selected pockets. Following three areas of tea cultivation are identified according to their importance as tea producers and their location.

(1) North-East India (2) South India (3) North-West India.

TABLE 22.37. Distribution of tea in India (2005-06)

States	Area		Production		Yield	No. of tea
	'000 hectares	%age of all India	'000 tonnes	%age of all India	Quintals/ hectare	gardens
1. Assam	272	52.01	474	51.08	17.4	790
2. West Bengal	115	21.99	215	23.17	18.8	315
3. Tamil Nadu	76	14.53	155	16.70	20.3	6,795
4. Kerala	37	7.07	67	7.22	18.1	4,215
5. Tripura	8	1.53	8	0.86	8.7	15
6. Karnataka	2	0.38	5	0.54	25.3	25
Others	13	2.49	4	0.43	—	13,635
All India	**523**	**100.00**	**928**	**100.00**	**17.7**	

Source : Data collected from different sources.

1. North-Eastern India

It is more or less a triangular area mainly in Assam and West Bengal. It extends from 23°N to 28°N latitudes and 88°E to 96°E longitudes. This is the most important tea producing region of India accounting for about three-fourth production and about the same percentage of area under tea production. Tea plantations are small in number (see **Table 22.37**) but fairly large in size, generally more than 200 hectares.

Assam. Assam is the largest producer of tea accounting for over 51 per cent of the production and over 52 per cent of area under tea cultivation in India. The average yield is 17.4 quintals/hectare. Two destinct areas of tea production can be identified.

(*a*) ***The Brahmaputra Valley*** extending from Sadiya to Goalpara comprises the main tea producing belt. It accounts for 44 per cent of India's tea from 40 per cent of tea area of the country. There are 676 tea estates mainly in the districts of Dibrugarh, Lakhimpur, Sibsagar, Darrang, Kamrup, Nagaon, and Goalpara. With summer temperature of 30°C and winter temperature never falling below 10°C, frost free weather throughout the year and 300-400 cm annual rainfall extended over 9 months; the area provides ideal climatic conditions for tea cultivation. Tea estates are located on the raised grounds (upto 450 metres) so that annual inundations and stagnant water during the rainy season do not harm the crop.

(*b*) ***Surma Valley*** is the second important in producing area in Assam. This valley, lying in Cachar district, produces about 5 per cent of country's tea from 9 per cent of land under this crop. Here the tea gardens are scattered over small mounds called *teelas* or *bheels* or well drained flats along the river and its tributaries. Here rainfall is 300-400 cm and no month is completely dry.

West Bengal. West Bengal is the second largest producer contributing over 23 per cent of India's tea from about 22 per cent of the country's total area under tea cultivation. Entire tea of West Bengal is produced in three northern districts of Darjeeling, Jalpaiguri and Koch Bihar. These districts are contiguous to the main tea producing belt of Assam. Tea producing areas of West Bengal are divided into two geographical regions.

(*a*) ***The Duars*** in Koch Bihar and Jalpaiguri districts is a 16 km wide strip at the foot of the Himalayas. Here tea is raised on slightly elevated areas where suitable slope for proper drainage is available. Tea estates are found upto a height of 900-1,200 m.

(*b*) ***Darjeeling*** district is well known all over the world for its most exquisite aromatic tea. Annual rainfall of 300 cm; moderate temperature and fertile soils give special flavour to tea although yields are quite low, generally below 20 quintals/hectare. Tea estates are found within 900-1,800 m elevation beyond which the temperature is low and does not support tea cultivation. According to a study conducted by Tea Board in 2002, land under tea cultivation can be increased by more than 5 per cent. In some of the smaller gardens of Darjeeling, land under tea cultivation can be increased by about 22 per cent.

Some tea gardens are also found in Tripura, Arunachal Pradesh and Manipur in north-east India.

2. South India

In South India tea is produced in Nilgiri, Cardamom, Palni and Anaimalai hills in Tamil Nadu, Kerala and Karnataka states extending from 9°N to 14°N latitudes. This region accounts for 25 per cent production and about 44 per cent of area under tea in India. Tea gardens are mostly located on the hill slopes of the Western Ghats between 300 and 1,800 m altitude. The tea estates are quite large in number (*see* **Table 22.37**) but quite small in size. The temperatures are uniformally high and the annual rainfall exceeds 400 cm. There is no fear of frost in south India and weather conditions are quite congenial. Therefore, the productivity is higher, generally 15-25 quintals/hectare, although the quality of tea is inferior. But some of the south Indian teas have a good combination of taste and flavour.

In South India, **Tamil Nadu** is the largest producer of tea accounting for over 16 per cent of total tea production of India from over 14 per cent of the land. Nilgiri and Anaimalai produce 46 per cent and 33 per cent of Tamil Nadu's tea respectively. **Kerala** is another important producer of tea in South India accounting for 7.22 per cent of the total production of India. Kottayam, Kollam and Thiruvananthapuram are the main tea producing districts. Some tea is produced in Hassan and Chikmaglur districts of **Karnataka.** This state has the distinction of giving the highest yield of over 25 quintals per hectare.

3. North West India

Some of tea is produced in Dehra Dun, Almora and Garhwal districts of Uttarakhand and in Kangra Valley and Mandi district of Hiamchal Pradesh. Green tea is produced in Kangra valley of Himachal Pradesh.

Tea in small quantity is also produced in Ranchi and Hazaribagh districts of Chota Nagpur plateau in Jharkhand.

Trade

Besides being the third largest producer, India is also one of the leading exporters of tea in the world. India had a long tradition of being the largest exporter of tea in the world, but her predominant position as an undisputed leader of tea exporting country has been severely shattered by fast increasing domestic consumption and by tough competition by some other tea exporting countries in the world market. Despite impressive increase in the production of tea from 0.4 million tonnes in 1970-71 to one million tonnes in 2013-14, our exports have been varying from 2.0 lakh tonnes to 2.6 lakh tonnes between 2008-09 and 2012-13.

In the year 2012-13, India exported 267.49 thousand tonnes of tea worth ₹ 4,677.8 crore.

Our present per capita consumption of about 0.6 kg is much lower than that of 0.8 kg in Australia, 0.9 kg in Japan, 1.0 kg in New Zealand, 1.5 kg in Ireland and 2.4 kg in United Kingdom. If our per capita consumption also increases along with the increase in population, for which there is a vast scope, we shall be left with very little surplus for export. Internal consumption of tea has already grown from a modest of 319 million kg in 1981 to a staggering 960 million kg in 2012-13.

Any attempt to increase production and thereby increase export after meeting the increasing domestic demand will largely involve new seeds and techniques of tea cultivation because prospects of acquiring virgin land for expanding tea plantations are extremely bleak. A study by the Tea Board in 2007 has revealed that 38 per cent of all tea bushes are over 50 years and another 90 per cent are in the age group of 40-50 years, and are not capable of giving high yields. There is urgent need to replace the old bushes with new plants. TV-29, a high yielding clone of tea was introduced in 1991. This seed gives four times as large as the average yield given by the conventional seeds and holds out great possibilities for increasing tea production in India. Old bushes giving low yields are likely to be replanted gradually with high yielding tea plants. In order to achieve this goal of meeting the growing demand in the home market and to produce surplus for export a plan for additional 5,000 hectares of new plantations in the non-traditional areas, replanting of 20,000 hectares of old bushes by new plants and rejuvenation of 40,000 hectares by irrigation, proper drainage and improved cultural practices has been chalked out. In 2007, a plan was approved for replantation of 1.71 lakh hectares and rejuvenation of 0.42 lakh hectares in 1600 estates. Forty six per cent of the total area to be replanted/rejuvenated falls in Assam, 28 per cent in West Bengal and 22 per cent in Tamil Nadu and other south Indian states.

In addition to the increasing domestic demand and dwindling exportable surpluses, India has to face tough competition from other tea exporting countries especially from Sri Lanka, China, Japan, Vietnam, Indonesia and some African countries like Kenya. India's share in the world market has come down from 45 per cent in 1950-51 to about 10 per cent in 2012-13. Exports from Sri Lanka occasionally surpass the exports from India. India exports tea to as many as 80 countries but Russia, U.K., the USA, Germany, Australia, Afghanistan, Ireland, Sudan, Iran, Iraq, Egypt, etc. are our main customers. U.K. is generally the chief buyer. A remarkable feature of export during 2002 was the sharp rise tea exports to Iraq, which had become the second largest (22 per cent) destination of Indian tea after Russia (24 per cent). Tea exports to West Asia—North Africa region jumped to 76 million kg in 2002, from 48 kg in 2001 mainly due to increased exports to Iraq under the 'Oil-for-Food Programme'. Pakistan imports about 140 million kg of tea annually and we export only eight million kg to our neighbouring country. Thus there is lot of scope to increase our tea exports to Pakistan. Kolkata is the chief port of tea export from India. The other major ports through which tea is exported are Chennai, Mangalore and Kochi.

TABLE 22.38. Exports of Tea from India

Year	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Quantity (Thousand tonnes)	182.8	177.77	183.4	162.86	185.63	197.39	207.46	207.53	238.34	292.35	267.49
Value (₹ crore)	1652.67	1637.35	1840.30	1730.73	1969.51	2034.17	2688.87	2943.53	3354.31	4078.53	4677.08

Source : Agricultural Statistics at a glance, (2012), pp. 248-49 and 2013 pp. 245-46.

TABLE 22.39. Imports of Tea by India

Year	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Quantity (Thousand tonnes)	23.64	10.77	31.76	18.75	23.29	19.73	25.16	34.46	20.82	22.43	22.30
Value (₹ crore)	125.30	64.60	146.92	108.14	127.06	130.95	197.00	276.54	202.00	218.90	274.43

Source : Agricultural Statistics at a glance, (2012), pp. 245-46 and 2013, pp. 242-43.

Of late, some quality of tea is being imported for blending and re-exports. Large quantities of inferior quality tea are imported and re-exported, severely affecting India's quality image in the international market. **Table 22.39** shows the trends in tea imports by India.

Over 80 per cent of the imported tea was supplied by Vietnam, Indonesia and Sri Lanka. Vietnam was the largest source accounting for 55 per cent of the total imports. Taking a serious note of falling tea exports, the Government of India took several steps in 2004 to help tea growers in increasing the production and exports of tea.

COFFEE

Coffee is the second most important **beverage crop** of India next only to tea. It is indigenous to Abyssinia Plateau (Ethiopia) from where it was taken to Arabia in 11th century. From Arabia, its seeds were brought to India by Baba Budan in the 17th Century and were raised in the Baba Budan Hills of Karnataka. British planters took keen interest in coffee plantations and large coffee estates were established near Chikmagalur (Karnataka) in 1826, in Manantody (Waynad) and Shevoroys in 1830 and Nilgiris in 1839. Currently, there are over 52,000 coffee gardens giving employment to 2.5 million persons.

Conditions of Growth

Coffee plant requires hot and humid climate with temperature varying between 15°C and 28°C and rainfall from 150 to 250 cm. It does not tolerate frost, snowfall, high temperature above 30°C and strong sun shine and is generally grown under shady trees. Prolonged drought is also injurious to coffee. Dry weather is necessary at the time of ripening of the berries. Stagnant water is harmful and this crop is grown on hill slopes at elevations from 600 to 1,600 metres above sea level. Northern and eastern aspects of slopes are preferred as they are less exposed to strong afternoon sun and the south-west monsoon winds. Well drained, rich friable loams containing good deal of humus and minerals like iron and calcium are ideal for coffee cultivation. The soil must be properly manured to retain and replenish fertility and to increase productivity. Coffee cultivation requires plenty of cheap and skilled labour for various operations including sowing, transplanting, pruning, plucking, drying, grading and packing of coffee.

Production and Distribution

India produces about 3.5 per cent of world's coffee on almost the same percentage of coffee plantations. Thus India is an insignificant producer of coffee and stands nowhere when compared with Brazil (25%), Colombia (15%) and Indonesia (7%). However, India has progressed a lot in terms of absolute figures as is clear from **Table 22.40**.

TABLE 22.40. Production of Coffee in India

Year	1970-71	1980-81	1990-91	2000-01	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
Area (Million/hectares)	0.1	0.2	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4
Production (Million tonnes)	0.1	0.1	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Yield (kg/hectare)	814	624	759	959	748	815	838	838	766	766

Source : Economic Survey 2013-14, Statistical Appendix, pp,. 17-19.

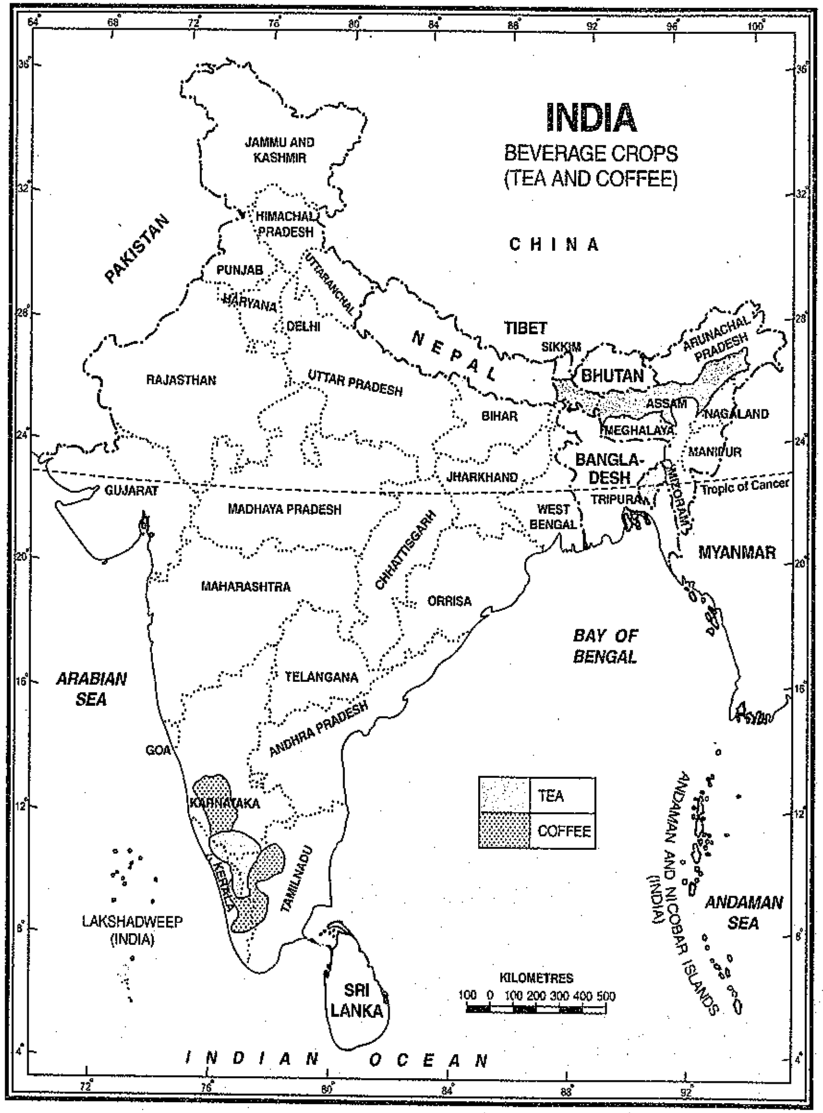

FIG. 22.6. India : Beverage Crops (Tea and Coffee)

Currently, India is the seventh largest producer of coffee in the world after Brazil, Vietnam, Colombia, Indonesia, Ethiopia, and Mexico.

Coffee Arabica and *Coffee Robusta* are the two main varieties of coffee grown in India accounting for 49 per cent and 51 per cent of area respectively under coffee.

The restricted agro-climatic conditions have forced the coffee plantations to confine themselves to small area in south India comprising hill areas around Nilgiris. Almost the entire production is shared by three states namely Karnataka, Kerala and Tamil Nadu.

Karnataka is the largest producer accounting for over 71 per cent of total coffee production and 59 per cent of the area under coffee in India. This state also gives the highest yield of 9.6 quintals/hectare. Most of the 4,650 plantations are at about 1,370 metres above sea level where annual rainfall is 125-150 cm. Kodagu and Chikmagalur account for over 80 per cent of the state's total output. The other important coffee producing districts are Shimoga, Hassan and Mysore. **Kerala** is the second largest producer of coffee but lags far behind, accounting only for about 22.27 per cent of the total production of the country. Its yield of 7.6 quintals/hectare is also low as compared to 9.6 quintals/hectare of Karnataka. Most of the coffee plantations are at an altitude of 1,200 m where annual rainfall is over 200 cm. Kozhikode, Waynad, Malappuram, Kollam, Kannur and Palakkad are the chief producing districts. **Tamil Nadu** is the third largest producer where India's 6.5 per cent coffee is produced. About half of Tamil Nadu's coffee is produced in Nilgiri district. The other districts are Madurai, Tirunelveli, Salem and Coimbatore.

Some coffee is also grown in Satara and Ratnagiri districts of Maharashtra. In line with the national policy of tribal development, coffee cultivation is being encouraged in such non-traditional areas as Andhra Pradesh, Odisha, Maharashtra, the north-eastern states and Andaman and Nicobar Islands.

Trade

Among the plantation crops, coffee has made significant contribution to the Indian economy during the last 50 years. Although India contributes only a small per cent of the world production, Indian coffee has created a niche for itself in the international market, particularly Indian Rebustas, which are highly preferred for their good blending quality. Arabic coffee is also well received in the international market. In short Indian coffee is well known for its quality and is much in demand in the international market. Therefore, India exports coffee to a large number of countries including U.K., the U.S.A., Russia, Australia, Iraq and a large number of countries of continental Europe. Chennai, Mangalore and Kozhikode are the chief ports of export. Indian coffee exports have registered significant increase, both in terms of quantity and earnings during the last few years (*see* **Table 22.41**). In 2011-12 India exported 278.94 thousand tonnes of coffee which was two-thirds of the total production. The total earnings from the export of coffee in that year amounted to ₹ 4,533.31 crore.

RUBBER

Rubber is a coherent elastic solid obtained from latex of a number of tropical trees of which *Hevea brasiliensis* is the most important. Rubber is used for a variety of purposes from erasing pencil marks to manufacturing of tyres, tubes and a large number of industrial products. The first rubber plantations in India were set up in 1895 on the hill slopes of Kerala.

TABLE 22.41. Export of Coffee from India

Year	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Quantity ('000 tonnes)	184.87	188.44	167.55	177.68	213.65	178.30	174.08	157.41	232.63	278.94
Value (₹ Crore)	993.98	1,085.92	1,069.08	1,588.69	1,969.00	1,872.27	2,255.76	2,032.06	3,009.91	4,533.31

Source : Agricultural Statistics at a glance, 2012, pp. 247-248.

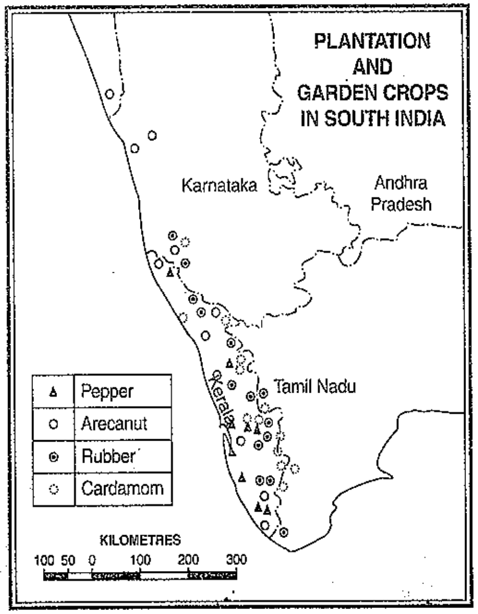

FIG. 22.7. Plantation and Garden Crops in South India.

However, rubber cultivation on a commercial scale was introduced in 1902.

Conditions of Growth

Rubber tree (*Hevea brasiliensis*) is a quick growing tall tree acquiring 20-30 metre height. It begins to yield latex in 5-7 years after planting. It requires hot and humid climate with temperature of 25°-35°C and annual rainfall of over 200 cm. The rainfall should be well distributed throughout the year. Dry spell, and low temperatures are harmful. Daily rainfall followed by strong sun is very useful. Deep well drained loamy soils on the hill slopes at elevation ranging from 300 to 450 metres above sea level provide best conditions for its growth. The yields decline at higher elevations and no rubber plantations are found above 700 m elevation.

Production and Distribution

India is the third largest natural rubber producing country of the world, next to Thailand and Indonesia, producing about 9 per cent of the global output. From about 200 hectares in 1902-03, the total area under rubber plantations increased to about 0.7 million hectares in 2013-14. Similarly, the production that was 80 tonnes in 1910 increased to about 0.9 million tonnes in 2013-14. The most important and noteworthy achievement has been the increase in productivity from 653 kg/hectare in 1970-71 to 1,206 kg/hectare in 2013-14 (*see* **Table 22.42**).

Though the rubber plantation sector was dominated by large estates during the initial five decades, it has subsequently undergone important structural transformation leading to dominance of small holdings. Today small holdings account for 88 per cent of area and production of rubber in India. The average size of small holding is 0.49 hectares only. However, the average productivity realised by small holders is much higher than that produced by the estates. **Table 22.42** gives the production trends of rubber in India. This table shows that India has made phenomenal progress in all the three aspects of rubber *i.e.* production, area and yields.

Almost entire rubber is produced in Kerala, Tamil Nadu and Karnataka.

Kerala is the largest producer of natural rubber producing 92 per cent of total rubber production of India. Kottayam, Kollam, Ernakulam, Kozhikode districts produce practically all the rubber of this state. **Tamil Nadu** is the second largest producer of rubber but lags far behind Kerala producing only 3 per cent of the total Indian production. Nilgiri, Madurai, Kanniyakumari, Coimbatore and Salem are the chief rubber producing districts of Tamil Nadu. **Karnataka** produces less than 2 per cent of total Indian production. Chikmagalur and Kodagu are the main producing districts. Tripura is the fourth largest producer but contributes less than 2% of India's rubber. Andaman & Nicobar Islands also produce small quantities of rubber.

TABLE 22.42. Production of Rubber in India

Year	1970-71	1980-81	1990-91	2000-01	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
Area (Million hectares)	0.2	0.3	0.5	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7
Production (Million tonnes)	0.1	0.2	0.3	0.6	0.8	0.9	0.8	0.8	0.8	0.9	0.9
Yield (kg/hectare)	653	788	1076	1576	1299	1306	1211	1211	1211	1206	1206

Source : Economic Survey 2013-14, Statistical Appendix pp. 17-19.

Trade

In India, consumption of rubber is almost always higher than the production and the production-consumption gap is likely to widen as the rate of consumption is faster than that of production. The per capita consumption of rubber in India is less than one kg as against 14 kg in the developed countries. This calls for larger quantities of import of both natural and synthetic rubber.

Considering the long-term requirements of natural rubber in the country, the Rubber Board of India has conducted exploratory surveys and has identified North Eastern region, parts of West Bengal, Odisha, Maharashtra and Karnataka as potential regions of rubber cultivation. Rubber can be grown in an area of 1.2 million hectares with appropriate refinements in agro-management practices in these regions. In the North-Eastern regions about 4.5 lakh hectares of land can be brought under rubber plantations.

SPICES

India has a glorious past, pleasant present and a bright future with respect to production and export of spices. Pepper, cardamom, chillies, turmeric and ginger are some of the important spices produced in India. India is a great exporter of spices. During the past few years, there has been a steady increase in area and production of spices in India. The annual growth rate in area and production of spices is estimated to be 3.6 and 5.6 per cent respectively.

PEPPER

Among the spices, black pepper, "the king of spices" is the most important dollar earning crop which has a decisive role in our national and state economies. It is an important spice which is used for flavouring foodstuffs. It is a tropical plant which requires a minimum of 10°C and maximum of 30°C temperature. A well distributed rainfall of 200-300 cm helps its growth. The plant grows as a vine and needs support of other trees for its growth. It thrives well on deep, friable, well drained loamy soils, overlaying the lateritic hill tops of Western Ghats, though it can also be grown on red and laterite soils. It can be grown well from almost sea level to an altitude of 1,200 m but the coastal sandy plains are not much suited for its growth.

Production and Distribution

India is the second largest producer of pepper in the world after Indonesia. Varying trends have been observed with respect to area, production and yields of pepper depending on the weather conditions. These variations become obvious when we look at **table 22.43**.

Its distribution is highly concentrated in Kerala, Karantaka and Tamil Nadu. **Kerala** produces 60 thousand tonnes (94% of India) of pepper. Though it is produced in almost all the districts of Kerala, the largest production comes from Kannur district, followed by Kottayam, Thiruvananthapuram, Kollam, Kozhikode and Ernakulam. **Karnataka** is a distant second contributing only 3 per cent of the total

TABLE 22.43. Production of Pepper in India

Year	1997-98	2000-01	2004-05	2005-06	2007-08	2008-09	2009-10	2010-11	2011-12	2011-12	2012-13
Area (thousand hectares)	181.5	213.9	228.3	260.2	246.0	197.0	238.7	195.9	184.0	200.3	124.6
Production (thousand tonnes)	57.3	63.7	73.0	92.9	69.0	47.1	47.4	51.0	52.0	42.6	52.6
Yield (kg/hectare)	318	298	320	357	281	239	199	260	183	203	422

Source : Agricultural Statistics at a glance, 2013, p. 194.

production of India. Kodagu and Uttar Kannad are the major contributing districts. **Tamil Nadu** also produces small quantity of pepper.

About one-third of total production of pepper finds its way to the foreign markets. India exports pepper to as many as 80 countries. The Russian Federation, the USA, Canada, East and South European countries, Sudan and Egypt are the main buyers. However, India's hitherto unquestioned status throughout history as the largest producer and exporter of black pepper in the world is now under threat with preliminary forecast on production and export data from Vietnam. India has to face this challenge to maintain her supremacy with respect to exports of pepper.

CARDAMOM

Cardamom is known as the 'queen of aromatic spices' and is mainly used for masticatory, flavouring and for medicines. It grows well in climate of high heat and humidity with temperature ranging between 15°C and 32°C and a fairly distributed annual rainfall of 150-300 cm. Well drained forest loams, deep red and laterite soils with plenty of humus and leaf mould are some of the soils which are ideally suited to its successful growth. Tropical rain forests at an altitude of 800-1,600 metres above sea level provide the most congenial environment for its growth. It is a shade loving plant and is grown under shady trees.

Production and distribution

India produces a major part of the world's total cardamom. The production and productivity of cardamom in India have increased in spite of decrease in cardamom area from 94.3 thousand hectares in 1997 to 92.4 thousand hectares in 2012-13. The production of cardamom in India was 18.4 thousand tonnes in 2012-13. Demand for cardamom is increasing in the world market. To meet this demand the productivity will have to be increased from the present level of 199 kg/ha to 250 kg/ha.

The entire production comes from three states *viz*., Kerala, Karnataka and Tamil Nadu and these states contribute 53, 42 and 5 per cent respectively of the total production of India. (*see* **Fig. 22.7**). In **Kerala**, the crop is largely concentrated in the Cardamom hills, Idukki, Palakkad (Palghat), Kozhikode and Kannur are the leading producing districts. In **Karnataka** the main producing districts are Kodagu, Hassan, Chikmagalur, Uttara and Dakshin Kannad. Madurai is the most outstanding district of **Tamil Nadu.** This is followed by Salem, Coimbatore, Ramnathpuram, the Nilgiris and Tirunelveli.

About half of the total production is exported. More than 60 countries buy our cardamom but our major customers are Saudi Arabia, Russia, U.K., Germany, Sweden, Finland, Kuwait, Afghanistan and Bahrain. India enjoyed near monopoly in area, production and export of cardamom upto early 1980s. As Guatemala stepped up its production from mid-1980s, India was relegated to second position in productivity and export of cardamom. India needs to boost up its production to regain the lost eminence of cardamom trade. Presently Guatemala has emerged as the top producer and exporter of cardamom sharing 90 per cent of the world export of cardamom.

Chillies

Chilli is another important spice produced in India. It requires temperatures ranging from 10° to 30°C and moderate annual rainfall of 60 to 125 cm

TABLE 22.44. Production of Cardomom in India

Year	1997-98	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Area (thousand hectares)	94.3	92.4	95.8	98.2	81.8	92.0	90.2	87.0	89.0	92.4
Production (thousand tonnes)	11.7	14.5	17.8	15.7	13.4	15.5	15.7	16.0	15.8	18.4
Yield (kg/hectare)	123	157	186	160	164	168	174	184	178	199

Source : Agricultural Statistics at a glance, 2013, p. 198.

TABLE 22.45. Production of Chilli in India

Year	1997-98	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Area (thousand hectares)	840.6	836.5	654.0	763.2	805.8	779.1	767.2	792.0	792.0	794.1
Production (thousand tonnes)	870.1	983.3	1,014.6	1,242.1	1,297.9	1,269.9	1,202.9	1,223.0	1,260.0	1,304.4
Yield (kg/hectare)	1,035	1,176	1,551	1,627	1,611	1,630	1,568	1,544	1,591	1,643

Source : Agricultural Statistics at a glance, 2012, p. 192.

Too scarce or too heavy rainfall is harmful. It can be grown on a wide variety of soils including black cotton soil, and different types of loamy soils. It can be grown upto elevations of 1,700 metres.

The production of chillies has almost trebled from 351 thousand tonnes in 1997-98 to 1,304 thousand tonnes in 2012-13.. The yield per hectare had also increased by about 1.5 times from 1.76 kg in 2000-01 to 1,643 kg in 2012-13. Although all states of India produce some quantity of chillies, **Andhra Pradesh** with 50 per cent of the all India production was the largest producer in 2012-13. Guntur, East Godawari and West Godavari, Prakasam are the main chilli producing districts. Warangal, Khammom and Karimnagar are the main chilli producing districts in **Telangana. Maharashtra** and **Odisha** produce equal amount of chilli, although way behind Andhra Pradesh. The other major producers were Rajasthan, West Bengal, Karnataka, Tamil Nadu, Gujarat, Uttar Pradesh, Madhya Pradesh and Assam.

Most of the chillies produced in India are consumed within the country and only 5 to 7 per cent are exported, mainly to Sri Lanka, the USA and Russia.

Ginger

Ginger is used both as a spice and for making medicines. It is grown in tropical and sub-tropical climates and requires 10° to 25°C temperature and 125-250 cm rainfall. Well drained sandy, clayey or red loams and laterites are best suited soils for its cultivation. It can be grown from sea level to an altitude of 1,300 m above sea level.

India is the largest producer of ginger in the world producing about 80 per cent of the world production. The production of ginger has increased from 252.1 thousand tonnes in 1997-98 to 682.6 thousand tonnes in 2012-13. The area occupied by this crop also increased considerably from 75.6 thousand hectares in 1997 to 136.3 thousand hectares in 2012-13. A corresponding increase in yield per hectare has also been recorded from 3,335 kg in 1997-98 to 5,010 kg in 2012-13. This shows the overall progress made by this crop. (**Table 22.46**).

TABLE 22.46. Production of Ginger in India

Year	1997-98	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Area (thousand hectares)	75.6	86.2	110.6	106.1	104.1	108.6	107.5	149.0	155.1	136.3
Production (thousand tonnes)	252.1	288.0	391.2	393.4	382.6	380.1	385.3	702.0	755.6	682.6
Yield (kg/hectare)	3,335	3,341	3,537	3,708	3,676	3,499	3,583	4,717	4,873	5,010

Source : Agricultural Statistics at a glance, 2013, p. 194.

Meghalaya, Andhra Pradesh, Kerala, Sikkim, Odisha, Mizoram, Karnataka etc. are the main producers.

About 80-90 per cent of the total production of ginger is consumed within the country and still India is a major exporter of ginger in the international market and accounts for about half of the total world trade. About 80 per cent of our exports go to the West Asian countries.

Turmeric

Turmeric is the native of the tropical lands of South-East Asia. It is an important condiment and is used in dyes and medicines also. It requires tropical climate and well drained sandy and clayey loams, medium black, red or alluvial soils for its growth.

India is an important producer of turmeric in the world. The production almost doubled from 549 thousand tonnes in 1997-98 to 1,062.5 tonnes in 2011-12. The area under turmeric also increased from 139.7 thousand hectares in 1997-93 to 199 thousand hectares in 2011-12. The yield per hectare did not lag behind and increased from 3,931 kg in 1997-98 to 5,340 kg in 2011-12.

Andhra Pradesh is the largest producer, producing about half of the total production of India. Guntur and Cuddapah districts account for two-thirds of the state's total production. Second place is occupied by **Tamil Nadu,** which produces more than 12 per cent turmeric of the country. Coimbatore accounts for 60 per cent of the state's production. **Karnataka** is the third largest producer accounting for 10.5% of the total production. Mysore and Belgaum are the outstanding producers. **Odisha** produces 9.7% where Phulabani and Koraput are the main producing districts. The other producers are *Gujarat, West Bengal, Maharashtra, Bihar, Assam* and *Tripura.*

About 90 per cent of the total production is consumed within the country and only 10 per cent is exported. The leading buyers of Indian turmeric are the USA, Russia, Japan, Sri Lanka and Singapore.

Arecanut

It is a hard nut which is cut into small pieces and used for chewing with betel leaves, lime and catechu. It is also used in Hindu religious ceremonies. Its stem is used for construction purposes and leaves for thatching.

Areca is a tropical tree which, on maturity, attains a height of 20-25 metres. It flourishes well in areas having 15° to 35°C temperature and 200-300 cm annual rainfall. It grows on a variety of soils ranging from well-drained laterite, red loamy to alluvial soils. Its cultivation can be done from sea level to 1,000 metres.

India is the largest producer of arecanut in the world. In the year 2012-13 India produced 6 lakh tonnes of arecanut from 4.5 lakh hectares of land. About 40 lakh people who are engaged in cultivating, curing, processing and trading of arecanut earn their livelihood from this nut. Kerala, Karnataka, Tripura, Assam and Meghalya are the major producing states accounting for about 90 per cent of the total output of India. **Kerala** is the largest producer accounting for 37 per cent of the Indian production. Kannur, Malappuram, Kollam, Kozhikode and Thrissur are the main producing districts of Kerala. In **Karantaka,** it is grown in Dakshina Kannada, Uttar Kannada, Chickmagalur, Shimoga and Tumkur districts. **Assam** produces about one-fourth of India's arecanut where Kamrup, Sibsagar and Darrang districts are important producers. Ratnagiri and Kolaba districts of **Maharashtra,** Coimbatore and Salem districts of **Tamil Nadu** are other important producers. West Bengal, Andhra Pradesh, Goa and Pondicherry also produce some arecanut.

Most of the arecanut is consumed within the country especially in the south Indian states and only a small quantity is exported mainly to Nepal, UAR, Pakistan, Saudi Arabia, Aman, Kenya and Singapore.

Coconut

Coconut palm is a very useful tree which gives us several items of every day use. Coconut is used for the manufacturing of ***copra*** which gives us oil. This oil is used for cooking and for several other purposes. The tree trunk gives timber and the shells of the nut are used as fuel. Leaves are used for various purposes such as making of mats, baskets, screens, etc. and for roofing the huts. Juice of green nuts serves as a sweet drink. *Gur*, sugar, *toddy* and vinegar are made from the juice collected from coconut spaths. Coconut oil-cake serves as food for poor people and is also fed to

cattle. Being a perennial crop, coconut has distinct features such as long period of economic life span of more than 60 years and long gestation period of 5-7 years.

Coconut is a tropical crop and is grown where temperature is 25° to 30°C and a fairly well distributed annual rainfall of 125 to 130 cm. In a few places, especially in Odisha, coconut is grown with as little as 100 cm annual rainfall. Frost and drought are very harmful to coconut. It is predominantly grown under rainfed condition in Kerala and parts of coastal Karnataka and Tamil Nadu. In rest of the country it is mainly grown under irrigation. Well drained rich loamy soils are best suited for its cultivation. It grows well on sandy loams along sea-coasts and in adjoining river valleys.

India is the third largest coconut producing country of the world next to Philippines and Indonesia. It is an important plantation crop grown in an area of 2.14 million hectares mainly in four southern states, *viz.,* Kerala, Tamil Nadu, Karnataka and Andhra Pradesh. Small and marginal farmers (with an average holding size of less than 0.20 ha in Kerala and 2 ha in other three states) predominate coconut production sector in the country. Production of coconut increased from 35.82 hundred million nuts in 1950-51 to 226.84 hundred million nuts in 2012-13. The area under coconut also increased from 0.62 million hectare in 1950-51 to 2.14 million hectares in 2012-13. **Kerala** is the largest producer accounting for 26.6% of the total production of India in 2012-13. Though coconut is grown throughout the state, largest production comes from Thrissur, Ernakulam, Kollam, Thiruvananthapuram, Alappuzha, Kannur, Kottayam and Malappuram districts. These districts produce more than three-fourths of the total production of Kerala. Next is **Tamil Nadu** producing about one-fifth of the total production of India. Though every district of Tamil Nadu produces some quantity of coconut, over half the production of the state comes from Thanjavur, Coimbatore and Salem districts. **Karnataka** is the third largest producer accounting for 12 per cent of the total production of the country. About 80 per cent of Karnataka's coconut is produced by Uttara Kannada, Dakshina Kannada, Tumkur, Hassan, Chikmagalur and Chitradurg districts. **Andhra Pradesh's** 80 thousand tonnes mainly come from East Godavari, West Godavari and Srikakulam districts. The other producers are *West Bengal, Odisha, Maharashtra, Goa, Assam, Andaman and Nicobar Islands, Lakshadweep and Pondicherry.*

The export of coconut products indicate that India has done well in coir and coir products, while in the export of other coconut based products, its share is very negligible compared to other coconut growing countries of the world. However, the export of coconut products showed considerable increase from 1990-91 to 2013-14. The global demand for coconut and coconut products has increased considerably. It is estimated that 9 per cent increase per annum for fresh coconuts, 45 per cent increase for coconut milk, 45 per cent for activated carbon, eight-fold increase for coir products and 100 per cent increase in coir dust will be recorded in the next 5 to 10 years.

HORTICULTURE

The importance of horticulture in improving the productivity of land, generating employment, improving economic condition of the farmers and entrepreneurs, enhancing exports and, above all providing nutritional security to the people is widely acknowledged. Horticulture sector, which includes fruits, vegetables, spices, floriculture and coconut, among others covered 23.7 million hectares of land in 2012-13. The horticulture sector contributed about 30 per cent of GDP from agriculture in 2011-12. In 2011-12, India accounted for about 10 per cent of the global production of fruits and was the second largest producer of fruits in the world. Immense agro-climatic diversity enables India to grow a large variety of horticulture crops. The country holds first position in global production of bananas, mangoes and cashew and is among the first ten in citrus, pineapple and apple production. India holds first position in global production of cauliflower, second in onion, third in cabbage and is among the top ten in production of potato, tomato, onion and green peas.

Cashewnut

Cashew tree is grown for cashewnut and cashew apple. Cashew kernel is used as a dry fruit delicacy. It is extracted from the nut by roasting, shelling and peeling. The oil drawn from the shell is used for manufacturing paints and varnishes. Juice from the cashew apple is used for making syrup, jam, squash and wine.

Cashew requires average temperature between 16°C and 25°C and a wide range of rainfall from 50 to 350 cm. It can be easily grown on poor rocky soils. It grows well on laterite soils on the west coast and on sandy soils on the east coast. The average yield of cashew kernel varies from 110 to 220 kg/hectare.

Cashew plantations were introduced in India by the Portuguese on the western coast of the country during 16th and 17th centuries. At present, India holds first position in the world in the production of cashew and it is now widely grown on western and eastern coasts. In 2012-13, India produced 7.53 lakh tonnes of cashew from 9.92 lakh hectares of land. In 2012-13, Maharashtra (29.9%), Andhra Pradesh

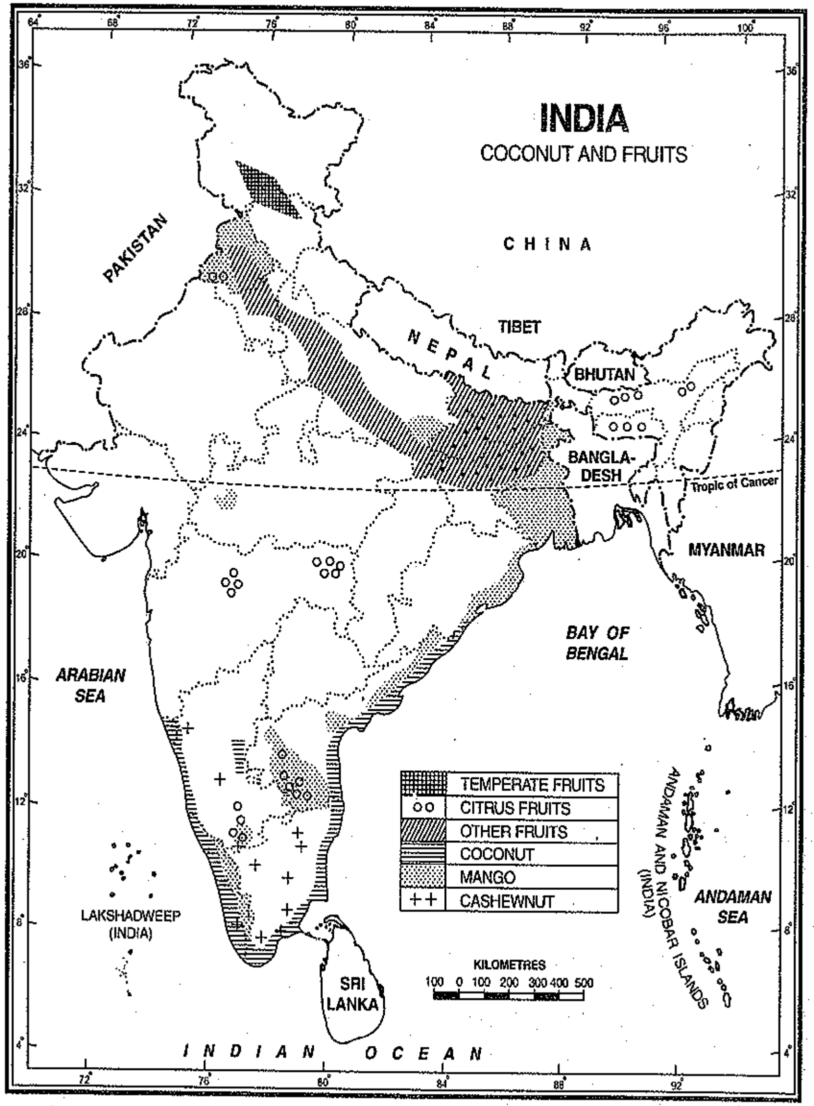

FIG. 22.8. India : Coconut and Fruits

(15.7%), Odisha (13.4%), Kerala (10.2%), Karnataka (9.9%) and Tamil Nadu (8.2%) were the major producers of cashewnut. The other producers were Goa, West Bengal and Jharkhand.

India is the largest exporter of cashewnut kernel in the world. She meets about 90 per cent of the world demand of cashewnuts. In 2012-13, India exported 299.52 thousand tonnes of cashew kernel valued at ₹2,881.55 crore. India exports cashew kernel to about 50 countries, the chief among which are the U.S.A., Russia, the U.K., Germany, Canada, Australia, the Netherlands, Malaysia and Japan.

Mango

Mango is the native of monsoon lands and is grown in areas with temperature from 20°C to 30°C and rainfall 75 to 250 cm. It can grow in almost all soils of India but prefers rich clayey loams. It is largely grown in groves especially near towns and villages where it has a ready market.

India is the largest producer where about 1,000 varieties of mango are grown. The main varieties are *dashari, langda, chausa, sapheda, fajli, malda, mohanbhog alfonso* and *shahpasand*. Mango occupied an area of around 2.5 million hectares and the annual production was about 18 million tonnes in 2012-13. India contributes over 54% of world production of mango. Uttar Pradesh, Bihar, Andhra Pradesh, West Bengal, Odisha, Kerala, Tamil Nadu, Maharashtra, Gujarat and Karnataka are its main producers.

Most of the mango produced is consumed within the country as a delicious fruit and for making pickles, *chutneys* and squashes. Even then, India is the largest exporter of mango in the world. Major importers of Indian mango are Bangladesh (33.76%), UAE (27.21%), Saudi Arabia (6.83%) and U.K. (4.95%).

Apple

Apple is a temperate fruit crop. It requires average temperature from 21° to 24°C during the active growing season. For optimum growth, 100-125 cm rainfall, well-distributed throughout the growing season is considered most favourable. The orchard localities should be free from hail storms and frost. Low temperature, rain, fog and cloudy weather hampers its proper growth at the time of maturity. These conditions are found on hill slopes at altitudes ranging from 1,500-2,700 m above mean sea level.

Loamy soils, rich in organic matter and having good drainage are most suitable for apple cultivation. Soil should be free from hard substrata and waterlogging.

In most areas apple orchards have replaced millet crop which is a low value crop. This has raised the income levels and standard of living of the farmers. In addition it has generated employment in processing, packing and transporting apples.

Apple is a nutritive fruit and is in great demand throughout the country, particularly in urban markets. At the same time, it is a perishable commodity and has to be brought to the market as early as possible. This requires quick and efficient means of transport.

The main areas of apple production are Kullu and Shimla districts in Himachal Pradesh, the Kashmir Valley and hilly areas of Uttarakhand.

Banana

Banana is primarily a tropical and sub-tropical crop, requiring average temperature of 20° to 30°C throughout in growth period. The rainfall should be fairly above 150 cm. The banana tree grows well in rich, well drained soil with ample moisture and humus.

India is the largest producer of banana in the world. Banana ranks third in area covering 12.46% of the total fruit area but first in total production accounting for over one-third of total fruit production. The production more than doubled from 12,642.5 thousand tonnes in 1997-98 to 26,646.5 thousand tonnes in 2011-12. Although banana growing is spread all over India, peninsular India provides ideal conditions for its cultivation. Tamil Nadu and Maharashtra are two main producers accounting for about half of total banana produced in India. The other producers are Gujarat, Karnataka, Kerala, Andhra Pradesh and Assam. Most of banana is produced on a small scale under different production systems. Some banana is exported. The main destination of banana export is the UAE.

Orange

Orange is the most important citrus fruit which is widely grown both in north and south India. Soil seems to be important factor for orange than climate. Most of orange orchards are rainfed and are located at heights from 600 to 1,500 m. Well-drained, even textured sandy loams which permit root penetration upto 2-4 metres are best for orange cultivation.

Although orange is grown in almost all the states, its cultivation is more prominently concentrated in the hilly region of Uttarakhand, Kangra valley of Himachal Pradesh, Darjeeling in W. Bengal, Khasi and Jaintia Hills in Meghalaya. Hyderabad in Telangana, Kodagu district of Karnataka, Waynad district of Kerala, Nilgiri district of Tamil Nadu and Nagpur and Pune districts of Maharashtra.

Grape

Grape is a sub-tropical plant and requires long summer, short winter, a moderately fertile well drained soil, relatively low water supply during the growing period and a bright sunshine during the three months in which the fruit matures. In northern India, the plant gives only one crop during summer but in south India the plant grows throughout the year and yields two crops a year, one in March-April and the other in August-September.

Grapes can be grown any where in India but there are certain areas where this fruit is grown more intensively. Among the major producing states are Uttarakhand, Himachal Pradesh, Jammu and Kashmir and Punjab in the north and Maharashtra, Andhra Pradesh, Telangana, Tamil Nadu and Karnataka in the south. Some grape is exported. The main export destinations for grape are Bangladesh, the Netherlands, U.K. and U.A.E.

Peach

Peach is more of a luxary than apple, due to its more perishable nature. It grows well in temperate climate. The main areas of peach cultivation are in Himachal Pradesh, Uttarakhand and Kashmir Valley. It cannot be transported over long distances due to its highly perishable nature and is primarily used in local market. However, some peach is carried over long distances at heavy transportation costs.

Pear

Pear is another temperate fruit, mainly grown in Kashmir, Kumaon region of Uttarakhand and Himachal Pradesh in the north and the Nilgiri hills in the south. These areas offer suitable conditions of cold winters, cool summers, moderate rainfall, high percentage of cloudiness and mist.

Apricot

Apricot is also a temperate fruit which requires 130 to 200 cm rainfall, moderate temperatures and humid nights. It requires cool weather with abundant moisture during early parts and moderately high temperature during the later part of its growth. It is mainly grown in Kashmir valley, Himachal Pradesh and Kumaon region of Uttarakhand.

Strawberry

Strawberry requires above 16°C temperature during its growing season and a lot of water because strawberry fields are submerged under 10 cm of fresh and slowly moving water for atleast three months. Any fertile soil which can retain water for a sufficiently long time is suitable for its cultivation but sandy loams are best suited for it. The hilly areas of J & K., H.P. and Uttarakhand are the main producers. Jeolikote in Nainital district is the largest producer of strawberry, producing nearly all the canned strawberries.

Almond and walnut are two other temperate fruits grown mainly in the Kashmir Valley, Himachal Pradesh and Kumaon-Garhwal region of Uttarakhand.

VEGETABLES

India also grows a large variety of vegetables. With growing population, health care and urbanization, demand for vegetables has increased considerably after Independence. With 100 million tonnes of annual production of vegetables, India ranks as the highest producer of vegetables in the world. Most of the vegetables are short duration crops as a result of which two to three crops are raised from the same piece of land in one year. Since, different vegetables are grown in different seasons, the process of vegetable cultivation continues throughout the year. Most of the vegetables are grown around urban areas where they find ready market for their sale. A strong vegetable sector in India will lead to economic growth throughout the country. Cultivating vegetables provides more jobs compared to cereal production. It

will diversify and generate farm income larger than other products. India grows an amazing number of different vegetables—175 different types in all—but potato, tomato, onion, cabbage and cauliflower account for 60 per cent of the total production. The other important vegetables are cucumber, carrot, brinjal, mushroom, coloquintida, pumpkin, gourd, and many more. It is projected that the domestic vegetable requirements will increase from current level of 83-91 million tonnes to 151-183 million tonnes in 2030. This demand will have to be fulfilled by increasing home production or by resorting to imports.

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CHAPTER 23

Mineral Resources

MINERALS AND MINING

Minerals are closely associated with mining. Mining and quarrying covers underground and surface mines, quarries and wells and includes extraction of minerals and also all supplemental activities such as dressing and benefication of ores and other crude materials, like crushing, screening, washing, cleaning, grading and several other preparations carried out at the mine site, which are needed to render the material marketable. *Open cast mining* and *underground mining* are two chief methods of mining practised in India. Open cast mining is more useful for minerals found just below the surface while underground mining is done to extract minerals found at greater depths. Drilling and pumping is practised for extracting oil and natural gas.

MINERAL WEALTH OF INDIA

India is endowed with a rich variety of minerals. Large size and diverse geological formations have favoured India in providing a wide variety of minerals. According to **Meher D.N. Wadia**, "The mineral wealth of India, though by no means inexhaustible, is varied enough to provide for sound economic and industrial development of the country but has at the same time, certain important deficiencies. It has been estimated that nearly 100 minerals are known to be produced or worked in India, of which nearly 30 may be considered more important including several which although comparatively unimportant in quantity today are capable of material development in future with expansion of industries. The country has fairly abundant reserves of coal, iron and mica, adequate supplies of manganese ore, titanium and aluminium, raw materials for refractories and limestone; but there is a deficiency in ores of copper, lead and zinc. There are workable deposits of tin and nickel." India earns a lot of foreign exchange by exporting a large variety of minerals such as iron ore, titanium, manganese, bauxite, granite and a host of other minerals. At the same time India has to depend upon imports to meet her requirements of some other minerals such as copper, silver, nickel, cobalt, zinc, lead, tin, mercury, limestone, platinum, graphite and so many other minerals.

DISTRIBUTION OF MINERALS AND MINERAL BELTS

The most striking feature of the Indian minerals is their uneven distribution. Some areas are very rich in minerals while some others are completely devoid of this valuable asset. The high rainfall areas of India lack in limestone, gypsum and salts which are soluble. The northern plains of India have thick layers of alluvium which has completely concealed the bedrocks. This region of the country is poor in mineral resources. The Himalayas have a variety of rocks but its geological structure is too complex. The exploitation of minerals in this mountainous terrain is not economically viable not only due to small quantity available at any one location but also due to difficult terrain, lack of transportation, sparse population and adverse climatic conditions. It is, thus, evident that our rich mineralised zone with relatively sizeable quantities is confined to the old, crystalline rock structures of plateaus and low hills of peninsular India. This has resulted in the emergence of well defined mineral belts which are briefly described as under :

1. The North-Eastern Peninsular Belt. This belt comprising of Chhota Nagpur plateau, and Odisha Plateau in the states of Jharkhand, West Bengal and Odisha is the richest mineral belt of India. It contains large quantities of coal, iron ore, manganese, mica, bauxite, copper, kyanite, chromite, beryl, apatite and many more minerals. In fact you ask for any major mineral of India and you will find it in this belt. Thus it is a mineral region *par excellence*. The Chota Nagpur plateau is known as the *mineral heart land* of India. According to **Wadia**, this region possesses India's 100 per cent Kyanite, 93 per cent iron ore, 84 per cent coal, 70 per cent chromite, 70 per cent mica, 50 per cent fire clay, 45 per cent asbestos, 45 per cent china clay, 20 per cent limestone and 10 per cent manganese. However, many changes have taken place in the recent years.

2. Central Belt. This belt encompassing parts of Chhattisgarh, Madhya Pradesh, Telangana, Andhra Pradesh and Maharashtra is the second largest mineral belt of India. Large deposits of manganese, bauxite, limestone, marble, coal, gems (panna), mica, iron ore, graphite, etc. are available here. A comprehensive geological survey is still needed to know about the mineral wealth of this belt.

3. The Southern Belt. It covers mostly the Karnataka plateau but extends over the contiguous Tamil Nadu upland. It is more or less similar to the north-eastern peninsular belt, as far as deposits of ferrous minerals and bauxite are concerned but it lacks coal deposits excepting lignite at Neyveli. It also does not have mica and copper deposits. Therefore, its mineral diversity is not as pronounced as that of the north-eastern peninsular belt.

4. The South-Western Belt. Western Karnataka and Goa are included in this belt. It has deposits of iron ore, garnet and clay.

5. The North-Western Belt. This belt extends along the Aravalis in Rajasthan and in adjoining parts of Gujarat. This belt has developed recently and is gradually becoming a productive region, holding great promise for the mining of non-ferrous metals (copper, lead, zinc), uranium, mica, stealite, beryllium and precious stones (aquamarine and emerald). Gujarat is fast becoming an important producer of petroleum, besides producing gypsum, manganese, salt, bauxite, etc.

Outside the main belts described above, minerals in some other parts of the country are scattered here and there. Assam has reserves of petroleum and lignite. The Himalayan region has some deposits of coal, bauxite, copper, slate, etc. Mumbai High and Godavari basin have reserves of oil and natural gas.

With the advancement of technology, even the sea bed is being exploited for minerals. There are great possibilities of obtaining large quantities of oil and natural gas, uranium, manganese, copper, zinc, lead and so many other minerals from the sea bed.

TYPES OF MINERALS

Normally two types of minerals are recognised :

(*i*) Metallic Minerals. These minerals contain metal. Iron ore, copper, manganese, nickel, etc. are important examples of metallic minerals.

Metallic minerals are further sub-divided into ferrous and non-ferrous minerals.

(*a*) ***Ferrous Minerals.*** These minerals have iron content. Iron-ore, manganese, chromite, pyrites, tungsten, nickel, cobalt, etc. are important examples of ferrous minerals.

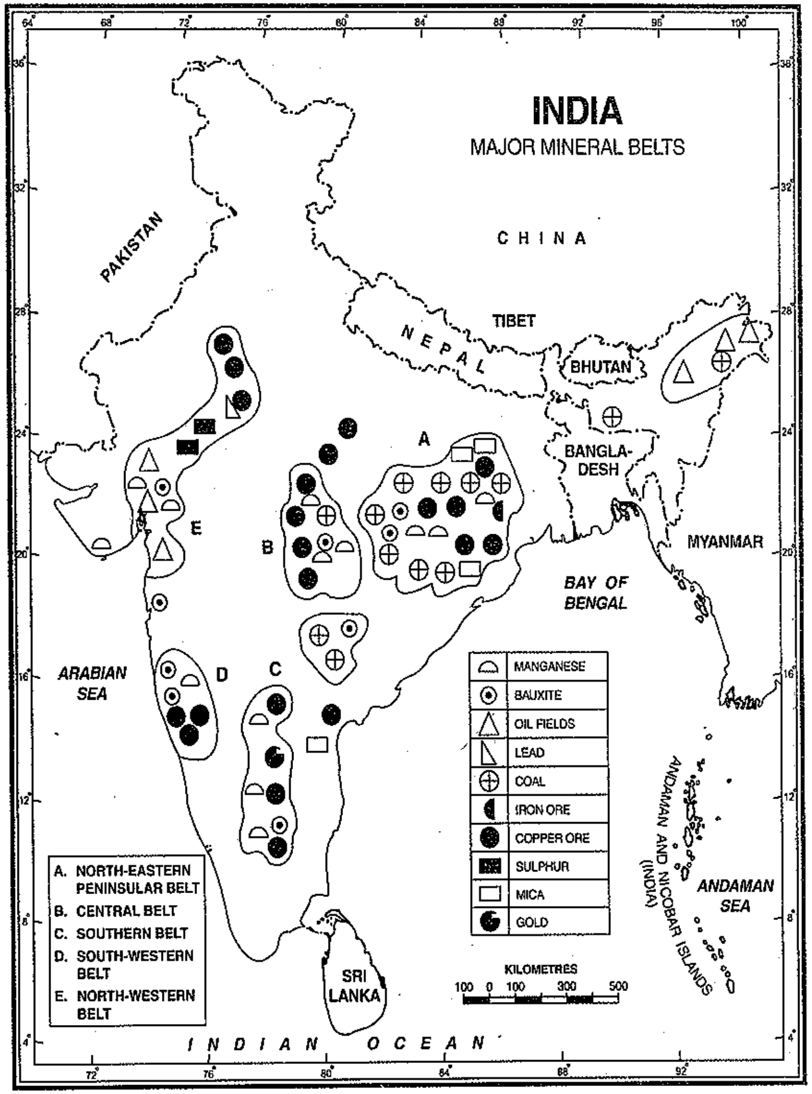

FIG. 23.1. India : Mineral Belts

(*b*) ***Non-ferrous Minerals.*** These minerals do not have iron content. Gold, silver, copper, lead, bauxite, tin, magnesium, etc. are important examples of non-ferrous minerals.

(*ii*) Non-metallic Minerals. These minerals do not contain metal. Limestone, nitrate, potash, dolomite, mica, gypsum, etc. are important examples of non-metallic minerals. Coal and petroleum are also non-metallic minerals. They are used as fuel and are also known as *mineral fuels*.

METALLIC MINERALS

Metallic minerals form an important section of mining activity in India and provide solid base to metallurgical industries in the country. **Fig. 23.2** shows the distribution of metallic minerals in India.

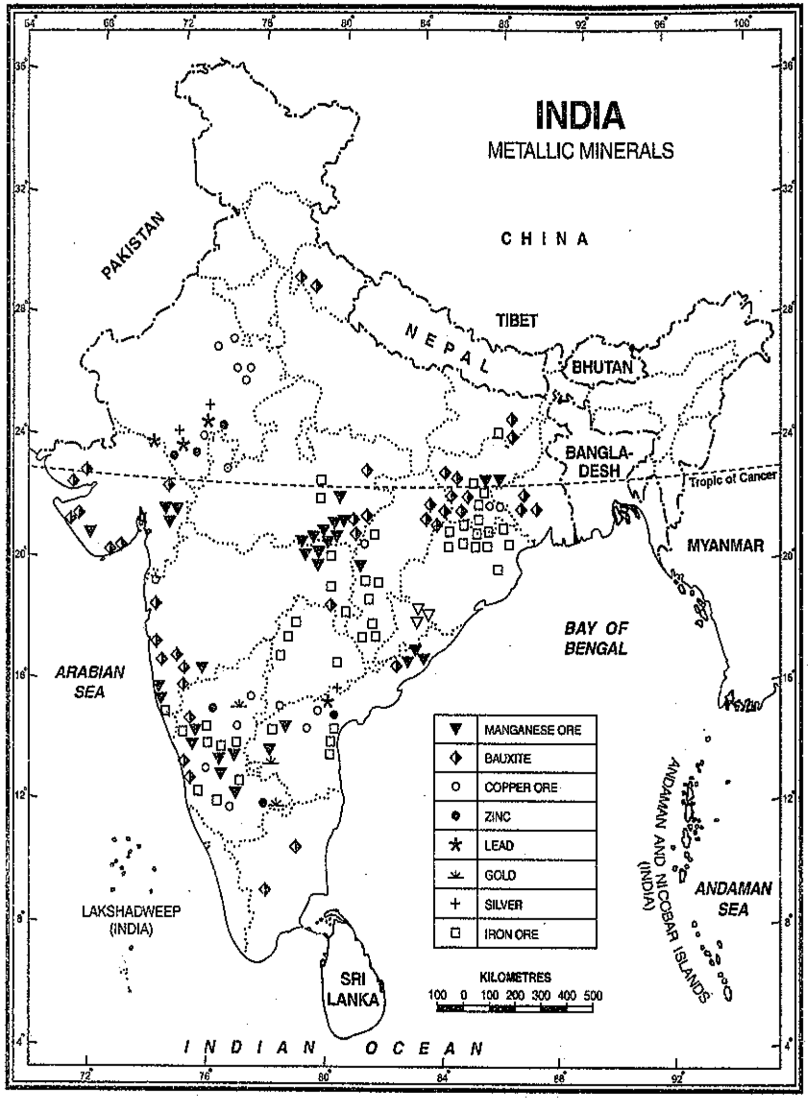

FIG. 23.2. India : Metallic Minerals

Iron Ore

Iron ore is a metal of universal use. It is the backbone of modern civilisation. It is the foundation of our basic industry and is used all over the world. The standard of living of the people of a country is judged by the consumption of iron. Iron is taken out from mines in the form of iron ore. Different types of iron ore contain varying percentage of pure iron. Following four varieties of iron ore are generally recognised.

1. Haematite. This is the best quality of iron ore with about 70 per cent metallic content and occurs as massive, hard compact and bumpy ore having reddish or coral red colour. Most of the haematite ores are found in Dharwad and Cuddapah rock systems of the peninsular India. Over 80 per cent of the haematite

ores are concentrated in eastern parts of India comprising of important iron ore producing states of Odisha, Jharkhand, Chhattisgarh and Andhra Pradesh. In the western section, the major concentration is in Karnataka, Maharashtra and Goa.

2. Magnetite. Also known as ***'black ore'***, due to blackish colour, this is the second best ore, next only to haematite with metallic content varying from 60 to 70 per cent. Like haematite, magnetite ores occur in the Darward and Cuddapah systems of the peninsular India. Magnetite ores have magnetic quality as a result of which they are known as ***magnetite ores***. Most of the reserves are found in Karnataka, Andhra Pradesh, Rajasthan, Tamil Nadu and Kerala.

3. Limonite. Limonite are inferior ores, yellowish in colour, which contain 40 to 60 per cent iron metal. These are found in Damuda series in Raniganj coal field, Garhwal in Uttarakhand, Mirzapur in Uttar Pradesh and Kangra valley of Himachal Pradesh. Though poor in quality, these have the advantage of easy and cheap mining.

4. Siderite. Also known as '*iron carbonate*' this type of iron ore is of inferior quality and contains less than 40 per cent iron. It also contains many impurities and its mining is not economically variable. However, it is self fluxing due to presence of lime.

Reserves. Hematite and magnetite are the two most important iron ores in India. According to United National Framework Classification (2010), the total reserves of haematite ore are estimated at 17,882 million tonnes. About 92 per cent of magnetic ore deposits occur in the eastern sector. Major sources of haematite ore located in Odisha, 5,930 million tonnes (33%), Jharkhand 4,597 million tonnes (26%) and Chhattisgarh 3,292 million tonnes (18%). The balance resources are spread in Andhra Pradesh, Assam, Bihar, Maharashtra, Madhya Pradesh, Rajasthan and Uttar Pradesh.

The total reserves of magnetite ore are estimated at 10, 644 million tonnes. About 97 per cent of magnetite ore resources are located in just four states namely, Karnataka 7,802 million tonnes (73%), Andhra Pradesh 1,464 million tonnes (14%), Rajasthan 527 million tonnes (5%) and Tamil Nadu (4.9%). The remaining about 3.1 per cent are found in Assam, Bihar, Goa, Jharkhand, Kerala, Maharashtra, Meghalaya and Nagaland.

Production and Distribution. Table 23.1 shows that India has progressed a lot with respect to production of iron ore and the production has consistently increased over the years. However, declining trends in production have be observed after 2009-10 which is not a good sign keeping in view the growth requirements of India.

It is worth mentioning that significant changes have taken place in the distribution pattern itself during the last few years. Goa occupied the first position among the major iron ore producing states for over a decade, but has been overtaken by Karnataka, Odisha and Chhattisgarh in due course of time. At present, over 96 per cent of India's iron ore is produced by just five states of Odisha. This fact speaks volumes of high concentration of iron ore reserves and their lopsided distribution in the country.

1. Odisha. Odisha produces over 40 per cent iron ore of India. The most important deposits occur in Sundargarh, Mayurbhanj, Cuttack, Sambalpur, Keonjhar and Koraput districts. India's richest haematite deposits are located in Barabil-Koira valley where 100 deposits are spread over 53 sq km. The ores are rich in haematites with 60 per cent iron content. Sizeable deposits occur near Gorumahisani, Sulaipat and Badampahar in Mayurbhanj district; Banspani, Tahkurani, Toda, Kodekola, Kurband, Phillora and Kiriburu in Keonjhar district; near Malangtoli, Kandadhar Pahar, Koira and Barsua in Sundargarh district, Tomka range between Patwali and Kassa in Sukind area of Cuttack district, Daitari hill along the boundary between Keonjhar and Cuttack districts, Hirapur hills in Koraput district and Nalibassa hill in Sambalpur district.

TABLE 23.1. Production of iron ore in India (Million tonnes)

Year	1950 -51	1960 -61	1970 -71	1980 -81	1990 -91	2000 -01	2005 -06	2006 -07	2007 -08	2008 -09	2009 -10	2010 -11	2011 -12P
Production	3.90	10.9	32.5	42.2	53.7	80.6	154.4	187.7	213.2	213.0	218.6	208.0	167.3

P = Provisional

Source : Economic Survey 2012-13, p. A-31.

TABLE 23.2. Production of Iron Ore in India (2011-12)

State	Production (thousand tonnes)	Percentage of all India
1. Odisha	67,013	40.06
2. Goa	33,372	19.95
3. Chhattisgarh	30,455	18.21
4. Jharkhand	18,942	11.32
5. Karnataka	13,189	7.88
6. Andhra Pradesh	1,714	1.02
7. Maharashtra	1,470	0.88
8. Madhya Pradesh	1,102	0.66
9. Rajasthan	32	0.02
Total	1,67,289	100.00

Source : Data computed from Mineral Wealth of India, 2013.

2. Goa. Production of iron ore in Goa started quite late and it is a recent development. Starting from a non-entity, Goa is now the second largest producer of iron ore in India. Though its reserves, amounting to only 11 per cent of India, are not very impressive as compared to other major producing states, it occupied the first position among the iron ore producers for several years and yielded this place to M.P. in 1990s. At present, Odisha produces more iron ore, relegating Goa to second place. Goa now produces about 20 per cent of the total production of India. In 1975, the Geological Survey of India located 34 iron bearing reserves which estimated the total ore deposits of 390 million tonnes. There are nearly 315 mines in North Goa, Central Goa and South Goa. Important deposits occur in Pirna-Adolpale-Asnora, Sirigao-Bicholim-Daldal, Sanquelim-Onda, Kudnem-Pisurlem and Kudnem-Surla areas in North Goa; Tolsia-Dongarvado-Sanvordem and Quirapale-Santone-Costi in Central Goa; and Borgadongar, Netarlim, Rivona-Solomba and Barazan in South Goa. The richest ore deposits are located in North Goa. These areas have the advantage of river transport or ropeways for local transport and that of Marmagao port for exporting the ore. Most of Goa's iron ore is exported to Japan. Most of the ore is of low grade limonite and siderite. Most of the mines are open-cast and mechanised which result in efficient exploitation of iron ore in spite of its inferior quality.

About 34,000 people earn their livelihood from iron ore mining and allied activities in Goa.

3. Chhattisgarh. Chhattisgarh, has about 18 per cent of the total iron ore reserves of India. This state produced about 18 per cent of the total iron ore production of the country in 2011-12. The iron ores are widely distributed, the prominent deposits being those of Bastar and Durg districts. The reserves in these districts are estimated to be of the order of 4,064 million tonnes. These reserves are of high grade ore, containing over 65 per cent iron. Bailadila in Dakshin Bastar, Dantewada and Bijapur district, and Dalli Rajhara in Durg district are important producers. In Bailadila, 14 deposits are located in 48 km long range running in north-south direction. With estimated reserves of about 1,422 million tonnes, the Bailadila mine is the largest mechanised mine in Asia. An additional ore benefication plant with a capacity of 7.8 million tonnes has been set up in Bailadila. A 270 km long slurry pipeline carries the ore from the Bailadila pithead to the Vizag plant. This has reduced the pressure on road route to a great extent. Bailadila produces high grade ore which is exported through Vishakhapatnam to Japan and other countries where it is in great demand. The Dalli-Rajhara range is 32 km long with iron ore reserves of about 120 million tonnes. The ferrous content in this ore is estimated to be 68-69 per cent. The deposits of this range are being worked by the Hindustan Steels Plant at Bhilai. Raigarh, Bilaspur, and Surguja are other iron ore producing districts.

4. Jharkhand. Jharkhand accounts for 25 per cent of reserves and over 11 per cent of the total iron ore production of the country. Iron ore mining first of all started in the Singhbhum district in 1904 (then a part of Bihar). Iron ore of Singhbhum district is of highest quality and will last for hundreds of years. The main iron bearing belt forms a range about 50 km long extending from near Gua to near Pantha in Bonai (Odisha). The other deposits in Singhbhum include those of Budhu Buru, Kotamati Buru and Rajori Buru. The well known Noamandi mines are situated at Kotamati Buru. Magnetite ores occur near Daltenganj in Palamu district. Less important magnetite deposits have been found in Santhal Parganas, Hazaribagh, Dhanbad and Ranchi districts.

5. Karnataka. Karnataka is the fifth largest producer and accounts for nearly 8 per cent of the

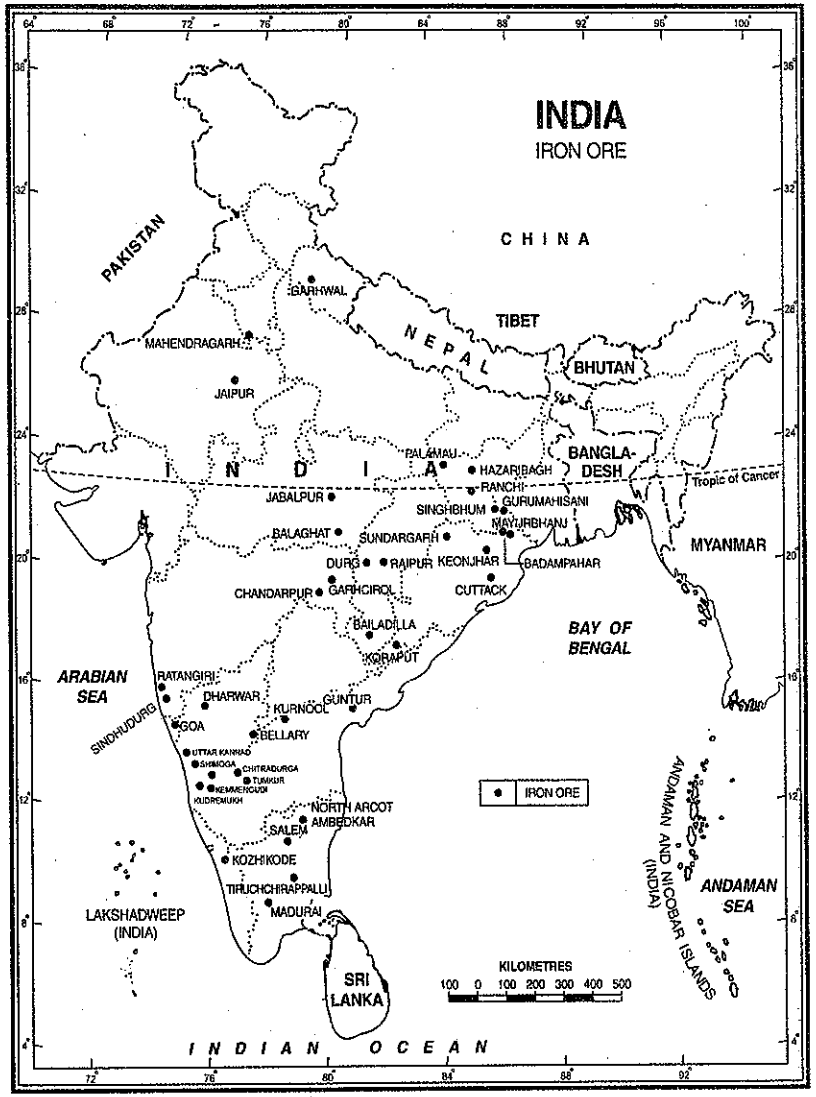

FIG. 23.3. India : Iron Ore.

total iron ore produced in India. In Karnataka production of iron ore has increased by about three times since 1980. Iron ores are widely distributed in the state, but high grade ore deposits are those of Kemmangundi in Bababudan hills of Chikmagalur district and Sandur and Hospet in Bellary district. Most of the ores are high grade haematite and magnetite. The other important producing districts are Chitradurga, Uttar Kannad, Shimoga, Dharwar and Tumkur.

Others. Apart from the major producing states described above, iron ore in small quantities is produced in some other states also. They include ***Andhra Pradesh*** (1.02%) : Kurnool, Guntur, Cuddapah, Ananthapur, Nellore; ***Maharashtra*** (0.88%) : Chandrapur, Ratnagiri and Sindhudurg.

TABLE 23.3. Exports of Iron Ore from India

Year	1960-61	1970-71	1980-81	1990-91	2000-01	2010-11	2011-12	2012-13	2013-14
Quantity (Million tonnes)	3.2	21.2	22.4	32.5	20.2	46.9	47.2	18.1	16.5
Value (₹ crore)	17	117	303	1,049	1,634	21,416	22,184	8,985	9,562

Source : The Economic Survey 2013-14, Statistical Appendix pp. 75-77.

Madhya Pradesh (0.66%); ***Tamilnadu*** : Salem, Tiruchirapalli, Coimbatore, Madurai, Nellai Kattabomman (Tirunelveli); ***Rajasthan*** : Jaipur, Udaipur, Alwar, Sikar, Bundi, Bhilwara; ***Uttar Pradesh*** : Mirzapur, ***Uttaranchal*** : Garhwal, Almora, Nainital; ***Himachal Pradesh*** : Kangra and Mandi; ***Haryana*** : Mahendragarh; ***West Bengal*** : Burdwan, Birbhum, Darjeeling; ***Jammu and Kashmir*** : Udhampur and Jammu; ***Gujarat*** : Bhavnagar, Junagadh, Vadodara; and ***Kerala*** : Kozhikode.

Exports

India is the fifth largest exporter of iron ore in the world. We export about 25 per cent of our total iron ore production to countries like Japan, Korea, European countries and lately to Gulf countries. Japan is the biggest buyer of Indian iron ore accounting for about three-fourths of our total exports. Major ports handling iron ore export are Vishakhapatnam, Paradip, Marmagao and Mangalore.

Increasing demand for iron ore in the domestic market due to expansion of iron and steel industry in India has adversely affected our export performance as is clear from **Table 23.3**. The exports have declined from 47.2 million tonnes in 2011-12 to 16.5 million tonnes in 2013-14.

Efforts are being made to increase the production so that sufficient quantity of iron ore is available for export after meeting the requirements of the expanding home market. Export of iron ore is necessary for earning the much needed foreign exchange.

Manganese

It is an important mineral which is used for making iron and steel and it acts as a basic raw material for manufacturing its alloy. Nearly 6 kilograms of manganese is required for manufacturing one tonne of steel. It is also used for the manufacture of bleaching powder, insecticides, paints, and batteries.

Production and Distribution

India has the second largest manganese ore reserves in the world after Zimbabwe. The total reserves of manganese ore are 430 million tonnes (2010). Odisha (44%), Karnataka (22%), Madhya Pradesh (13%), Maharashtra (8%), Andhra Pradesh (4%) and Jharkhand and Goa (3% each). Rajasthan, Gujarat and West Bengal together share the remaining 3 per cent resources.

TABLE 23.4. Production of Manganese Ore in India

Year	1980-81	2008-09	2009-10	2010-11	2011-12
Production (Thousand tonnes)	1,632	2,789	2,492	2,881	2,349

Source : Statistical Outline of India (Tata) 2012-13, p. 67.

India is the world's fifth largest producer of manganese ore after Brazil, Gabon, South Africa and Australia. Production of manganese ore in India remains more or less static with slight variations from year to year It was 1,632 lakh tonnes in 1994-95 and stood at 2,349 lakh tonnes in 2011-12.

TABLE 23.5. Distribution of Manganese in India 2011-12

State	Production in tonnes	Percentage of all India Production
1. Maharashtra	6,49,898	27.66
2. Madhya Pradesh	6,48,283	27.59
3. Odisha	5,65,662	24.08
4. Andhra Pradesh	3,22,087	13.71
5. Karnataka	1,36,072	5.79
6. Jharkhand	18,265	0.78
7. Rajasthan	7,483	0.32
8. Others	1,550	0.07
Total	**23,49,300**	**100.00**

Source : Data computed from Mineral Wealth of India, 2013.

Maharashtra, Madhya Pradesh, Odisha, Andhra Pradesh and Karnataka are the major manganese producing states which account for more than 98 per cent of the total production of India. Maharashtra and Madhya Pradesh together produce more than half of India's manganese (**Table 23.5**).

1. Maharashtra. It produces about 27.66 per cent of India's manganese ore. The main belt is in Nagpur and Bhandara districts. High grade ore is found in Ratnagiri district also.

2. Madhya Pradesh. Maharashtra is closely followed by Madhya Pradesh. About 27.59 per cent of India's manganese ore is obtained from Madhya Pradesh. The state produced only 11 per cent of

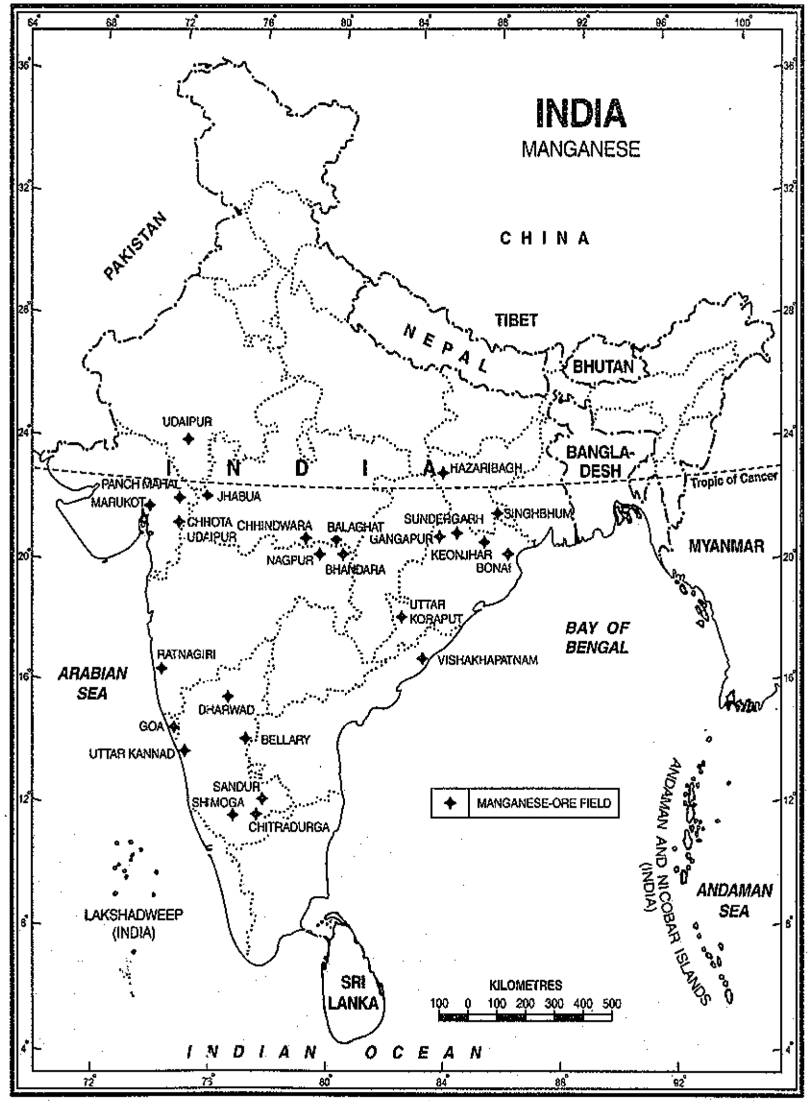

FIG. 23.4. India : Manganese

India's manganese ore just two decades ago. The main belt extends in Balaghat and Chhindwara districts. It is just an extension of the Nagpur-Bhandara belt of Maharashtra.

3. Odisha. Odisha is the third largest producer and produces over 24 per cent manganese ore of India. It is obtained from Gondite deposits in Sundargarh district and Kodurite and Khondolite deposits in Kalahandi and Koraput Districts. Manganese is also mined from the lateritic deposits in Bolangir and Sambalpur districts.

4. Andhra Pradesh. Andhra Pradesh produced more than 13% of India's manganese in 2011-12. The main belt is found between Srikakulam and Vishakhapatnam districts. Srikakulam district has the distinction of being the earliest producer (1892) of manganese ore in India. Cuddapah, Vijayanagaram and Guntur are other producing districts.

5. Karnataka. About 6 per cent of India's manganese ore is produced by Karnataka. The main deposits occur in Uttara Kannada, Shimoga, Bellary, Chitradurg and Tumkur districts.

Other producers. Jharkhand, Rajasthan, Goa, Panchmahals and Vadodara in *Gujarat*, Udaipur and Banswara in *Rajasthan* and Singhbhum and Dhanbad districts in *Jharkhand* are other producers of manganese.

Exports. Over four-fifths of the total production is consumed within the country and less than one-fifth is exported. Exports of manganese had been constantly decreasing because of rapidly increasing demand in domestic market. This is due to expansion of some of those industries, which use manganese as one of the basic raw materials. Such industries include iron and steel industry, manufacturing of dry batteries, chemicals used in photography and some other industries. So far so India had to impose ban on the export of high and medium grade ores with 35 per cent manganese content in 1971 to feed our industries. India is now exporting low grade ores with less than 35 per cent manganese content for which there is not much demand in the international market. It is worth mentioning here that the share of manganese ore exported to total production of the ore had fallen from 88.86 per cent in 1970-71 to less than 15 per cent in 2013-14. Japan is the largest buyer of Indian manganese accounting for about two-thirds of our total exports. The other buyers are the USA, UK, Germany, France, Norway, Sweden, Belgium, Czech Republic, Slovakia, Ukraine, etc.

Chromite

Chromite is an oxide of iron and chromium. It is widely used in metallurgical, refractories and chemical industries. As per United National Framework Classification (UNFC) system (2010), the total reserves of chromite is estimated at 203 million tonnes. Over 93 per cent of the resources are in Odisha, mostly in the Sukinda valley in Cuttack and Jajapur districts. Minor deposits are scattered over Manipur, Nagaland, Karnataka, Jharkhand, Maharashtra, Tamil Nadu and Andhra Pradesh. The production of chromite has recorded about three times increase during the last two decades.

Odisha is almost the sole producer, producing over 99 per cent of the total chromite production of India. Over 85 per cent of the total production of Odisha consists of high grade ore which is mainly found in Keonjhar, Cuttack and Dhenkanal districts. ***Karnataka*** is the second largest producer but lags far behind Odisha contributing less than one per cent of the total chromite of India. The main production comes from Mysore and Hassan districts. Krishna district of *Andhra Pradesh* and Tamenglong and Ukhrul districts of *Manipur* are other producers.

Copper

As a metal, copper came in use of man much earlier than iron. Copper has been used for making utensils and coins since long. Being a good conductor of electricity and ductile, it is extensively used in a vast variety of electrical machinery, wires and cables. It is also an important metal used by automobile and defence industries. Further, it is alloyed with iron and nickel to make stainless steel, with nickel to make 'morel metal' and with aluminium to make 'duralumin'. When alloyed with zinc it is known as 'brass' and with tin as 'bronze'.

Copper ore is found in ancient as well as in younger rock formations and occurs as veins, as dissemination and as bedded deposits. Mining for copper is a costly and a tedious affair because most of the copper ores contain a small percentage of the metal. Against the international average of metal content (in the ore) of 2.5 per cent, Indian ore grade averages less than one per cent.

Production and Distribution

The total reserves of copper in the country are estimated at 1558.46 million tonnes with about 12.29 million tonnes of copper metal (2010). Rajasthan has 777.17 million tonnes ore (50%) containing 4.39 million tonnes of copper. This is followed by Madhya Pradesh 377.19 million tonnes (24%) containing 3.82 million tonnes of copper and Jharkhand 288.13 million tonnes ore (19%) containing 3.09 million tonnes of copper. The rest 7 per cent of reserves are accounted for by Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharashtra, Meghalaya, Nagaland, Odisha, Sikkim, Tamil Nadu, Uttarakhand and West Bengal.

TABLE 23.6. Production of Copper concentrates in India

Year	Production (Thousand tonnes)
2008-09	138
2009-10	125
2010-11	137
2011-12	133

Source : Statistical Outline of India (Tata) 2012-13, p. 67.

The entire copper of India is produced by three states namely Madhya Pradesh, Rajasthan and Jharkhand.

1. Madhya Pradesh. Madhya Pradesh has become the largest producer of copper in India surpassing Karnataka, Rajasthan and Jharkhand in succession. In the year 2011-12 the state produced 59.85 per cent of the total copper production of the country. The state is blessed with a fairly large belt in Taregaon area, in Malanjkhand belt of Balaghat district. This district has recoverable reserve of 84.83 million tonnes of copper ore having 1,006 thousand tonnes of metal. Reserves of moderate size are also found in Kherlibazar-Bargaon area of Betul district. Some other areas are also reported to have copper ore reserves.

2. Rajasthan. Rajasthan has also progressed a lot with respect to production of copper and is now the second largest producing state in India accounting for over 28 per cent of the total production of the country. Most of the copper reserves are found along the Aravali range, spread over the districts of Ajmer, Alwar, Bhilwara, Chittaurgarh, Dungarpur, Jaipur, Jhunjhunu, Pali, Sikar, Sirohi and Udaipur. The Khetri-Singhana belt in Jhunjhunu district is the most important copper producing area. This belt runs in north-east to south-west direction over a distance of 80 km from Singhana to Raghunathgarh with average width varying from 3 to 5 km. The annual output of copper ore at Khetri is 1.8 million tonnes yielding around 16,000 tonnes of metal. The Kho-Dariba area about 48 km to the south-west of the Alwar city and Delwara-Kirovli area about 30 km from Udaipur are other important producers. In Kishangarh area of Ajmer district, 2.5 million tonnes of copper ore, having 0.60 per cent copper, have tentatively been estimated.

3. Jharkhand. Jharkhand, used to be the largest producer of copper till early 1980s but it has lost much importance and has slipped to third position, partly due to fall in its own production and mainly due to increased production of other states. The state's share of copper ore production has fallen from 62 per cent of the nation's total production in 1977-78 to a desperate 11 per cent in 2011-12. The main copper belt extends over a distance of 130 km. Singhbhum is the most important copper producing district where Rakha, Kendadih, Surda, Dhobani, Mosabani and some other areas have proved reserves of 58.044 million tonnes from which 1,480.12 thousand tonnes of metal may be recovered. Hasatu, Baraganda, Jaradih, Parasnath, Barkanath, etc. in Hazaribagh district; Bairakhi in Santhal Parganas area and some parts of Palamu and Gaya districts are also reported to have some deposits of copper ore.

Imports. The production of copper ore in the country always falls short of our requirements and India has to import copper from other countries. The major part of supply comes from the USA, Canada, Zimbabwe, Japan and Mexico. The quantity of import varies from year to year depending upon demand and supply.

Nickel

Nickel does not occur free in nature and is found in association with copper, uranium and other metals

It is used as an important alloying material. When alloyed with iron, rust proof stainless steel of superior quality is obtained, from which utensils are made. Because of its greater hardness and tensile strength nickel steel is used for manufacturing armoured plates, motor cars, bullet jackets and in naval construction. When alloyed with copper or silver, it is used for making coins. Nickel-aluminium alloys are used for manufacturing aeroplanes and internal combustion engines. Metallic nickel is used for making storage batteries and as a catalyst for hydrogenation or hardening of fats and oils intended for use in soap and foodstuffs and in making *vanaspati*.

Important occurrences of nickeliferous limonite are found in the Sukinda valley of Jajapur district, Odisha, where it occurs as oxide. A suitable process is being developed for its utilization. Nickel also occurs in sulphide form along with copper mineralization in east Sighbhum district, Jharkhand. In addition, it is found associated with uranium deposits at Jaduguda, Jharkhand and process is being developed for its recovery. Other important occurrences of nickel are in Karnataka, Kerala and Rajasthan. A polymetallic sea nodules are another source of nickel. The total resources of nickel ore have been estimated at 189 million tonnes in the country. About 92 per cent resources; *i.e.*, 175 million tonnes are in Odisha. The remaining 8 per cent resources are distributed in Jharkhand (9 million tonnes) and Nagaland (5 million tonnes). Nominal resources are reported from Karnataka (0.23 million tonnes).

Lead and Zinc

Lead is a widely used metal due to its malleability, softness, heaviness and bad conductivity of heat. The most important industrial use of lead is as a constituent in alloys such as type metal, bronzes and anti-friction metal. Lead oxide is used in lead sheeting, cable covers, ammunition, paints, glass making and rubber industry. It is also made into sheets, tubes and pipes which are used in buildings, especially as sanitary fittings. It is now increasingly used in automobiles, aeroplanes, and calculating machines. Lead nitrate is used in dyeing and printing.

Lead does not occur free in nature, rather it occurs as a cubic sulphide known as galena. Galena is found in veins in limestones, calcareous slates and sandstones and occasionally in metamorphic rocks or in association with volcanic rocks.

Zinc is a mixed ore containing lead and zinc and is found in veins in association with galena, chalcopyrites, iron pyrites and other sulphide ores. It is mainly used for alloying and for manufacturing galvanized sheets. It is also used for dry batteries, white pigments, electrodes, textiles, die-casting, rubber industry and for making collapsible tubes containing drugs, pastes and the like.

The total resources of lead and zinc ores are estimated at 685.59 million tonnes. Of these, 108.98 million tonnes (16 per cent) fall under 'reserves' while balance 576.61 million tonnes (84 per cent) are classified as 'remaining resources'. The total metal content in resources is 11.55 million tonnes lead and 36.66 million tonnes zinc. Besides, 118.45 thousand tonnes lead and zinc metal resources are available. In terms of reserves, 224 million tonnes of lead metal and 12.45 million tonnes of zinc metal are estimated. Rajasthan is endowed with the largest resources of lead-zinc ore amounting to 607.53 million tonnes (88.61 per cent), followed by Andhra Pradesh 22.69 million tonnes (3.31 per cent), Madhya Pradesh 14.84 per million tonnes (2.16 per cent), Bihar 11.43 million tonnes (1.67 per cent) and Maharashtra 9.27 million tonnes (1.35 per cent). Resources are also established in Gujarat, Meghalaya, Odisha, Sikkim, Tamil Nadu, Uttarakhand and West Bengal.

TABLE 23.7. Production of Lead and Zinc Concentrates in India (Thousand tonnes)

Year	1980-81	2008-09	2009-10	2010-11	2011-12
Lead concentrates	19	134	134	145	175
Zinc concentrates	50	1,224	1,280	1,420	1,482

Source : Statistical Outline of India, Tala Services, 2012-13, p. 167.

Almost the entire production comes from Rajasthan.

Tungsten

It is a valuable metal of which the chief ore is wolfram. This metal possesses some special properties as a result of which it is almost indispensable in several industries. Its most important property is that of *self-hardening* which it imparts to steel. Over 95 per cent of the worlfram is used by the steel industry. Steel containing the requisite proportion of tungsten is mainly used in manufacturing amunitions, armour plates, heavy guns, hard cutting tools, etc. Tungsten is easily alloyed with chromium, nickel, molybdenum, titanium, etc. to yield a number of hard facing, heat and corrosion resistant alloys. It is also used for various other purposes such as electric bulb filaments, paints, ceramics, textiles, etc.

The total resources of tungsten ore in the country, have been estimated at 87.4 million tonnes containing 142.094 tonnes tungsten (WO_3) content. These resources are mainly distributed in Karnataka (42 per cent), Rajasthan (27 per cent), Andhra Pradesh (17 per cent) and Maharashtra (9 per cent). Remaining 5 per cent resources are in Haryana, Tamil Nadu, Uttarakhand and West Bengal. At Degana, Rajasthan, WO_3 value in vein deposits varies from 0.25 to 0.54 per cent while in gravel deposit, it is, on an average 0.04 per cent. In West Bengal, Bankura deposit contains, on an average, 0.1 per cent WO_3. In Kuhi-Khobana-Agargaon belt, GSI has identified seven mineralised zones in Sakoli basin in Bhandara and Nagpur districts of Maharashtra. The analysis showed 0.01 to 0.19 per cent WO_3 in Kuhi block, 0.13 to 0.38 per cent WO_3 in Khobana block and 0.48 per cent WO_3 in Pardi-Dahegaon-Pipalgaon block. The deposit contains 0.17 per cent WO_3 on an average. Gold ore at Mysore mine of Bharat Gold Mines Limited (BGML) in Karnataka has been reckoned as a potential source of scheelite. The tailing dumps at Kolar Gold Fields contain about 0.035 to 0.18 per cent WO_3. The yearly production is 45 to 50 thousand kg of ore. This is not sufficient to meet our requirements and part of the domestic requirements are met by imports.

Bauxite

Bauxite is an important ore which is used for making aluminium. It is an oxide of aluminium (name derived after Le Beaux in France). It is not a specific mineral but a rock consisting mainly of hydrated aluminium oxides. It is a clay-like substance which is pinkish, whitish or reddish in colour depending on the amount of iron content.

Production and Distribution

Total resources of bauxite as per UNFC in the country are placed at 3,480 million tonnes in 2010. These resources include 593 million tonnes reserves and 2,887 million tonnes remaining resources. By grades, about 84 per cent resource are of metallurgical grade. The resources of refractory and chemical grades are limited and together account for about 4 per cent. Among states, Odisha alone accounts for 52 per cent of country's resources of bauxite followed by Andhra Pradesh 18 per cent, Gujarat 7 per cent, Chattisgarh and Maharashtra 5 per cent each and Madhya Pradesh and Jharkhand 4 per cent. Major bauxite resources are concentrated in the east coast in Odisha and Andhra Pradesh.

Odisha, Gujarat, Jharkhand, Maharashtra, Chhattisgarh, Tamil Nadu and Madhya Pradesh are the main bauxite producing states in India.

1. Odisha. Odisha is the largest bauxite producing state accounting for more than one-third of the total production of India. The main bauxite belt is in Kalahandi and Koraput districts and extends further into Andhra Pradesh. This 300 km long, 40 to 100 km wide and 950 to 1300 metre thick belt is the largest bauxite bearing region of the country. The main deposits occur in Kalahandi, Koraput, Sundargarh, Bolangir and Sambalpur districts. The important mining areas include Chandgiri, Baphalimoli Parbat, Kathakal, Manjimali, Pasenmali, Kunnumali, Kodingandi, Pottangi and Karalput in Kalahandi and Koraput districts. The new aluminium plant at Damanjoli provides ready market for bauxite of this area. The aluminium plant at Doragurha provides further impetus.

TABLE 23.8. Production of Bauxite in India (Thousand tonnes)

Year	Production
1980-81	1,932
2008-09	15,464
2009-10	14,124
2010-11	12,641
2011-12	13,172

Source : Statistical Outline of India 2012-13, p. 67.

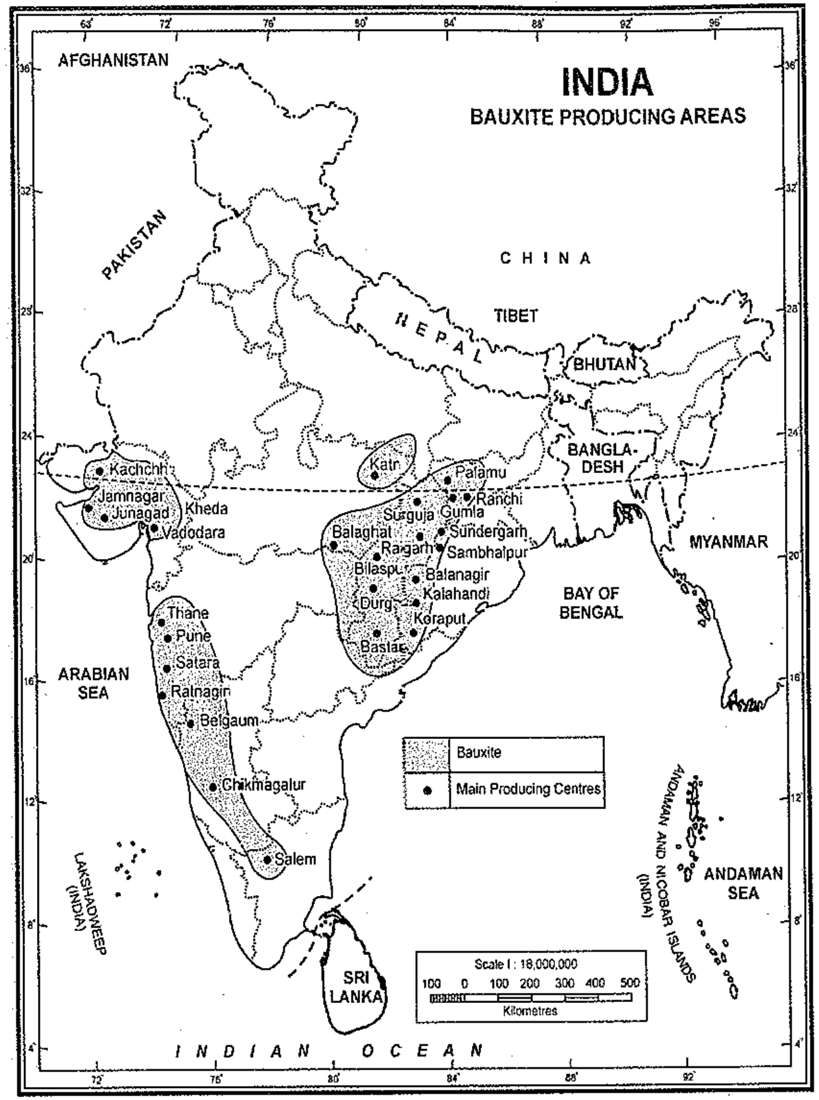

FIG. 23.5. India : Bauxite Producing Areas

2. Chhattisgarh. Chhattisgarh is the second largest producer of bauxite in India and produces more than 18 per cent bauxite of India. The Maikala range in Bilaspur, Durg districts and the Amarkantak plateau regions of Surguja, Raigarh and Bilaspur are some of the areas having rich deposits of bauxite.

3. Maharashtra. Maharashtra accounts for over 15 per cent of the total bauxite produced in India. The total recoverable reserves in the state, have been estimated to be of the order of 87.7 million tonnes. The largest deposits occur in Kolhapur district capping the plateau basalts. Udgeri, Dhangarwadi, Radhanagari and Inderganj in Kolhapur district contain rich deposits with alumina content 52 to 89 per cent. The other districts with considerable deposits are Thane, Ratnagiri, Satara and Pune.

4. Jharkhand. Jharkhand is an important bauxite producing state of India accounting for over 14 per cent of the total production. The reserves of this state are found in extensive areas of Ranchi, Lohardaga, Palamu and Gumla districts. Some bauxite is also found in Dumka and Munger districts. High grade ore occurs in Lohardaga and adjoining areas.

5. Gujarat. Gujarat produces over 6.5 per cent of the total bauxite of India, found in Jamnagar, Junagadh, Kheda, Kachchh, Sabarkantha, Amreli and Bhavnagar. The most important deposits occur in a belt which is 48 km long and 3 to 4.5 km wide lying between the Gulf of Kachchh and the Arabian sea through Bhavnagar, Junagadh and Amreli districts.

6. Madhya Pradesh. Amarkantak plateau area, the Maikala range in Shahdol, Mandla and Balaghat districts and the Kotni area of Jabalpur district are the main producers.

Goa and Karnataka also produce small quantities of bauxite.

TABLE 23.9. Distribution of bauxite in India 2011-12

State	Production in thousand tonnes	Percentage of all India production
1. Odisha	50,45,888	39.18
2. Chattisgarh	23,63,304	18.35
3. Maharashtra	19,37,898	15.05
4. Jharkhand	18,30,850	14.22
5. Gujarat	8,43,497	6.55
6. Madhya Pradesh	6,17,146	4.99
7. Goa	84,700	0.66
8. Karnataka	83,019	0.64
Others	69,092	0.56
Total	1,28,77,391	100.00

Source : Data computed from Mineral Wealth of India, 2013.

Trade. As much as 80 per cent of the bauxite is used for producing aluminium. India's exports of bauxite have been reduced considerably due to increasing demand in the home market. Still India manages to export small quantities of bauxite. The main buyers of Indian bauxite are Italy (60%), U.K. (25%), Germany (9%) and Japan (4%).

Pyrites

Pyrite is a sulphide of iron. Its economic value lies in its being the chief source of sulphur and not as an ore of iron because the high proportion of sulphur in it is injurious to iron. Sulphur is very useful for making sulphuric acid which in turn is used in several industries such as fertilizer, chemicals, rayon, petroleum, steel, etc. Elemental sulphur is useful for manufacturing explosives, matches, insecticides, fungicides and for vulcanising rubber.

Pyrite is widely distributed and occurs in many formations from the oldest crystalline rocks to the youngest sediments. The total recoverable reserves of pyrite are placed at 85.48 million tonnes of which 15.46 million tonnes are under proved category. The main deposits are found in the lower Son Valley at Amjor, Kasisiyakoh, and Kurriari in *Bihar*, in Chitradurga and Uttar Kannada districts of *Karnataka* and the pyritous coal and shale of Assam coalfields. The other deposits are in Rajasthan (Sikar), Tamil Nadu (Salem, Coimbatore, Nilgiri), Himachal Pradesh (Shimla), Meghalaya (Khasi and Jaintia Hills), Madhya Pradesh (Bilaspur, Chhindwara), Chhattisgarh (Durg and Surguja), Odisha (Mayurbhanj and Sundargarh), Uttarakhand (Garhwal, Tehri Garhwal and Almora), West Bengal (Jalpaiguri) and Arunachal Pradesh (Lower Subansiri). Production of pyrites had decreased from 1.4 lakh tonnes in 1996-97 to 9.5 thousand tonnes in 2011-12.

Gold

It is a valuable metal which occurs in auriferous lodes and some of it is found in sands of several rivers. It is used for making ornaments and is known as international currency due to its universal use.

Production and Distribution

The total resources of gold ore in the country were estimated at 493.69 million tonnes in 2010. Out of these, 24.12 million tones were placed under reserves category and the remaining 469.57 million tones under remaining resources category. Total resources of gold (primary), in terms of metal, stood at 659.84 tonnes. Out of these, 110.54 tonnes were placed under reserves category and 549.30 tonnes under remaining resources category. The resources include place-type gold ore in Kerala estimated at

26.12 million tonnes containing 5.86 tonnes gold metal. Among the states, the largest resources in terms of the metal ore (primary) are located in Bihar (45 per cent) followed by Rajasthan (23 per cent), Karnataka (22 per cent), Wet Bengal (3 per cent and Andhra Pradesh and Madhya Pradesh (2 per cent each) each. Remaining 3 per cent resources of ore are located in Chattisgarh, Jharkhand, Kerala, Maharashtra and Tamil Nadu. In terms of metal content, Karnataka has the highest followed by Rajasthan, Bihar, Andhra Pradesh, Jharkhand, etc.

There are three gold fields in the country, namely Kolar Gold Field, Kolar district, Hutti Gold Field in Raichur district (both in Karnataka) and Ramgiri Gold Field in Anantpur district (Andhra Pradesh).

Karnataka is the largest producer of gold in India. The main reserves are in Kolar, Dharwad, Hassan and Raichur districts. Some gold reserves are also reported from a number of scattered localities in Gulbarga, Belgaum, Bellary, Mysore, Mandya, Chikmagalur and Shimoga districts. This state used to produce about 88.7 per cent of India's gold.

Although every district of Karnataka has some reserves of gold, the most important reserves are found in Kolar Gold Fields, Kolar district and produces about 57.75 per cent of the total production of the state. The deposits in Kolar Gold Field occur in a 80 km long (north-south) and 3-4 km wide belt in which gold bearing quartz veins are confined to a 6-7 km section near Marikuppam. The first mining operations in the Kolar Gold Fields started in 1871 and the area still continues to be a major supplier of gold in India. About 3,539 thousand tonnes of gold ore having 17,738 kg of gold content have been proved during the recent surveys conducted by the Geological Survey of India for locating new lodes. The main gold mine at Kolar is one of the deepest mines of the world and the production from this mine is decreasing day by day due to heavy cost of extraction. Moreover, most of the gold has already been taken out and very little gold is left in the mine. Now gold is available at depth of more than 3,000 metres and it is not economically viable to extract gold at this depth.

Next to Kolar, but far below in production, are the Hutti mines in Raichur district. In the Hutti gold field the gold mining belt is 3.7 km long and 1,220 m wide with six auriferous quartz reefs. It produced 593.3 kg of gold in 1915, but the production fell and the mine had to be closed down in 1920. The main problem with the Hutti mines is the low grade of ore. The mine reopened in 1948 and has been operating irregularly since then. The *in situ* gold reserves of gold fields of Raichur district are estimated at 4.5 million tonnes with a total gold content of about 45,000 kg.

Some gold is found in the Gadag field in Dharwad district. New fields have been discovered in Ballara (Tumkur district), Kempinkole (Hassan district), Honnoli (Shimoga district), Siddarhalli (Chikmagalur district), and Munghur (Gulbarga district) areas.

Andhra Pradesh. Though lagging far behind Karnataka, Andhra Pradesh is the second largest producer of gold in India. On the basis of the detailed mapping done by the Geological Survey of India in recent years, a total of 7.06 million tonnes of ore and 37,025 kg of gold metal have been assessed in the state. The main deposits are found in Ramagiri in Anantapur district. However, this field is almost exhausted. The other areas of gold deposits are Bisanattam and Palachchur in Chittoor district and Jonnagiri in Kurnool district.

TABLE 23.10. Production of Gold in India

Year	Production in kg.
1980-81	2,412
2008-09	2,438
2009-10	2,084
2010-11	2,239
2011-12	2,817

Source : Statistical Outline of India (Tata) 2012-13, p. 67.

Alluvial Gold

Apart from the gold mines in the above mentioned areas, some gold is collected from the sands and gravels of several rivers. Gold is often liberated from the rocks by weathering and its particles get concentrated at certain places in the rivers. Such deposits are called placer deposits from which gold is recovered by *panning*. Although very small in quantity, this type of gold is widely spread in a large number of rivers.

Jharkhand. In addition to the above mentioned two states, Jharkhand is an important producer of gold in India. Jharkhand has both alluvial and native gold. Alluvial gold is obtained from the sands of the *Subarnarekha* (gold streak) river, as its name suggests, Sona nadi in Singhbhum district and the streams draining the Sonapat valley. Native gold is found near Lowa in Singhbhum district and in some other parts of Chota Nagpur plateau.

Kerala. The river terraces along the Punna Puzha and the Chabiyar Puzha have tracts of gold. Alluvial gold is found in the Ambankadava Puzha, Chabiyar Puzha and in the rivers near Mannarkkat.

Small quantities of gold are collected from rivers in Shimla and Bilaspur in Himachal Pradesh, Kargil area along the terraces of the Indus river and in alluvial and morainic deposits of Dras river in Jammu and Kashmir, Balaghat, and Seoni districts in Madhya Pradesh, Bastar, Raipur and Raigarh in Chhattisgarh and parts of Purulia district of West Bengal.

Silver

Silver is another precious metal produced in India. It is valued next only to gold for making ornaments due to its softness and attractive white colour. It had been an important currency metal in several parts of the world. It is also used in the manufacture of chemicals, electroplating, photography and for colouring glass, etc.

The chief ore minerals of silver are *agentine, stephanite, pyrargyrite* and *proustite.* It is found mixed with several other metals such as copper, lead, gold, zinc, etc.

India is not a major producer of silver in the world. The main production comes from Zawar mines in Udaipur district of Rajasthan. Here, silver is obtained as a by-product during the concentration and smelting of galena ore in Hindustan Zinc Smelter. The silver content varies from 171.4 gm to 774.5 gm per tonne of zinc and lead concentrates respectively. The Tundoo Lead Smelter in Dhanbad district of Jharkhand is another important producer of silver as a by-product of lead. Some silver is produced by Kolar Gold Fields and Hutti gold mines in Karnataka during refining of gold. The Hindustan Copper Ltd. at Maubhandar smelter in Singhbhum district of Jhakhand obtains silver from copper slimes. Silver is also produced by Vizag Zinc smelter in Andhra Pradesh from the lead concentrates.

Traces of silver occur in Hazaribag, Palamu, Ranchi and Singhbhum districts of Jharkhand; Cuddapah, Guntur and Kurnool districts of Andhra Pradesh; Vadodara in Gujarat, Bellary district of Karnataka, Baramula district of Jammu and Kashmir and Almora district of Uttarakhand.

NON-METALLIC MINERALS

India also produces a large number of non-metallic minerals although only a few of them have assumed as much industrial and economic importance as is done by the metallic minerals. However, they are used in a large variety of industries; the major industries being cement, fertilizers, electricals, etc.

Mica

Mica has been used in India since ancient times as a medicinal item in Ayurveda and is known as ***abhrak.*** With the development of electrical industry, mica found new vistas of use. Its insulating properties have made it a valuable mineral in electrical and electronics industry. It can withstand high voltage and has low power loss factor. The three major types of mica found in India are : *muscovite, phlogopite* and *biotite*.

Reserves

Most important mica-bearing pegmentities occur in Andhra Pradesh, Bihar, Jharkhand, Maharashtra and Rajasthan. Occurrences of mica pegmatites are also reported from Gujarat, Haryana, Karnataka, Kerala, Odisha, Tamil Nadu and West Bengal. The total resources of mica in the country are estimated at 5,32,237 tonnes out of which 1,90,741 tonnesa re placed under reserves category and 3,41,496 tonnes under remaining resources category. Andhra Pradesh leads with 41 per cent share in country's total resources followed by Rajasthan (21 per cent), Odisha (20 per cent), Maharashtra (15 per cent), Bihar (2 per cent) and balance (less than 1 per cent) in Jharkhand.

Production and Distribution

India has a near monopoly in the production of mica, producing about 60 per cent of world's total production. Production was just 772 tonnes in 1947-

48 which increased to about ten thousand tonnes within three years. The production increased at a rapid pace up to 1960-61 and there was a record production of 28,347 tonnes in that year. But afterwards it showed a declining trend and the production came down to 1,807 tonnes in 2011-12.

This decrease is the result of the fall in its demand in the international market. Earlier, there was no substitute for mica. Now materials like plastics and synthetics have been developed which can be used as substitutes for mica.

About 95 per cent of India's mica is found in just three states of Andhra Pradesh, Rajasthan and Jharkhand. Some mica is produced in Bihar also.

1. Andhra Pradesh. Andhra Pradesh is the largest mica producing state of India. In 2011-12, this

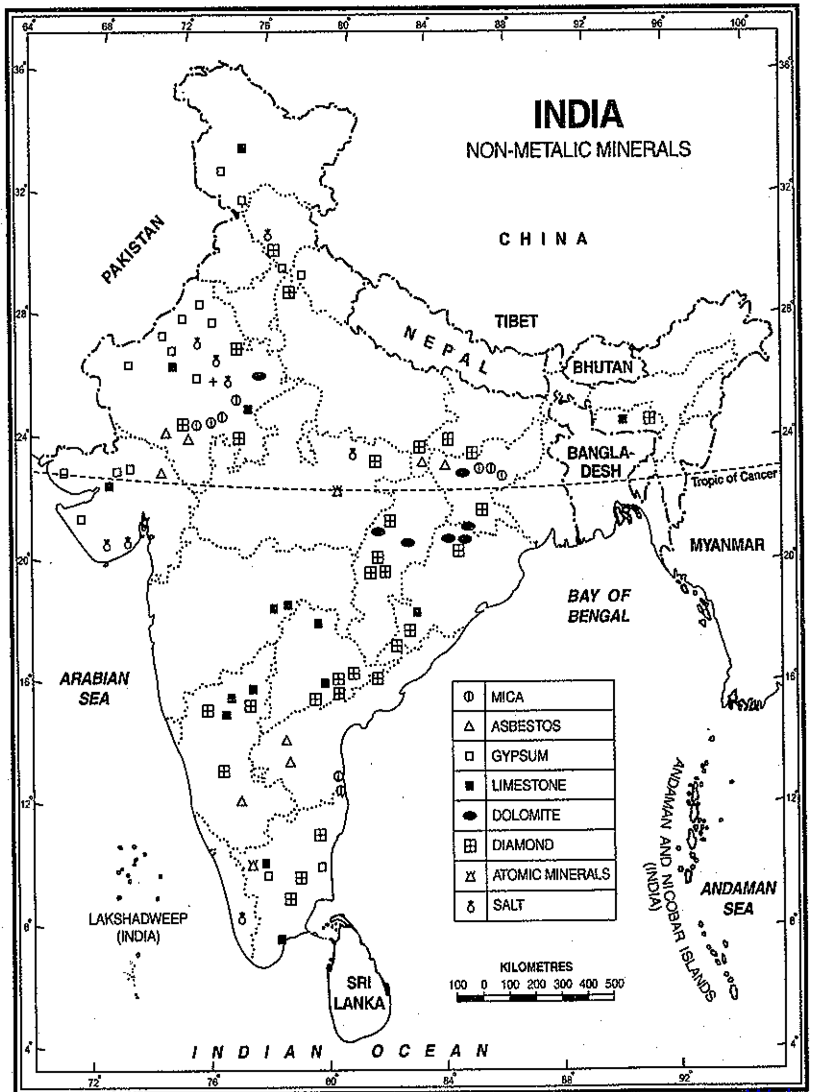

FIG. 23.6. India : Non-Metallic Minerals

state produced 1,694 tonnes of mica which was more than 93 per cent of all India production. In the recent years, share of Andhra Pradesh has progressed in respect to mica production. The mica belt lies in Nellore district and is 100 km long and 25 km wide. Nellore mica is generally light green in colour; it is generally stained and spotted. The other districts with workable mica deposits are Vishakhapatnam, West Godavari and Krishna (Tiruvur). Shah mine in Gudur taluka is the deepest with mining being done at 300 m depth.

2. Rajasthan. Although occupying the second position among the mica producing states of India, Rajasthan is not as important a producer as Andhra Pradesh is. This state produced 113 tonnes or 6.3 per cent of India in 2011-12. The main mica belt extends from Jaipur to Udaipur. This is 322 km long with an average width of 96 km. This belt broadens around Kumbhalgarh and Bhilwara. The main producing districts are Bhilwara, Jaipur, Tonk, Sikar, Dungarpur and Ajmer.

3. Jharkhand. Jharkhand is the third largest producer of mica in India. Mica in Jharkhand is found in a belt extending for about 150 km in length and 32 km in width from eastern part of Gaya district of Bihar across Hazaribagh, Girdih and Munger to Bhagalpur district. This belt contains the richest deposits of high quality ruby mica. The main centres of mica production in this belt are Kodarma, Dhorhakola, Domchanch, Dhab, Gawan, Tisri, Chakai and Chakapathal. Outside the main mica belt, mica occurs in Dhanbad, Palamu, Ranchi and Singhbum districts.

Other producers. The other areas with small deposits of mica are *Gujarat* (Banaskantha, Vadodara, Sabarkantha), *Kerala* (Alleppey and Kollam), *Tamil Nadu* (Nilgiri, Coimbatore, Salem and Tiruchirapalli), *Madhya Pradesh* (Balaghat and Chhindwara), *Chhattisgarh* (Bilaspur, Bastar and Surguja) and *Uttar Pradesh* (Mirzapur). Some deposits have also been reported from Odisha, Haryana, Himachal Pradesh and West Bengal.

Exports. India is not only the largest producer but also the largest exporter of mica in the world. In spite of the threat from synthetic mica, certain grades of Indian mica will remain vital to the world's electrical industries.

Most of the exports are routed through the ports of Kolkata and Vishakhapatnam. Japan (19%), the USA (17%), U.K. (7%), Norway (7%), Russia, Poland, Germany, Czech Republic, Slovakia, Hungary, France, the Netherlands, etc. are the main buyers purchasing about 80 per cent the total mica exported by India. However, trends in exports of mica from India are quite fluctuating (*see* **Table 23.11**).

Limestone

Limestone is associated with rocks composed of either calcium carbonate, the double carbonate of calcium and magnesium, or mixture of these two constituents. In addition to the main constituents of calcium and magnesium carbonates, limestone also contains small quantities of silica, alumina, iron oxides, phosphorus and sulphur. Limestone deposits are of sedimentary origin and exist in almost all the geological sequences from pre-cambrian to recent except in Gondwana.

The total resources of limestone of all categories and grades are estimated at ,84,935 million tonnes of which 14,926 million tonnes (8 per cent) are under reserves category and 170,009 million tonnes (92 per cent) are under remaining resources category. Karnataka is the leading state having 28 per cent of the total resources followed by Andhra Pradesh (20 per cent). Rajasthan (12 per cent), Gujarat (11 per cent), Meghalaya (9 per cent) and Chhattisgarh (5 per cent).

TABLE 23.11. Export of Mica from India

Year	1960-61	1970-71	1980-81	1990-91	2000-01	2010-11	2011-12	2012-13	2013-14
Quantity (Thousand tonnes)	28.4	26.7	16.7	42.0	63.2	125.8	131.1	126.8	126.4
Value (₹ crore)	—	16	18	35	64	189	238	276	304

Source : Economic Survey 2013-14, Statistical Appendix, pp. 75-77.

Limestone is used for a large variety of purposes. Of the total consumption, 75 per cent is used in cement industry, 16 per cent in iron and steel industry and 4 per cent in the chemical industries. Rest of the limestone is used in paper, sugar, fertilizers, glass, rubber and ferromanganese industries.

Rapid pace of industrialisation in the country has resulted in an accelerated rate of production of limestone. It has increased from a mere 30.2 million lakh tonnes in 1980-81 to over 256 million tonnes in 2011-12 (**Table 23.12**).

TABLE 23.12. Production of Limestone in India

Year	Production in million tonnes
1980-81	30.2
2008-09	222.0
2009-10	233.0
2010-11	238.0
2011-12	256.6

Source : Statistical Outline of India (Tata) 2012-13, p. 67.

Although almost all the states of India produce some quantity of limestone, over three-fourths of the total limestone of India is produced by six states of Andhra Pradesh and Telangana, Rajasthan, Madhya Pradesh, Gujarat, Tamil Nadu and Karnataka.

TABLE 23.13. Distribution of Limestone in India 2011-12

State	Production in thousand tonnes	Percentage of all India production
1. Andhra Pradesh (including Telangana)	53,882	20.99
2. Rajasthan	47,930	18.67
3. Madhya Pradesh	32,658	12.72
4. Gujarat	24,224	9.44
5. Tamil Nadu	21,736	8.47
6. Karnataka	20,228	7.88
7. Chhattisgarh	20,124	7.84
Others	35,887	13.99
Total	**2,56,669**	**100.00**

Source : Data computed from Mineral Wealth of India, 2013.

1. Andhra Pradesh. Andhra Pradesh possesses about one-third of the total reserves of the cement grade limestone in the country. This state along with Telangana produced about 21 per cent of India's limestone in 2011-12. Extensive deposits occur in Cuddapah, Kurnool, Guntur, Krishna. In **Telangana**, Nalgonda, Adilabad, Warangal, Mehbubnagar and Karimnagar are the major producing districts.

2. Rajasthan. Rajasthan has about 6 per cent of the reserves and produces over 18 per cent of the total limestone of India. Jhunjhunu, Banswara, Jodhpur, Sirohi, Bundi, Ajmer, Bikaner, Dungarpur, Kota, Tonk, Alwar, Sawai Madhopur, Chittaurgarh, Nagaur, Udaipur and Pali are the main producing districts.

3. Madhya Pradesh. Madhya Pradesh is the third largest producer of limestone and accounts for over 12 per cent of the total limestone production of India. Large deposits occur in the districts of Jabalpur, Satna, Betul, Sagar, Damoh and Rewa. The total reserves of all grades of limestone are estimated to be over 1,500 million tonnes.

4. Gujarat. Gujarat has about 13 per cent of the reserves but produces less than 10 per cent of the total limestone of India. High grade limestone deposits occur in Banaskantha district. The other important producing districts are Amreli, Kachchh, Surat, Junagadh, Kheda and Panchmahals.

5. Tamil Nadu. Large scale reserves in Ramnathapuram, Tirunelveli, Tiruchchirappalli, Salem, Coimbatore, Madurai, and Thanjavur districts enable Tamil Nadu to provide more than eight per cent limestone of the country. Most of the deposits, except those of Salem district, are of cement grade limestone.

6. Karnataka. Gulbarga, Bijapur and Shimoga districts of Karnataka possess about one-third of cement grade limestone of India. Currently, this state produces a little less than 8 per cent of the total limestone of India. The main producing districts of all grades of liemstone are Gulbarga, Chitradurg, Tumkur, Belgaum, Bijapur, Mysore and Shimoga.

7. Chhattisgarh. Chhattisgarh accounts for 7.84 per cent of total limestone of India. Deposits of limestone occur in Bastar, Bilaspur, Raigarh, Raipur and Durg districts.

Others. Apart from the above mentioned major producers, libmstone is also produced in *Sikkim*, *Maharashtra* (Yavatmal, Chandrapur, Nanded and Ahmadnagar), *Odisha* (Sundargarh, Sambalpur and

Kalahandi), *Jharkhand* (Palamu, Hazaribagh, Ranchi and Singhbhum), *Himachal Pradesh* (Bilaspur, Kangra and Chamba), *Haryana* (Mahendragarh and Ambala), *Assam* (Nagaon and Sibsagar), *Meghalaya* (Garo, Khasi and Jaintia hills), *Uttar Pradesh* (Mirzapur, Lucknow and Unnao), *Uttarakhand* (Dehra Dun and Mussoorie), *West Bengal* (Darjeeling and Jalpaiguri) and *Jammu and Kashmir* (Anantnag and Jammu).

Dolomite

Limestone with more than 10 per cent of magnesium is called dolomite; when the percentage rises to 45, it is *true dolomite*. The economic uses of dolomite are chiefly metallurgical; as refractories, as blast furnace flux as a source of magnesium salts and in fertilizer and glass industries. Iron and Steel industry is the chief consumer of dolomite accounting for over 90 per cent consumption followed by fertilizer (4%), ferro-alloys and glass (2% each), alloy steel (1%) and others (1%). Dolomite is widely distributed in the all parts of the country.

Total resources of dolomite are placed at 7,730 million tonnes, out of which 738 million tonnes are placed under reserves category and the balance 6,992 million tonnes under remaining resources category. Major share of about 91 per cent resources is distributed in eight states : namely, Madhya Pradesh (29 per cent), Andhra Pradesh (15 per cent), Chattisgarh (11 per cent), Odisha and Karnataka (9 per cent each), Gujarat (7 per cent), Rajathan (6 per cent) and Maharashtra (5 per cent). The remaining (9 per cent) resources are distributed in Arunachal Pradesh, Jharkhand, Haryana, Sikkim, Tamil Nadu, Uttarakhand, Uttar Pradesh and West Bengal.

Chhattisgarh, Odisha, Andhra Pradesh, Karnataka, and Madhya Pradesh are the main dolomite producing states which account for more than 90 per cent of India'a total production. Chattisgarh and Odisha are the two outstanding states which produce more than half of India's dolomite (**Table 23.14**).

1. Chhattisgarh. Chhattisgarh is the largest dolomate producing state of India which contributes more than 30 per cent of the total production of the country. The recoverable reserves of all grades of dolomite are estimated to be 1,638 million tonnes.

TABLE 23.14. Distribution of Limestone in India 2011-12

State	Production in thousand tonnes	Percentage of all India production
1. Chhattisgarh	16,28,165	30.06
2. Odisha	11,74,594	21.68
3. Andhra Pradesh	9,81,800	18.13
4. Karnataka	5,48,694	10.13
5. Madhya Pradesh	3,60,907	6.66
6. Rajasthan	2,34,709	4.33
7. Jharkhand	1,90,769	3.52
8. Gujarat	1,69,235	3.12
Others	1,27,944	2.37
Total	**54,16,817**	**100.00**

Source : Data computed from Mineral Wealth of India, 2013.

The main deposits occur in Bastar, Bilaspur, Durg and Raigarh districts.

2. Odisha. Odisha is the second largest producer of dolomite and accounts for over 21 per cent of the total production of dolomite in India. The total reserves of recoverable dolomite of all grades are of the order of 562.6 million tonnes out of which 256 million tonnes are in Birmitrapur locality alone. The main deposits occur in Sundargarh, Sambalpur and Koraput districts. In Gangapur area, they occur near Sukra and extend for a total length of about 100 km.

3. Andhra Pradesh. This is the third largest dolomite producing state of India contributing more than 18 per cent of the total production. Anantapur, and Kurnool are the main producing districts. In the neighbouring **Telangana** state, Khammam is the leading dolomite producing district.

4. Karnataka. Karnataka produces slightly more than ten per cent dolomite of India. Belgaum, Bijapur, Chitradurga, Mysore, Uttar Kannada and Tumkur contribute major part of the state's production.

5. Madhya Pradesh. This state has vast reserves of dolomite and accounts for more than 6 per cent of India's production. Most of the deposits occur along the Vindhya Range.

6. Rajasthan. Rajasthan produces over 4 per cent of India's dolomite. Ajmer, Alwar, Bhilwara

Jaipur, Jaisalmer, Jhunjhunu, Jodhpur, Nagaur, Pali, Sawai Madhopur, Sikar and Udaipur are the main producing districts.

7. Jharkhand. Dolomite occurs in bands to the north of Chaibasa in Singhbhum district. Some dolomite also occurs in Palamu district.

Others. Among the other producers are Gujarat (Junagad, Kheda, Jamnagar and Amreli), West Bengal (Jalpaiguri), Uttar Pradesh (Banda and Mirzapur), Uttarakhand (Dehra Dun, Nainital and Tehri Garhwal), Arunachal Pradesh (Kamang), Haryana (Mahendragarh), Himachal Pradesh (Shimla, Solan and Mandi), Maharashtra (Nagpur, Chandrapur and Yavatmal) and Tamil Nadu (Salem and Triunelveli).

Asbestos

Two quite different minerals are included under this name; one, a variety of amphibole, resembling tremolite and the other, more important, a fibrous variety of serpentine (chrysotile). Chrysotile is more important variety and accounts for 80 per cent of the asbestos of commercial use.

Asbestos has found great commercial value due to its fibrous structure, its capability to be readily separated into filaments of high tensile strength and its great resistance to fire. It is widely used for making fire-proof cloth, rope, paper, millboard, sheeting, belt, paint, etc. and for manufacturing fire proof safes, insulators, felts, etc. It is also used in making aprons, gloves, curtains, brake-linings in automobiles and insulating mats. Asbestos cement products like sheets, slates, pipes and tiles are used for building purposes. When asbestos is brittle, it is made into filter pads for filtering acids, organic liquids and other chemicals. Mixed with magnesia, it is used for making 'magnesia bricks' used for heat insulation.

Reserves of all categories and varieties of asbestos are placed at about 1.046 million tonnes. The production was at low key till 1971 but picked up after that. From a record production of 42,699 tonnes in 1993-94, it fell drastically to 27,180 tonnes in 1996-97 and further to 280 tonnes in 2011-12.

Two states of Rajasthan and Andhra Pradesh produce almost the whole of asbestos of India. *Rajasthan* is the largest producer. This state produced 13,539 tonnes of asbestos in 2012-13 which was over 94 per cent of the total production of India. Important occurrences are known in Udaipur, Dungarpur, Alwar, Ajmer and Pali districts. In **Andhra Pradesh,** asbestos of fine quality occurs in Pulivendla *taluk* of Cuddapah district. There are several occurrences between Chitravati and Papaghani rivers. The 15 km long zone between Lopatanuthula and Brahamnapalle is most promising. In **Karnataka,** the main deposits occur in Hassan, Mandya, Shimoga, Mysore and Chikmaglur districts.

In addition to the above mentioned major producers, some asbestos is produced in Jharkhand, Madhya Pradesh, Chhattisgarh, Tamil Nadu, Gujarat, Uttarakhand and Nagaland also.

Magnesite

It is an alteration product of dunites (peridotite) and other basic magnesian rocks. It is primarily used for manufacturing refractory bricks. It is also used as a bond in abrasives and in the manufacture of special type of cement for artificial stone, tiles, fire-proof floorings and for extraction of the metal magnesium. Steel industry also uses magnesite.

The total reserves/resources of magnesite are about 335 million tonnes of which reserves and remaining resources are 42 million tonnes and 293 million tonnes, respectively. Substantial quantities of resources are established in Uttarakhand (69 per cent), followed by Rajasthan (16 per cent) and Tamil Nadu (12 per cent). Resources are also located in Andhra Pradesh, Himachal Pradesh, Jammu and Kashmir, Karnataka and Kerala. Occurrences of magnesite in Tamil Nadu are low in lime and high in silica whereas those of Uttarakhand are high in lime and low in silica.

Production of magnesite recorded more than four-fold increase in forty years from 1.19 lakh tonnes in 1951 to 5.28 lakh tonnes in 1990-91 after which production regularly declined and stood at 2.17 lakh tonnes in 2011-12.

Tamil Nadu, Uttarakhand, Karnataka and Rajasthan produce almost the entire magnesite of India.

Tamil Nadu is the largest producer of magnesite in India. In 2011-12, this state produced more than two-thirds magnesite of India. Tamil Nadu has one of the largest deposits of magnesite in the world and the largest in India are found at Chalk Hills near Salem town. Some other deposits occur in Coimbatore, Dharmapuri, Nilgiri, Periyar and Tirunelveli. In **Uttarakhand,** Almora district with estimated reserves of 250 lakh tonnes has a 3.2 km long and 6 to 9 metre thick belt between Agar and Chahana. Chamoli district is also reported to have some deposits of magnesite. In **Karnataka,** magnesite veins are found in Hassan, Mysore and Kodagu districts. Ajmer, Udaipur and Pali districts in **Rajasthan,** Chamba in **Himachal Pradesh** and Udhampur in **Jammu and Kashmir** also produce some magnesite.

TABLE 23.15. Distribution of Magnisite in India 2011-12

State	Production in tonnes	Percentage of all India production
1. Tamil Nadu	1,47,207	67.63
2. Uttarakhand	62,124	28.54
3. Karnataka	8,331	3.83
Total	2,17,662	100.00

Source : Data Computed from Mineral Wealth of India 2013.

Kyanite

Kyanite occurs in metamorphic aluminous rocks and is primarily used in metallurgical, ceramic, refractory, electrical, glass, cement and a number of other industries due to its ability to stand high temperatures. It is also used in making sparking plugs in automobiles.

India has the largest deposits of kyanite in the world. All the three grades of kyanite are found here. The first grade has an aluminium content from 62 to 64 per cent, the second grade from 58 to 62 per cent and the third grade from 54 to 58 per cent.

The total resources of kyanite are placed at 103.24 million tonnes. Out of these resources, only 1.57 million tonnes are the reserve and 101.67 million tonnes are the remaining resources. Out of total resources, high and medium-grade resources together are merely 1.5 per cent, low grade 7.6 per cent, mixed grade 0.8 per cent, quartz kyanite gneiss and kyanite schist rock 88.6 per cent and granular, others and not-known grades 1.6 per cent. Statewise, the share of Andhra Pradesh alone is more than 78 per cent of the resources followed by Karnataka 13 per cent and Jharkhand 6 per cent. Remaining 3 per cent resources are in Kerala, Maharashtra, Rajasthan, Tamil Nadu and West Bengal.

The production of kyanite has been fluctuating since 1951 but there has been falling trend since 1990-91. The total production of Kyanite in 2011-12 was 4,064 tonnes. Jharkhand, Maharashtra and Karnataka produce practically the whole of kyanite of India.

1. Jharkhand is the largest producer of kyanite. This state produced 4,011 tonnes of kyanite in 2011-12 which was about 98 per cent of the total kyanite produced in India. Ores with high degree of purity with percentages of aluminium silicate reaching 95 to 97 are found in the Singhbhum district. Here kyanite occurs mainly as kyanite quartz rock and as massive kyanite-rock in beds of considerable size in the Archaean schists. This rock forms a bed nearly 130 km in length stretching from Lapsa Buru to Kharsawan in Saraikela. This has been the largest in the world and also the best in quality but now it is nearly exhausted. The other deposits in this district occur near Ghagidih, Badia, Bakra, Mohanpur, Jagnathpur, Bhakar, Hatiland, Singpura, Daontauri, Padampur and Shirbai. Small deposits are reported from Dhanbad and Ranchi districts also.

2. Maharashtra. Maharashtra produced only 45 tonnes or 1.4 per cent of the total kyanite produced in India in 2011-12 and occupied a distant second position among the major producing states of the country. Most of the reserves are in the districts of Bhandara and Nagpur where the total reserves of all grades are estimated at 70,652 tonnes.

Others. Some deposits of kyanite are also reported from **Odisha** (Dhenkanal, Sundargarh and Mayurbhanj), **Rajasthan** (Udaipur, Bhilwara and Dungarpur), **Tamil Nadu** (Kanniyakumari, Tiruchirapalli) and **Andhra Pradesh** (Nellore). Telangana (Khammam), Karnataka (Chickmaglur, Chitradurga, Mandya, Mysore, Dakshin Kannada and Shimoga)

Sillimanite

The occurrence and uses of sillimanite are almost the same as those of kyanite. The total resources of sillimanite are placed at 66.98 million tonnes.

these resources, the reserves are only 4.08 million tonnes, while about 62.90 million tonnes are the remaining resources. Out of total resources, more than 72.1 per cent are granular high-grade, while quartz sillimanite rocks and sillimanite bearing rocks are about 22.7 per cent Resources of massive sillimanite of all grades are about 5.0 per cent. The resources are located mainly in Tamil Nadu (27 per cent), Odisha (20 per cent), Uttar Pradesh (17 per cent), Andhra Pradesh (14 per cent), Kerala (11 per cent) and Assam (7 per cent). Remaining 4 per cent resources are in Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Meghalaya, Rajasthan and West Bengal.

Odisha, Kerala, Maharashtra and Rajasthan produce practically the whole of sillimanite of the country.

Odisha is the largest producer of sillimanite in India. This state produces as much as 56 per cent sillimanite of India. About 16.48 million tonnes of sillimanite reserves have been reported mainly from Ganjam district. **Kerala** is the second largest producing state which contributes about one-third of India's sillimanite. The beach sands of Kerala contain 5 to 6 per cent of sillimanite. Kozhikode, Palakkad, Ernakulam and Kottayam districts are major producers. In **Maharashtra** all grades of sillimanite have been reported from the Bhandara district, where the reserves are reported to be of the order of 2,32,055 tonnes. Small quantity of sillimanite is produced in **Rajasthan** also. Udaipur is the main producing district. **Karnataka** has about 85 thousand tonnes reserves of sillimanite mainly in Hassan, Mysore and Dakshin Kannad. The recoverable reserves in **Meghalaya** are estimated to be 77,246 tonnes of all grades mainly confined to the Khasi hills. The other areas with some sillimanite reserves are **Assam** (Karbi-Anglong), **Madhya Pradesh** (Sidhi), **West Bengal** (Darjeeling, Bankura and Purulia) and **Tamil Nadu** (Kanniyakumari, Tirunelveli, Tiruchchirappalli).

Gypsum

Gypsum is a hydrated sulphate of calcium which occurs as white opaque or transparent mineral in beds or bands in sedimentary formations such as limestones, sandstones and shales. In some cases it occurs as transparent crystals associated with clays. It is mainly used in making ammonia sulphate fertilizer and in cement industry. It is an essential constituent of cement, though its proportion is only 4-5 per cent. It is also used in making plaster of Paris, moulds in ceramic industry, nitrogen chalk, partition blocks, sheets, tiles, plastics, etc. It is conveniently applied as surface plaster in agriculture for conserving moisture in the soil and for aiding nitrogen absorption.

The total resources of mineral gypsum in the country are estimated at 1,286 million tonnes of which 39 million tonnes have been placed under 'reserve' and 1,247 million tonnes under 'remaining resources' category. Of the total resources, fertilizer/pottery grade accounts for about 82 per cent and cement/paint grade 12 per cent. The unclassified and not-known grades together account for 5 per cent resources. The remaining one per cent of resources is shared by surgical plaster and soil reclamation grades. Of the states, Rajasthan alone accounts for 81 per cent resources and Jammu and Kashmir 14 per cent resources. The remaining 5 per cent resources are in Tamil Nadu, Gujarat, Himachal Pradesh, Karnataka, Uttarakhand, Andhra Pradesh and Madhya Pradesh.

Table 23.16 shows that there have been wide temporal variations in the production of gypsum in India. It increased rapidly from 984 thousand tonnes in 1980-81 to 3,877 thousand tonnes in 2008-09, reached its peak to 4,347 thousand tonnes in 2010-11 and fell to 3,480 thousand tonnes in 2011-12 (**Table 23.16**).

TABLE 23.16. Production of Gypsum in India (thousand tonnes)

Year	Production
1980-81	948
2008-09	3,877
2009-10	3,370
2010-11	4,347
2011-12	3,480

Source : Statistical Outline of India (Tata), 2012-13, p. 67.

Rajasthan is by far the largest producer of gypsum in India. This state produced 3,159.7 thousand tonnes of gypsum in 2011-12 which was over 90 per cent of India's production. The total recoverable reserves of all grades of gypsum in Rajasthan are of the order of 1055 million tonnes. The main deposits occur in the Tertiary clays and shales of Jodhpur, Nagaur and Bikaner, Jaisalmer, Barmer, Churu, Pali and Ganganagar also have some gypsum bearing rocks. The remaining gypsum is produced by Tamil Nadu, Jammu and Kashmir, Gujarat and Uttar Pradesh in order of production. **Tamil Nadu** has most of its deposits in Tiruchirapalli district between Chittali in the north and Tappay and Periyakurukhai in the south. Some gypsum is also reported from Coimbatore district. Minor occurrences are found along the coast and in some salt pans in Nellai Kattabomman, Ramanathapuram, South Arcot Vallalar and Chingleput districts. The recoverable deposits are estimated to be 16.35 million tonnes. **Jammu and Kashmir** has estimated reserves of 112.9 million tonnes. The main deposits occur in Baramula and Doda districts and in Uri. **Gujarat** has total reserves of 10.3 million tonnes mainly confined to Bhavnagar, Junagadh, Jamnagar and Kachchh districts. Minor deposits occur in Kheda and Surendranagar districts. In **Uttarakhand**, the main deposits of gypsum are found in Tehri Garhwal, Dehra Dun and Musoorie.

Some gypsum is also produced in **Andhra Pradesh,** (Nellore, Guntur, Prakasam), **Himachal Pradesh** (Spiti, Sirmur, Chamba), **Karnataka** (Gulbarga) and **Madhya Pradesh** (Shahdol).

In addition to mineral gypsum, water and phosphoric acid plants are important sources of by product gypsum. Marine gypsum is recovered from salt pans during the processing for common salt in coastal regions particularly of Gujarat and Tamil Nadu. Phospho-gypsum is obtained as a by-product while manufacturing phosphoric acid whereas fluro-gypsum is obtained while manufacturing aluminium flouride and hydro-fluoric acid. Similarly, boro-gypsum is the by-product of refining calcium borates. It is worth mentioning that the recovery of by-product phospho-gypsum, fluoro-gypsum, and marine gypsum together is higher than mineral gypsum.

Diamonds

Diamonds have been highly valued and cherished throughout the ages because of their brilliance, adamantine, lustre, transparency and hardness. They are widely used for ornaments and for polishing the surface metals, minerals and gem cutting. The most important industrial use of diamonds is in cutting-edges of drills used for exploration and mining of minerals.

The production of diamonds had increased from 1,674 carats valued at ₹ 5.34 lakh in 1950 to 18,489 carats valued at ₹ 19.8 crore in 2011-12. The main diamond bearing areas are Panna belt in Madhya Pradesh; Wajrakarur Kimberlite pipe in Anantapur district and the gravels of the Krishna river basin in Andhra Pradesh. Reserves have been estimated only in Panna belt and Krishna Gravels in Andhra Pradesh. The total *in situ* reserves are about 26,43,824 carats. There are conditional resources of 19,36,512 carat. The new kimberlite fields are discovered recently in Raichur-Gulbarga districts of Karnataka. Further investigations for diamonds are being carried out in Andhra Pradesh, Madhya Pradesh and Karnataka.

Reserves of diamonds in India are not yet exhausted and modern methods are being applied for intensive prospecting and mining in Panna, Kurnool, Bellary and some other selected places in central India.

Indian diamonds are in great demand in the international market, especially for jewellery. Cutting and polishing of diamonds is done by modern techniques at important centres like Surat, Navasari, Ahmedabad, Palampur, Bhavnagar and Mumbai. Khambhat, Jaipur, Trichur and in Goa state are comparatively new centres.

Atomic Minerals

Uranium and Thorium are the main atomic minerals to which many be added *i.e.,* beryllium, lithium and zirconium. Uranium is perhaps the only chemical element that has been dominating the world strategic scene since the mid-twentieth century. Discovered more than 200 years ago in mineral known as pitchblende by a German chemist Martin Heinrich Klaproth, it derives its name from the planet Uranus, which was discovered only a few years earlier in 1781. Henry Beaquerel, a French physicist discovered the new property of radioactivity in uranium which opened a new era in nuclear technology. Later it was discovered that uranium with atomic number 92 occurs in nature in two principal isotopic farms of mass number U-238 (99.3%) and U-35 (0.7%). Uranium occurs in the earth crust with average concentrations 2 to 4 ppm (parts per million) and in sea water with average concentration 0.003 ppm. It occurs with much higher concentration in certain minerals like uraninite, pitchblende, autunite and uranophane. Australia is said to have largest deposits of uranium which amount to about 11,42,000 tonnes (about 30% of the world deposits). This is followed Kazakhistan, Canada, U.S.A., South Africa, Namibia, Brazil, Niger and Russia. The world production of uranium at present is in the vicinity of forty thousand tonnes. Canada with 25% of the world production is at the top followed by Australia, Kazakhistan and some other countries.

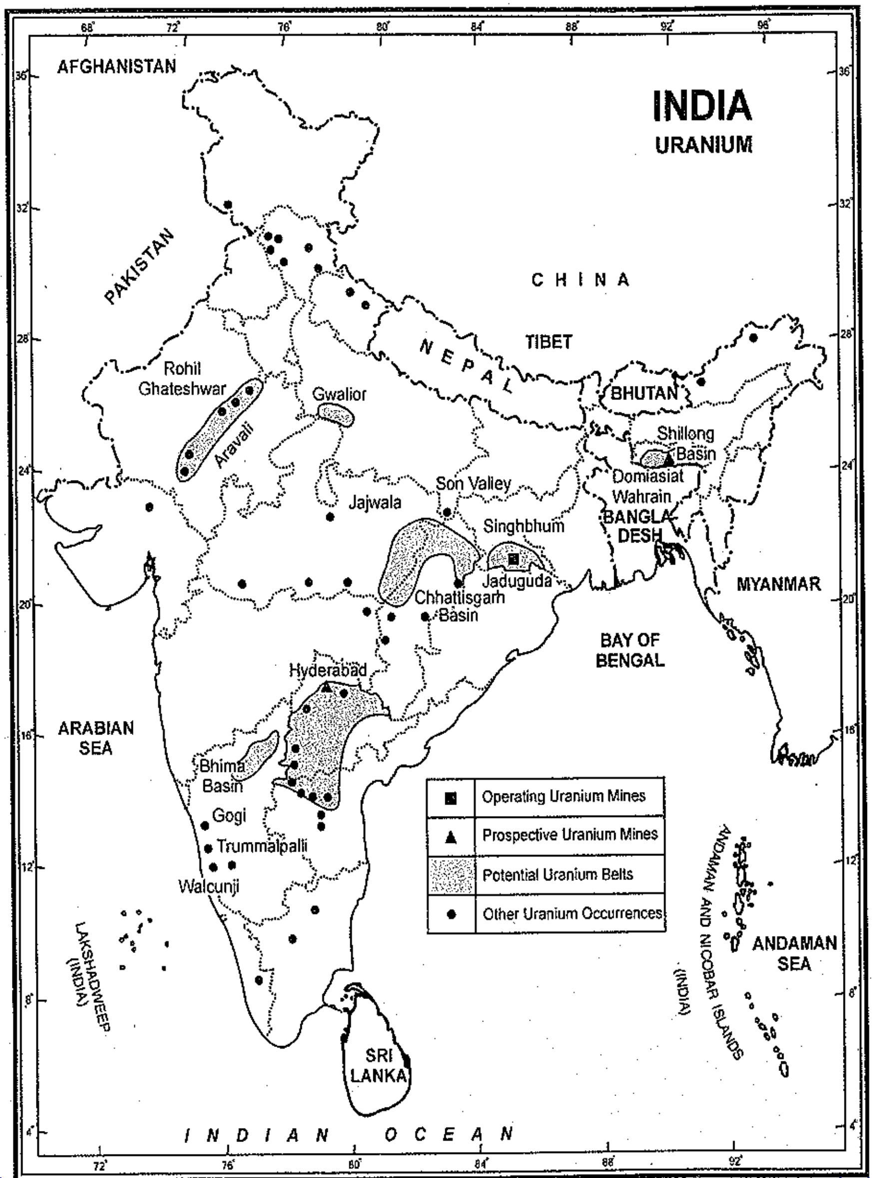

FIG. 23.7. India : Uranium

In India, the Atomic Mineral Directorate (AMD) set-up under the Department of Atomic Energy (DAE), is responsible for geological exploration to discover mineral deposits like uranium, thorium, and others like zirconium, beryllium, lithium, etc. These minerals provide necessary base for nuclear industry. Modern techniques like satellite pictures and aerial survey are employed to delineate geological formations containing these minerals. Commercial exploitation of atomic minerals is done by the Uranium Corporation of India Limited.

One kg of uranium can produce as much electricity as is done by 1,500 tonnes of coal.

The first uranium deposit was discovered in 1951 at Jaduguda in Jharkhand and the mine was commissioned in 1967. Three more mines have been established in Jharkhand one each in Narwapahar (1995), Turamdih (2002) and Bagjata (2007). The other major deposits have been found at Bodal in Chhattisgarh and Jajawal in Madhya Pradesh; Domiasiat (known to be one of the largest and richest), Wahkyn and Tyrani in Meghalaya and Lambapur-Peddagattu and Tummalapalle in Andhra Pradesh. Favourable uranium mineralization has also been identified at Gogi in Karnataka, Kuppam and Gandi in Andhra Pradesh, Rohil in Rajasthan, Bastar district in Chhattisgarh and many other places.

The mixed mineral ore is processed at uranium mills at Jaduguda, Batin and Narwapahar where it is converted into uranium oxide (U_3O_8), popularly known as "Yellow Cake".

According to Department of Atomic Energy (DAE) India has the capacity to generate 21,180 megawatts of electricity by 2020. The country has an estimated uranium oxide reserve 11,17,800 metric tonnes in six states (**Table 23.17**).

TABLE 23.17. Distribution of Uranium reserves (2011-12)

State	Uranium reserves (metric tonnes)
1. Jharkhand	46,700
2. Andhra Pradesh	22,000
3. Karnataka	21,000
4. Meghalaya	16,400
5. Rajasthan	2,900
6. Chattisgarh	2,800
Total	1,17,800

Source : Department of Atomic Energy.

A study of samples of magnetic rocks from the Nubra-Shyok valley in Lakakh has found uranium (0.31-5.36 per cent) and thorium (0.76-1.43 per cent). The study made in the isotope laboratory of the University of Tuebingen in Germany in 2007 says that uranium found in these rocks is exceptionally high when compared with 0.1 per cent or even less in ores present elsewhere in the country.

Timeline

1951 : Uranium deposits discovered in Jaduguda.

1956 : Uranium found in Umbra, Rajasthan.

1957 : Exploratory mining begins in Umbra and Jaduguda.

1962 : Exploratory mining in Bhatin (Jharkhand); Narwapahar the next year.

1973: Deposits discovered in Bodal, Chhattisgarh.

1979 : Evaluation and resource estimation of Bhatin, Turamidih (East) Deposits completed Discovery of spondumene bearing tantaliferous pegmatite at Mariagalla, Karnataka.

1984 : Deposits found at Domiasiat, Meghalaya.

1985 : Evaluation and resource estimation of Bodal completed.

1986 : Discovery of dolostone-hosted uranium mineralisation in Tummalapella, Andhra.

1987 : Evaluation and resource estimation of Turamdih (West) deposit completed.

1989 : Evaluation and resource estimation of Mohuldih deposit (Jharkhand) completed.

1991 : Discovery in Lambapur, Andhra.

1992 : Test recovery plant set up in Domiasiat for uranium extraction.

1993 : Evaluation and resource estimation of Domiasiat completed.

1994 : Find in Wahkyn, Meghalaya.

1997 : Discovery of Gogi, Karnataka.

2001 : Evaluation and resource estimation of Lambapur-Peddagattu deposit (Andhra) completed.

However, the largest source of uranium comprise the monazite sands, both beach and alluvial. Although monazite sands occur on east and west coasts and in some places in Bihar, the largest concentration of monazite sand is on the Kerala coast. Over 15,200 tonnes of uranium is estimated to be contained in monazite. Some uranium is found in the copper mines of Udaipur in Rajasthan.

Thorium is also derived from monozite which contains 10 per cent thoria and 0.3 per cent urania. The other mineral carrying thorium is thorianite. The known reserves of thorium in India are estimated to be between 4,57,000 and 5,08,000 tonnes. Kerala, Jharkhand, Bihar, Tamil Nadu and Rajasthan are the main producers.

Beryllium oxide is used as a 'moderator' in nuclear reactors for atomic power generation. India has sufficient reserves of beryllium to meet her requirement of atomic power generation.

Lithium is a light metal which is found in lepidolite and spodumene. Lepidolite is widely distributed in the mica belts of Jharkhand, Madhya Pradesh and Rajasthan as well as in Bastar region of Chhattisgarh. ***Zirconium*** is found along the Kerala coast and in alluvial rocks of Ranchi and Hazaribagh districts of Jharkhand.

Salt

It is an important mineral which is used in chemical industry. Sodium chloride, known as *common salt*, is used as a food item. Salt is obtained from sea water, brine springs, wells and salt pans in lakes and from rocks. Rock salt is taken out in Mandi district of Himachal Pradesh and in Gujarat. It is less than 1 per cent of the total salt produced in India. Sambhar lake in Rajasthan produces about 10 per cent of our annual production. Sea brine is the source of salt in Gujarat, Maharashtra and Tamil Nadu. Gujarat coast produces nearly half of our salt. Production of salt in India increased from 30 lakh tonnes in 1951 to 100 lakh tonnes in 2011-12. In 2005-06, 1,871 tonnes rock salt worth ₹ 29.54 lakh was produced.

CONSERVATION OF MINERAL RESOURCES

Conserving the mineral resources is the most serious problem because they are exhaustible resources. Once taken out of the mines, minerals are used for ever. This is the reason that mining is often called a *robber industry*.

The mineral resources are being exploited at an accelerated rate due to advancement in mining technology. India exports a large number of minerals to earn the much needed foreign exchange. But it will be much better if we export goods manufactured from the minerals rather than exporting minerals in their raw form. Minerals can be conserved by bringing in efficiency in mining technology as well as in the technology of benefication. There are many 'cyclic' minerals such as iron, aluminium, copper, brass, tin, etc. Recycling of these minerals can help in reducing the waste. Japan, Britain, Italy, etc. are some of the countries which are using scrap iron on a large scale for iron and steel industry. Scarce minerals may be saved by substituting them by those minerals which are cheaper and are found in abundance. The best example is that of aluminium which is now extensively used in electrical industry in place of copper.

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CHAPTER 24

Energy Resources

Energy is the primary input in the production of goods and services. *The wheels of progress move with the flow of energy*. One of the critical elements in raising the standard of living of a country's population is the provision of affordable and reliable energy services in sufficient quantities. More regular and ample is the availability of energy, more even will be the path to economic prosperity. The role of energy has significantly increased with the increase in industrialization and urbanization in the present day society. From its early role, which was confined to kitchen as a fuel for household cooking, energy is now a major input in sectors such as industry, commerce, transport and telecommunications, besides the wide range of services required in the household sector.

Depending upon its source and utilization, energy can be divided into two broad classes *viz.* (*i*) *traditional or non-commercial*, and (*ii*) *commercial energy*. The non-commercial energy includes fire-wood, charcoal, cow dung, agricultural wastes and also animal power. The commercial sources of energy comprise coal, oil, natural gas, hydro-electricity, nuclear power, as well as wind and solar power. Energy may also be classified as *conventional* and *non-conventional* depending upon its nature. Coal, petroleum, natural gas and electricity are the main sources of *conventional energy* while solar, wind, tidal, geothermal energy and biogas, etc. are some of the outstanding examples of *non-conventional energy*.

CONVENTIONAL SOURCES OF ENERGY

As mentioned in the preceding paragraph, coal, petroleum, natural gas and electricity are conventional sources of energy. A brief description of their production, distribution and consumption is given in the following pages.

COAL

Coal is an inflammable organic substance, composed mainly of hydrocarbons, found in the form of sedimentary rocks and capable of being used as fuel to supply heat or light or both. It also contains volatile matter, moisture and ash in varying proportions. Combustible matter in coal consists of carbon and hydrogen.

Coal was, is and will continue to be the main-stay of power generation in India for a longtime. It constitutes about 70 per cent of total commercial energy consumed in the country. The power sector and industries account for 94 per cent of total consumption. Manufacturing of iron and steel and a variety of chemicals largely depend upon the availability of coal. Due to its high utility as a source of energy and as a raw material for a large number of industries, it is often called ***black gold***. A recent study conducted by energy experts shows that the world coal reserves are six times the known reserves of oil and coal has been described as the *bridge into the future*.

Origin of Coal

Coal has originated from the organic matter wood. Large tracts of forest lands were buried under sediments in the geological past *i.e.* in the Carboniferous age. Wood was burnt and decomposed due to heat from below and pressure from above. During the process of decomposition of wood, hydrogen originates in the form of methane and water, oxygen in the form of carbon dioxide and water. During the process of change from wood to coal, the amount of oxygen and nitrogen decreases and the proportion of carbon increases. The capacity of coal to give energy depends upon the percentage of carbon contained in it. The percentage of carbon in coal depends upon the duration and intensity of heat and pressure on wood.

Varieties of Coal

Depending upon its grade from highest to lowest, following four varieties of coal are generally recognized.

1. Anthracite Coal. This is the best quality of coal and contains 80 to 95 per cent carbon. It has very little volatile matter and negligibly small proportion of moisture. It is very hard, compact, jet black coal having semi-metallic lustre. It ignites slowly and burns with a nice short blue flame. It has the highest heating value and is the most prized among all the varieties of coal. In India, it is found only in Jammu and Kashmir and that too in small quantity.

2. Bituminous Coal. This is the most widely used coal. It derives its name after a liquid called bitumen released after heating. It varies greatly in composition-in-carbon content (from 40 to 80 per cent)–and moisture and volatile content (15 to 40 per cent)–so that it is often sub-divided into several minor divisions such as sub-bituminous and bituminous coals. It is dense, compact, and is usually of black colour. A good bituminous coal is composed of alternate dull and bright bands. It does not have traces of original vegetable material from which it has been formed. Its calorific value is very high due to high proportion of carbon and low moisture content. By virtue of this quality, bituminous coal is used not only for steam raising and heating purposes but also for production of coke and gas. Most of the bituminous coal is found in Jharkhand, Odisha, West Bengal, Chhattisgarh and Madhya Pradesh.

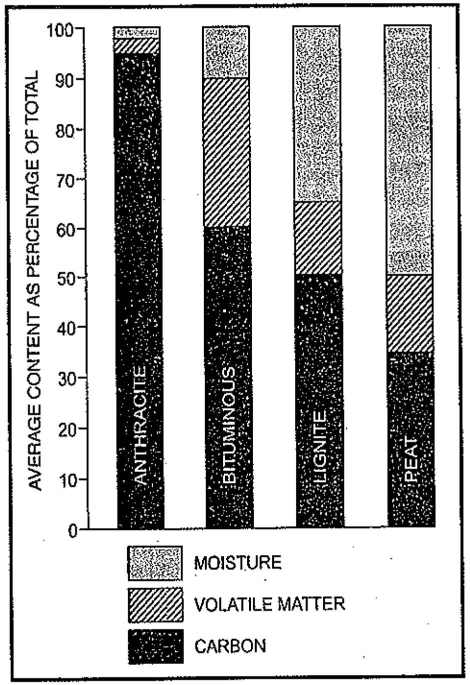

FIG. 24.1. Constituents of different types of coal

3. Lignite. Also known *as **brown coal***, lignite is a lower grade coal and contains about 40 to 55 per cent carbon. It represents the intermediate stage in the alteration of woody matter into coal. Its colour varies from dark to black brown. It is friable and pyritious. Its moisture content is high (over 35 per cent) so that

it gives out much smoke but little heat. Its typical qualities make it liable to disintegrate on exposure and even to spontaneous combustion. It is found in Palna of Rajasthan, Neyveli of Tamil Nadu, Lakhimpur of Assam and Karewa of Jammu and Kashmir.

4. Peat. This is the first stage of transformation of wood into coal and contains less than 40 to 55 per cent carbon, sufficient volatile matter and lot of moisture. It is seldom sufficiently compact to make a good fuel without compressing into bricks. Left to itself, it burns like wood, gives less heat, emits more smoke and leaves a lot of ash after burning.

Occurrence of Coal in India

The coal bearing strata of India are geologically classified into two main categories, *viz*., the Gondwana coal fields and the Tertiary coal fields.

(*a*) **Gondwana Coal.** Gondwana coal contributes overwhelmingly large proportion of both the reserves and production of coal, accounting for 98 per cent of the total reserves and 99 per cent of the production of coal in India. It is the store house of India's metallurgical as well as superior quality coal. Of the 113 major coal fields found all over India, 80 are located in the rock systems of the lower Gondwana Age. There are about 75 separate basins covering an area of 77,700 sq km mainly confined to the Peninsular India. The size of these basins varies from 1 sq km to 1,550 sq km. These basins occur down in the valleys of certain rivers *viz*., the Damodar (Jharkhand-West Bengal); the Mahanadi (Chhattisgarh-Odisha); the Son (Madhya Pradesh-Jharkhand); the Godavari and the Wardha (Maharashtra-Andhra Pradesh); the Indravati, the Narmada, the Koel, the Panch, the Kanhan and many more.

Gondwana coal is said to be about 250 million years old. It includes coking as well as non-coking and bituminous as well as sub-bituminous coal. Anthracite is generally not found in the Gondwana fields. The volatile compounds and ash (usually 13 to 20, rising to as much as 25 to 30 per cent) are present in too large a proportion to allow the carbon percentage to rise above 55 to 60; generally much less than that. The Gondwana coal is almost free from moisture, but it contains sulphur and phosphorus in small variable quantities.

It is possible that some coal bearing Gondwana rocks are hidden beneath the great pile of lava of the Deccan trap. At several places, chiefly in the Satpuras, denudation has exposed coal bearing Gondwana strata, from which it can be inferred that considerable quantities of valuable coal can be obtained from these areas. The Damuda series (*i.e.* Lower Gondwana) possesses the most valuable and best worked coalfields and accounts for about 80 per cent of the total coal production in India.

(*b*) **Tertiary Coal.** The tertiary rock system bears coals of younger age; from 15 to 60 million years and are mainly confined to the extra-Peninsula. This coal generally has low carbon and high percentage of moisture and sulphur. Important areas of Tertiary coal include parts of Assam, Meghalaya, Arunachal Pradesh, Nagaland, Himalayan foothills of Darjeeling in West Bengal, Jammu and Kashmir, Uttar Pradesh, Rajasthan, Kerala, Tamil Nadu and the union territory of Puducherry.

Reserves. According to the Geological Survey of India, the coal reserves of India as on 1 April, 2008 (down to a depth of 1,200 metre) have been estimated at 293.497 billion tonnes. State-wise distribution of coal reserves is given in **Table 24.1**.

TABLE 24.1. Distribution of Coal Reserves in India as on 1 January 2008

State	Total reserves in million tonnes	Percentage of all India reserves
1. Jharkhand	75,460.14	28.53
2. Odisha	65263.34	24.67
3. Chhattisgarh	44,134.04	16.68
4. West Bengal	28,334.84	10.71
5. Madhya Pradesh	20,559.96	7.77
6. Andhra Pradesh	18,696.59	7.07
7. Maharashtra	9,818.09	3.71
8. Others	226.06	0.86
Total	**2,64,535.06**	**100.00**

Source : Data computed from India 2009, A Reference Annual, p. 637.

The **table 24.1** shows that the distribution of coal reserves is highly uneven. Over four-fifths of coal reserves are concentrated in just four states of

Jharkhand, Odisha, Chhattisgarh and West Bengal. Jharkhand and Odisha have more than half of the coal reserves of India.

Lignite. As on 1 April, 2010, the total reserves of lignite in India have been estimated at 38.7 billion tonnes by Geological Survey of India. Over 90 per cent of the reserves of lignite are concentrated in Tamil Nadu. Neyveli area of Cuddalore district in Tamil Nadu has 4,150 million tonnes of lignate reserves out of which 2,360 million tonnes has been proved. The other lignite reserves of considerable importance in Tamil Nadu are those of Jayamkondacholapuram of Trichy district, Mannargudi and East of Veeranam. Lignite reserves have been identified in Rajasthan, Gujarat, Jammu & Kashmir and Kerala to the extent of 3,099 million tonnes, 1,778 million tonnes, 128 million tonnes and 108 million tonnes respectively.

Production

Although the first coal mine was opened in 1774 at Raniganj in West Bengal, the real beginning was made in 1814 in the same area. Coal mining industry registered a much faster growth after Independence (see **Table 26.2**).

The production rose steadily from 119.02 million tonnes in 1980-81 to 609.82 million tonnes in of coal and lignate.

The nationalisation of coal industry in 1973-74 gave much needed impetus to coal and lignite production and India is now the third largest coal producer in the world after China and the USA. At present, the coal industry provides employment to nearly seven lakh persons.

Distribution of Coal in India

Majority of the coal-fields are found in the eastern part of India particularly to the east of 78° E longitude. Maximum concentration of coal fields is in the north-eastern part of the Peninsular plateau of India comprising parts of Jharkhand, Chhattisgarh, Odisha and eastern Madhya Pradesh and western part of West Bengal adjoining Jharkhand. Southern part of Madhya Pradesh, eastern part of Andhra Pradesh and eastern part of Maharashtra also have large deposits of coal (**Fig. 24.3**).

Table 24.3 makes it clear that about three-fourth of India's coal is produced by four states of Chhattisgarh, Jharkhand, Odisha and Madhya Pradesh. More than 40 per cent of India's total coal production comes from just two states of Chhattisgarh and Jharkhand. About one-third of the total coal of the country is obtained from Andhra Pradesh, Maharashtra, West Bengal, Uttar Pradesh and Meghalaya.

TABLE 24.2. Production of Coal (including lignite) in India in million tonnes

Year	Cocking		Non-cocking	Total	Lignite	Total (coal + lignite)
	Metallurgical	Non-metallurgical				
1950-51	NA	NA	NA	32.30	NA	NA
1960-61	16.99	NA	38.14	NA	NA	NA
1970-71	17.82	NA	55.13	NA	3.39	NA
1980-81	24.59	8.03	81.29	113.91	5.11	119.02
1990-91	24.10	21.20	166.43	211.73	13.77	225.50
2000-01	19.31	11.70	278.55	309.63	22.95	332.58
2010-11	17.70	31.85	483.15	532.70	37.73	566.11
2011-12	16.24	35.42	488.29	539.95	42.33	582.28
2012-13	14.55	37.03	504.82	556.40	46.45	602.85
2013-14	—	—	507.42	565.64	44.18	609.82

NA = Data Not Available

Source : Economic Survey 2013-14, Statistical Appendix, p. A-26.

TABLE 24.3. Production of Coal in India 2011-12

State	Production in thousand times	Percentage of all India production
1. Chattisgarh	1,13,918	21.10
2. Jharkhand	1,09,702	20.32
3. Odisha	1,05,476	19.54
4. Madhya Pradesh	71,658	13.27
5. Andhra Pradesh and Telangana	52,210	9.69
6. Maharashtra	39,178	7.26
7. West Bengal	24,287	4.49
8. Uttar Pradesh	15,650	2.89
9. Odisha	7,773	1.44
Total	5,39,852	100.00

Source : Data computed from Mineral Wealth of India, 2013.

Gondwana Coalfields

As mentioned earlier, the Gondwana Coal fields are exclusively found in the Peninsular plateau of India. State-wise major Gondwana coal producing areas are described as under :

1. Chhattisgarh. Chhattisgarh holds the third position with respect to coal reserves but occupies the first position, so far as production is concerned. This state has 16.09 per cent of the coal reserves and produces over 21 per cent coal of India. Most of the coal fields of Chhattisgarh are located in the northern part of the state. The *Korba* coalfield stretches over an area of 515 sq km in the valleys of Hasdo (a tributary of the Mahanadi) and its tributaries (Ahram and Kurang) in Korba district. Coal occurs in the Barakar measures with total thickness of 700 m. Most of the coal from the field is sent to thermal power plant at Korba. The *Birampur* coalfield lies in Surguja district. With total reserves of 542 million tones this field has coal seams of thickness varying from 30 cm to 1.8 m. The *Hasdo-Arand* coalfield extends from Rampur in Surguja district to Arand valley in Bilaspur district and covers an area of about 1004 sq km. The coal reserves in this field are estimated at 4,321 million tonnes. The coal seams have average thickness of 2.5 m to 7.0 m. *Chirmiri* coalfield in Surguja district spreads over an area of 128 sq km. The total reserves of this field are estimated at 362 million tonnes. There are four coal seams in this field out of which three seams contain good quality coal. *Lakhanpur* coalfield lies south of Bisrampur coalfield and spreads over Surguja, Koriya, Korba and Bilaspur districts. Here the coal seams are 1 to 3 m thick. *Jhilmili* coalfield occupies a total area of 106 sq km. Being an extension of Sahagpur coalfield of Shahdol district (in Madhya Pradesh), most of it lies in Koriya district of Chhattisgarh. It has five coal seams which belong to Talcher and Barakar measures. The coal is non-cocking type and has high proportion of ash. *Johilla* coalfield, lying in the Johilla valley, covers an area of about 38 sq km. The reserves are estimated at 311 million tonnes. *Sonhat* coalfield in Surguja district has superior quality coal. Kutkona, Charch and Sardih coal bearing strata have high grade coal. *Tatapani-Ramkota* coalfields lie between Kanhar and Rehar rivers in the north-eastern part of Surguja district. Coal of Tatapani coalfields belongs to the Damuda series.

2. Jharkhand. Jharkhand is the richest state with respect to reserves but has conceded the first place to Chhattisgarh. This state was the largest producer of coal in India till recent past. Jharkhand has over 28 per cent of the coal reserves and produces more than 20 per cent coal of India. In the year 2011-12, Jharkhand produced 1097.02 lakh tonnes of coal.

Most of the coal fields are located in a narrow belt running in east-west direction almost along the 24°N latitude (Fig. 24.2). There are 21 prominent coal fields in Jharkhand of which 8 are in Dumka (Santhal Parganas), 7 in Hazaribagh and 3 each in Dhanbad and Palamu. Amongst these, Jharia, Bokaro, Girdih and Karanpura are outstanding. The *Jharia coal-field* lies to the south-west of Dhanbad city and covers an area of 453 sq km. It is one of the oldest and the richest coal fields of India and has been recognised as the ***store house*** of the best metallurgical coal in the country. The total estimates of all grades of coal upto a depth of 900 metre are estimated to be 16,985.69 million tonnes. The *Bokaro coal-field* in Hazaribagh district lies within 32 km of western end of the Jharia coal field. It is a long but narrow strip in the catchment area of the Bokaro river spreading over an area of 674 sq km. The entire Bokaro coalfield is divided into two parts *viz*. West Bokaro and East Bokaro. The reserves in West Bokaro upto a depth of

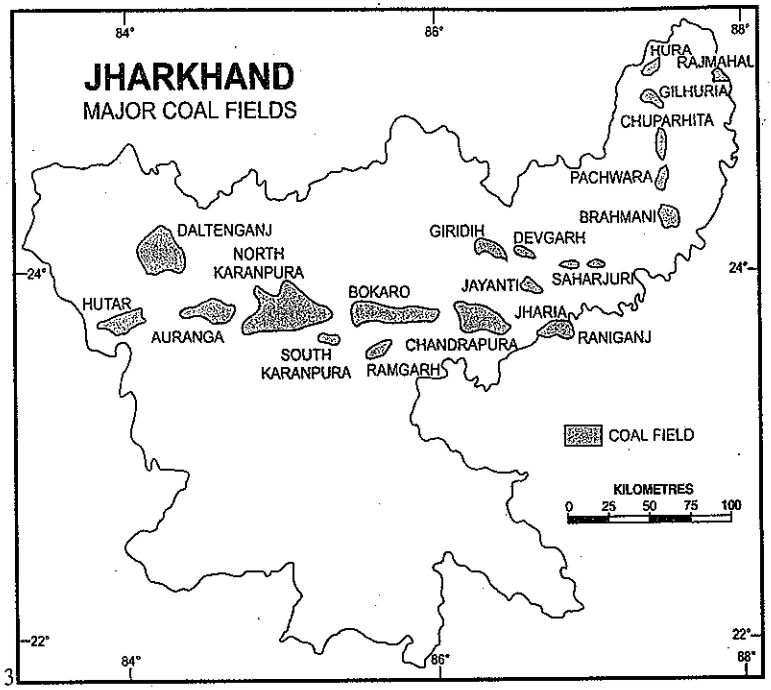

FIG. 24.2. Jharkhand : Major coal fields

900 metre have been estimated at 4,473.73 million tonnes with seams ranging from 3.5 to 11 metre thick. East Bokaro has 4,246.32 million tonnes of reserves upto a depth of 600 metre. The *Girdih* (also known as ***Karharbari***) coalfield lies to the south-west of Girdih in Hazaribagh district. Spreading over an area of 28.5 sq km this field has three main seams of varying thicknesses: (*i*) the Lower Karharbari (*ii*) the Upper Karharbari and (*iii*) the Badhua seams. The Lower Karharbari seam is 3 to 7.5 metre thick and gives out of the finest coking coal in India for metallurgical purposes. The *Karanpura and Ramgarh* coalfields lie to the west of Bokaro and cover an area of about 1,522 sq km. The *North Karanpura* covers an area of 1,230 sq km having estimated reserves of 13,110.84 million tonnes upto a depth of 900 metre. The *South Karanpura* field covers an area of 194 sq km and possesses estimated reserves of 5,757.85 million tonnes down to 900 metres in depth. *Ramgarh coal field* situated about 9 km away from the Bokaro field covers an area of 98 sq km having 22 seams. The total coal reserves of this field are estimated to be at 1,059.20 m tonnes down to a depth of 900 m. The *Auranga* coalfield in Palamu occupies an area of 240 sq km with a seam of 3 m thickness. Coal taken out from this field is of inferior quality which is used in cement furnaces and brick kilns. The *Hutar* coalfield, about 19 km west of Auranga field in Palamu district, covers an area of about 200 sq km with 5 seams of inferior coal. The *Deltenganj* coalfield in Palamu district covers a total area of 51 sq km. This field has proved reserves of 84 million tonnes. There are 14 coal seams near *Rajhera* whose thickness varies from 15 cm to 1.5 m. Devgarh coalfields lie in Dumka district where Jayanti, Saharjuri and Kundithuraih are the main mining areas. These coalfields occupy the valleys of the Adjai and Barakar rivers and covers a total area of about 46 km. *Jayanti* coalfields have 5 seams while the remaining two have two seams each. The coal here is of inferior quality and has high ash content. The *Rajmahal* coalfield along the western side of the Rajmahal hills is in a scattered form which spreads over an area of about 182 sq km. It lies in the north of the river where Hura, Gilhuria Chuparhita, Pachwara, Mahuagahi and Brahmki are important mines. This coalfield has proved coal

reserves of 1,913 million tonnes. However, coal available here is of inferior quality and is mostly used in brick kilns.

3. Odisha. Odisha is the second largest state with regard to coal reserves possessing 24.64 per cent of the total reserves of India but is the third largest producer of coal contributing a little over 19 per cent of the total coal production of the country. This means that there is a large scope for increasing coal production in this state. Most of the deposits are found in Dhenkanal, Sambalpur and Sundargarh districts. The *Talcher* field stretching eastward from

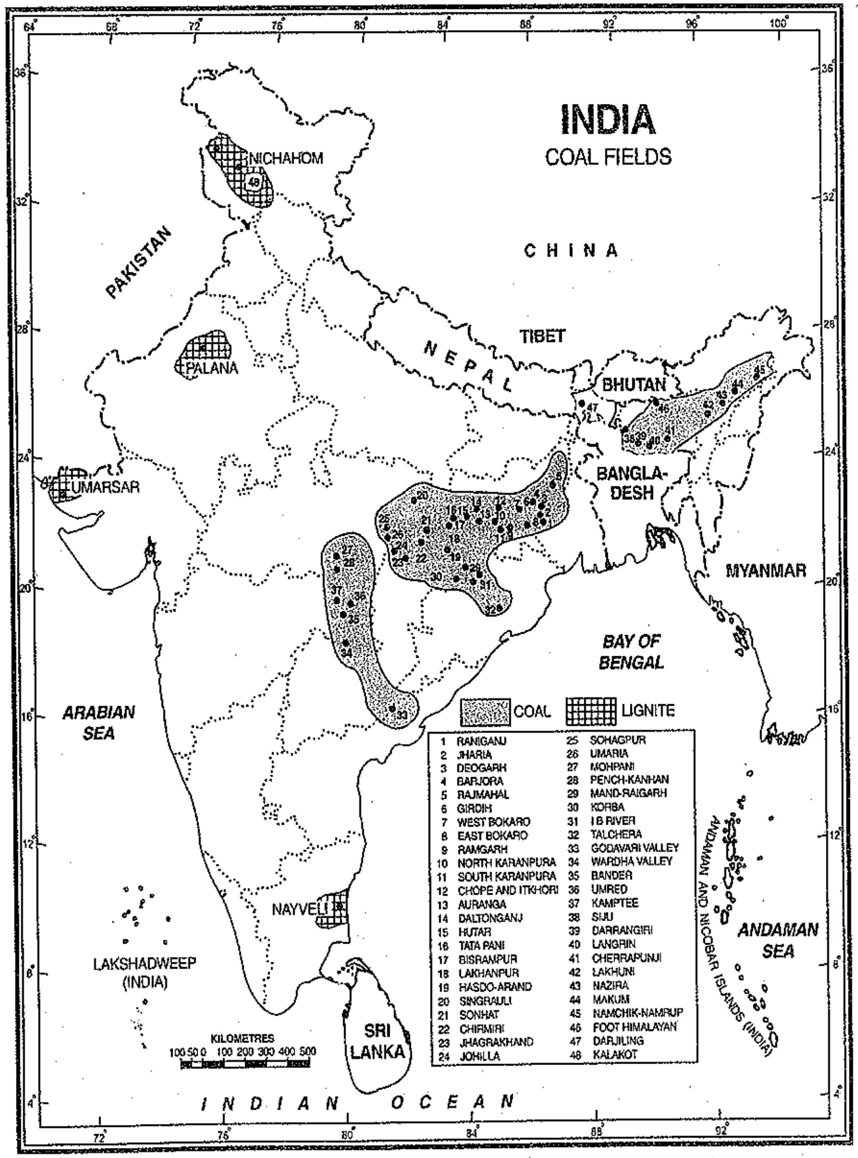

FIG. 24.3. India : Coal Fields

Talcher town to Rairkhol in Dhenkanal and Sambalpur districts ranks second in reserves (24,374 million tonnes) after Raniganj. This field covers an area of 578 sq km. Two workable seams of coal 3 to 4 metre thick had earlier been discovered in an area of 295 sq km near Talcher town. Coal from this field is most suitable for steam and gas production. Most of the coal is utilised in thermal power and fertilizer plants at Talcher. The *Rampur-Himgir* coalfields in the districts of Sambalpur and Sundargarh spread over an area of 520 sq km. Coal occurs here in middle and lower Barakar seams. Bulk of the coal is of inferior quality. The **Ib river** coalfield covers a total area of 512 sq km in Sambalpur and Gangpur districts. The inferred reserves in this area are estimated at 1,754 million tonnes. The coal belongs to the middle and lower Barakar systems in which Rampur, Lajkuria and Gamhadera seams are important. Much of the coal is of inferior quality with about 50 per cent fixed carbon.

4. Madhya Pradesh. Madhya Pradesh has about 7.77 per cent of the coal reserves but contributes about 13.27 per cent of the total coal production of India. Currently Madhya Pradesh is the fourth largest coal producing state of India. *Singrauli* (Waidhian) coalfield in Sidhi and Shahdol districts is the largest coalfield of Madhya Pradesh. Spreading over an area of 2,337 sq km, this coalfield has 9,207 million tonnes of coal reserves. Jhingurda, Panipahari, Khadia, Purewa and Turra are important coal seams. Jhingurda with a total thickness of 131 m is the richest coal seam of the country. This field supplies coal to thermal power plants at *Singrauli* and *Obra*. *Pench-Kanhan-Tawa* in Chhindwara district is another important coalfield of Madhya Pradesh. It contains 1956 million tonnes of semi-coking and non-coking coal. Ghoravari seam in Kanhan field is 4.6 m thick and contains coking coal. *Sohagpur* coalfield in Shahdol district has 2,284 million tonnes reserves of coal. Here coal seams attain a thickness of 3-5 m and even more. *Umaria* coalfield is situated at a distance of 58 km to the south of Katni. It contains 6 coal seams of which 4 are important (thickness 2 to 4 m). The total reserves are estimated at about 58 million tonnes. However, the coal is of inferior quality with high percentage of moisture and ash.

5. Andhra Pradesh and Telangana. With only 7.07 per cent of the reserves Andhra Pradesh and Telangana produce about 9.69 per cent of India's coal. Most of the coal reserves are in the Godavari valley spread over an area of 10,350 sq km in the districts of Adilabad, Karimnagar, Warangal, Khammam, East Godavari, and West Godavari. The actual workable collieries are situated at Tandur, Singareni and Kothagudam. Almost the entire coal is of non-coking variety. The reserves of all types of coal in the Godavari valley upto a depth of 1210 metre have been estimated at 10,435.50 million tonnes. These are the southern most coalfields of India and a source of coal supply to most of south India.

6. Maharashtra. Though Maharashtra has only 3 per cent reserves, the state accounts for over 7 per cent of the production of coal in India. Most of the coal deposits are found in the Kamptee coalfields in Nagpur District; Wardha valley, Ghughus, Ballarpur and Warora in Chandrapur district and the Wun field in Yavatmal district. Coal has also been located in Umrer, Nand, Makardhokra and Bokhara areas.

7. West Bengal. Although West Bengal produces just over four per cent of India's coal, the state has over 11 per cent of the coal reserves of the country. Barddhaman, Bankura, Purulia, Birbhum, Darjeeling and Jalpaiguri are the chief producing districts. Raniganj is the largest coalfield of West Bengal. In fact, it is at Raniganj that coal-mining started in India in 1,774. It covers an area of 1,500 sq km mainly in Barddhaman, Bankura and Purulia districts. Small part of this field is in Jharkhand state. This field produces mainly non-coking steam coal, which is mainly used by thermal power plants.

In Darjeeling district, coal reserves are found in Dalingkot coalfield; several seams occur near Tindharia where the best seam is about 3.3 metre thick. In Jalpaiguri district, a few seams are located near the Duars area.

8. Uttar Pradesh. Most parts of Uttar Pradesh are covered with sediment brought by rivers and do not possess coal reserves. But some of the coal seams of Madhya Pradesh project into the terrritory of this state. A small portion of the Singrauli field of Madhya Pradesh falls within Mirzapur district of Uttar Pradesh. A high grade coal seam, about 1 to 1.5 m thick occurs near Kotah.

Tertiary Coal-fields

Tertiary coal-fields mainly occur in association with limestone and slates of either Eocene or Oligocene-Miocene age. The statewise distribution of tertiary coal is as follows :

1. Assam. The major coalfields in Assam are the Makum, Nazira, Mikir Hills, Dilli-Jeypore and Lakhuni. Of these, the Makum coalfield in Sibsagar district is the most developed field. It is 28 km long and about 5 km wide. The total reserves of all types of coal in this field are estimated to be 235.6 million tonnes, down to a depth of 600 m. In the Mikir Hills coalfield, Koilajan, Langlor, Diogarang river areas are worth mentioning. Assam coals contain very low ash and high coking qualities but the sulphur content is high, as a result of which this coal is not suitable for metallurgical purposes. But these coals are best suited for hydrogenation process and are used for making liquid fuels.

2. Meghalaya. Garo, Khasi and Jaintia hills are believed to have deposits of tertiary coal belonging to lower Eocene. The total reserves of all types of coal in Meghalaya are estimated to be 459 million tonnes. The Garo hills have important coalfields near Darrangiri. In the Khasi and Jaintia hills, Siju, Cherrapunji, Liotryngew, Maolong and Langrin coalfields are important.

3. Arunachal Pradesh. The Upper Assam Coal belt extends eastwards as Namchick-Namrup coalfield in the Tirap district of Arunachal Pradesh. The seams of this coalfield are 4 to 19 metre thick. The coal is generally high in volatiles and in sulphur. The total reserves of all kinds of coal upto a depth of 330 m are estimated to be about 90 million tonnes.

The other tertiary coalfields include the Kalakot, Jangali, Chinkah, Metka, Maholgala and Ladde areas of Jammu and Kashmir and the Chamba district of Himachal Pradesh.

LIGNITE

That there has been a phenomenal increase in the production of lignite in India. Although lignite deposits are found in Tamil Nadu, Gujarat, Jammu and Kashmir, Kerala, Rajasthan, West Bengal and Puducherry; Tamil Nadu excels all other states regarding reserves and production of lignite.

1. Tamil Nadu. Tamil Nadu accounts for 90 per cent of the reserves and about 57 per cent of the production of lignite in India. This state produced 24,592 thousand tonnes of lignite out of a total of 42,897 thousand tonnes for the whole of India in 2011-12. The Neyveli Lignite fields of Cuddalore district, extending over an area of 480 sq km, have an estimated reserves of 4,150 million tonnes. These are the largest deposits of lignite in south-east Asia and can sustain power generation for more than a hundred years. However, Neyveli mines suffer from the artesian structure and constant pumping of water is a formidable task. Lignite reserves at Neyveli are exploited by Neyveli Lignite Corporation Limited (NLC). Incorporated as a private limited company in 1956, NLC was wholly owned by the Government and converted into a public limited company with effect from 7 March, 1986. Over the years, it has acquired considerable expertise and has established itself as a premier organisation in the field of lignite mining and lignite based power generation. Geological reserves of about 1,168 million tonnes of lignite have been identified in Jayamkondacholapuram of Trichy district of Tamil Nadu. In Mannargudi and east of Veeranam, geological reserves of around 22,898 million tonnes and 1,342.45 million tonnes have been estimated respectively.

TABLE 24.4. Distribution of Lignite in India 2011-12

State	Production in thousand times	Percentage of all India production
1. Tamil Nadu	24,592	57.33
2. Gujarat	14,761	34.41
3. Rajasthan	3,544	8.26
Total	42,897	100.00

Source : Data Computed from Mineral Wealth of India 2011-12.

2. Gujarat. Lignite occurs in Kachchh district at Umarsar, Lefsi, Jhalrai and Baranda and also in Bharuch district. The lignite of all the places except that of Umarsar is of poor quality. The total reserves of the state are estimated at 465 million tonnes. In 2011-12 Gujarat produced over 14.7 million tonnes of lignite which amounted to over 34 per cent of the total lignite production of India.

3. Rajasthan. Lignite deposits occur over an area 4 km long and 0.8 km wide at Palana in Bikaner district. Most of lignite is found at depths varying from 61 to 78 metres in 6 to 12 metre thick seams. Huge lignite reserves to the tune of 1,640 million tonnes were discovered in Barmer district in the year 2003. This discovery has made the state richer at total reserves of 2,300 million tonnes. The 250 MW thermal plant at Bikaner wholly depends upon lignite as the basic fuel. Lignite is found in some other parts of the state also. In 2011-12, Rajasthan produced 3,544 thousand tonnes of lignite which amounted to 8.26 per cent of total lignite produced in the country in that year.

4. Jammu and Kashmir. Lignite deposits belonging to Pliocene or even a newer age have been found here in sufficient quantity. The main lignite fields occur in the Shaliganga river, continuing to the northwest upto Nichahom area in Handwara region of Baramula district. The lignite here is of poor quality. The total reserves are 90 million tonnes.

5. Kerala. Irregular seams of lignite occur near Pathiarpally in Alappuzha district, Warkala in Thiruvananthapuram district and Paravur in Kollam district. But the main deposit of lignite occurs as a band of 45 to 60 cm thick near Kannur and Kasargod taluka. It is also found in Kozhikhode district.

6. West Bengal. Good quality lignite is reported to occur on the western side of the Jainti river and in Buza hills north-west of Jainti. Darjeeling and Jalpaiguri districts have small pockets of lignite. Beds of lignite also occur in the Ganga delta.

7. Puducherry. The total reserves of lignite in Puducherry are estimated at 250 million tonnes. The main deposits are reported from near Bahur, Araganur and Kanniyankovil. Pudukaddai, Vadapuram, Kadvanur and Paliayam also have some deposits.

PEAT

Peat is confined to a few areas only. It occurs in Nilgiri hills at an elevation of over 1,800 m. In the Kashmir valley, peat occurs in the alluvium of the Jhelum and in swampy grounds in higher valleys. In West Bengal peat beds at depths ranging from 2 to 11 metre have been noted in Kolkata and its suburbs. In the Ganga delta, there are layers of peat which are composed of forest and rice plants.

Problems of Coal Mining in India

Coal mining industry in India is facing a lot of problems. Some of the major problems confronting the coal mining are discussed as under :

1. The distribution of coal is uneven. The major coal producing areas are confined to Jharkhand, Chhattisgarh, Madhya Pradesh, Odisha and West Bengal. Most of north plains and western parts of India are devoid of coal. This involves high transport cost to carry a heavy commodity like coal over long distances. Consequently, the coal consuming industries have to pay much higher prices for coal.

2. Indian coal has high ash content and low caloric value. The ash content varies from 20 to 30 per cent and sometimes exceeds even 40 per cent. This reduces the energy output of coal and complicates the problem of ash disposal.

3. A large percentage of coal is taken out from underground mines where the productivity of labour and machinery is very low. This has stagnated at an output per man shift (OMS) of 0.55 tonnes for the last two decades despite massive investments made in modernisation of underground mines. The underground mines employ 80 per cent of the man power, but contribute only 30 per cent of the total output. The per tonne production cost has increased from ₹ 50 in 1973-74 to ₹ 550 in 2011-12.

4. There are heavy losses due to fires in the mines and at pit heads. Pilferage at several stages also adds to losses. This leads to hike in price of coal and sets off a vicious circle of price spiral in the economy.

5. Mining and utilisation of coal leads to serious problem of environmental pollution. The open cast mining ravages the whole area converting it into a rugged and ravinous land. The coal dust in mines and near pit-heads creates health hazards to workers and their families. The burning of coal in thermal plants and factories releases several toxic gases in the atmosphere. Safety measures against environmental pollution caused by mining and utilisation of coal are very costly and complicated and are beyond the reach of ordinary entrepreneurs.

Conservation of Coal

The misuse of good quality coal for burning into transport and industries, the short life of metallurgical

coal, selective mining leading to large scale wastage of raw coal, frequent fires in mines and unscientific method of extraction of coal have been identified as important indications for conservation of coal in India. Conservation of coal implies that every bit of energy that can be obtained from coal must be obtained and every bit of by-product that can be recovered must be recovered. Conservation of coal is an integral part of mine planning and operation. Following measures are suggested for conservation of coal in India.

1. Coking coal should be used for metallurgical industry only.
2. Low grade coal should be washed and blended with superior quality coal in requisite proportion and used in industries.
3. Selective mining should be discouraged and all possible coal from the mines should be taken out.
4. New reserves should be discovered and new techniques should be adopted.
5. Small and uneconomic collieries should be amalgamated and be made economically viable units.

PETROLEUM OR MINERAL OIL

The word 'petroleum' has been derived from two Latin words Petra (meaning rock) and Oleum (meaning oil). Thus petroleum is oil obtained from rocks; particularly sedimentary rocks of the earth. Therefore, it is also called mineral oil. Technically speaking, petroleum is an inflammable liquid that is composed of hydrocarbons which constitute 90 to 95 per cent of petroleum and the remaining is chiefly organic compounds containing oxygen, nitrogen, sulphur and traces of organo-metallic compounds. Crude petroleum consists of a mixture of hydrocarbons—solid, liquid and gaseous. These include compounds belonging to the paraffin series and also some unsaturated hydrocarbons and small proportion belonging to the benzene group.

Utilisation of Petroleum

Petroleum and petroleum products are mainly used as motive power. It is a compact and convenient liquid fuel which has revolutionised transportation on land, in the air and on water. It can be easily transported from the producing areas to the consuming areas with the help of tankers and more conveniently, efficiently and economically by pipelines. It emits very little smoke and leaves no ash, (as is the case in coal utilisation) and can be used upto the last drop. It provides the most important lubricating agents and is used as an important raw material for various petro-chemical products.

Origin and Occurrence of Petroleum

Petroleum has an organic origin and is found in sedimentary basins, shallow depressions and in the seas (past and present). Most of the oil reserves in India are associated with anticlines and fault traps in the sedimentary rock formations of tertiary times, about 3 million years ago. Some recent sediments, less than one million years old also show evidence of incipient oil. Oil and natural gas originated from animal or vegetable matter contained in shallow marine sediments, such as sands, silts and clays deposited during the periods when land and aquatic life was abundant in various forms, especially the minor microscopic forms of flora and fauna. Conditions for oil formation were favourable especially in the lower and middle Tertiary period. Dense forests and sea organisms flourished in the gulfs, estuaries, deltas and the land surrounding them during this period. The decomposition of organic matter in the sedimentary rocks has led to the formation of oil. Though oil is mainly found in sedimentary rocks, all sedimentary rocks do not contain oil. An oil reservoir must have three pre-requisite conditions : (*i*) porosity so as to accommodate sufficiently large amounts of oil; (*ii*) permeability to discharge oil and/or gas when well has been drilled; (*iii*) the porous sand beds sandstone, conglomarates of fissured limestone containing oil should be capped by impervious beds so that oil does not get dissipated by percolation in the surrounding rocks. Oil on a commercial scale is usually found where the sedimentary rock strata are inclined and folded; in a sort of chamber or reservoir, in the highest possible situation *e.g.* crests of anticlines. Normally, oil is associated with water. Being lighter than water (specific gravity of 0.8 to 0.98), it collects in the anticlines or fault traps above the surface of water. Gas is still lighter and occurs above oil. Thus on drilling an oil well, one finds gas followed by oil.

although gas seepage is not always a sure indication of an oil reservoir.

As already mentioned, oil as well as natural gas in India occur in sedimentary rocks. About 14.1 lakh sq km or about 42 per cent of the total area of the country is covered with sedimentary rocks out of which about 10 lakh sq km form marine basins of Mesozoic and Tertiary times. Besides, the country has offshore areas having Mesozoic and Tertiary rocks of marine origin covering an area of 2.5 lakh sq km upto a depth of 100 metre and another area of 0.7 lakh sq km upto a depth between 100 and 200 metre. Thus the total continental shelf of probable oil bearing rocks amounts to 3.2 lakh sq km (*see* **Fig. 24.4**) The total sedimentary area including both on shore and offshore comprises 27 basins. The geological and geophysical studies have been conducted in 14 basins while exploratory drilling has been done in 9 basins. Mumbai High, the Khambhat Gulf and the Assam are the most productive areas.

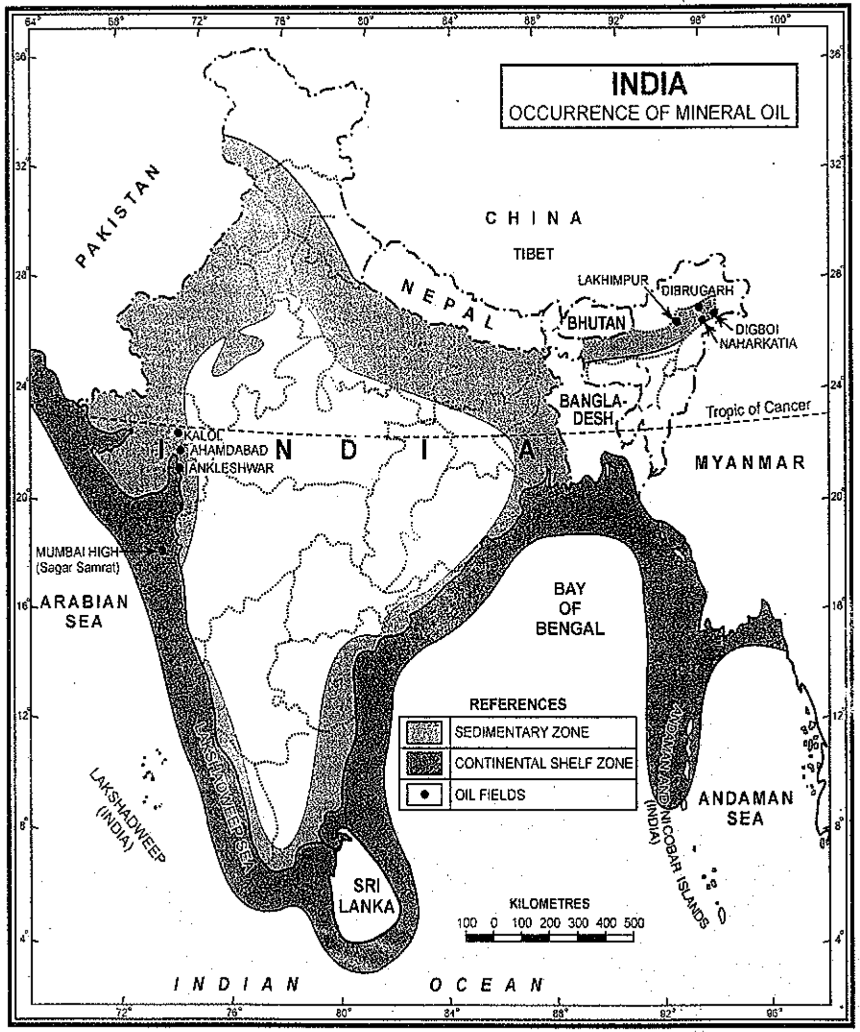

FIG. 24.4. India : Mineral Oil

TABLE 24.5. Production of Petroleum (Crude) in India (Million tonnes)

Year	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
On-shore	0.3	0.5	6.8	5.5	11.8	11.8	11.4	11.3	11.2	11.3	11.8	16.4	18.0	19.44	19.54
Off-shore	—	—	—	5.0	21.2	20.6	20.8	22.7	22.9	22.2	21.9	21.3	20.1	18.42	18.19
Total	**0.3**	**0.5**	**6.8**	**10.5**	**33.0**	**32.4**	**32.2**	**34.0**	**34.1**	**33.5**	**33.7**	**37.7**	**38.1**	**37.86**	**37.78**

Source : The Economic Survey, 2012-13, p. A-31 and Economic Survey 2013-14, Statistical Appendix, p. 27.

Production

India was a very insignificant producer of petroleum at the time of Independence and remained so till Mumbai High started production on a large scale. In fact, off-shore production did not start till the mid 1970s and the entire production was received from on-shore oil fields.

In 1980-81 about half of the production of crude oil came from on-shore fields while the remaining half was received from the off-shore resources. After that juncture, the off-shore production increased at a much faster rate than the on-shore production. From 1990-91 to 2009-10, about two-thirds of the production had been received from off-shore sources but after that on-shore production has picked up very fast. The total production recorded more than three times increase after 1980-81.

TABLE 24.6. Production of Petroleum (crude) in India 2011-12

State/Region	Production in thousand tonnes	Percenage of all India production
1. Off-shore	20,664	52.68
2. Rajasthan	6,553	17.20
3. Gujarat	5,774	15.16
4. Assam	5,023	13.19
5. Andhra Pradesh	305	0.81
6. Tamil Nadu	249	0.65
7. Arunachal Pradesh	120	0.31
All India	**38,088**	**100.00**

Source : Data computed from Mineral Wealth of India 2013.

As mentioned earlier, oil in India is obtained both from on-shore and off-shore areas, but off-shore areas made a major contribution (*see* **table 24.5** and **24.6**).

On-shore Oil Production. On-shore oil fields are located in the Brahmaputra valley of north-east India, Barmer area of Rajasthan, Gujarat coast in western India and Cauvery on-shore basin in Tamil Nadu. Besides Andhra Pradesh has both on-shore and off-shore oil reserves.

OILFIELDS IN NORTH-EAST INDIA

The major oilfields in north-east India are those of the Brahmaputra valley in Assam and its neighbouring areas including Arunachal Pradesh, Nagaland, Meghalaya, Tripura, Manipur and Mizoram.

Assam. Assam is the oldest oil producing state in India. The main oil bearing strata extend for a distance of 320 km in upper Assam along the Brahmaputra valley. Following are some of the important oilfields of Assam :

1. ***The Digboi field.*** Located in the north-east of Tipam hills in Dibrugarh district of Upper Assam, Digboi is the oldest oil field of India. The oil bearing strata cover an area of about 13 sq km where oil is available at 400 to 2,000 metre depth. Over 800 oil wells have been drilled so far. Before the opening of the oil fields of west India, Digboi used to account for three-fourths of the total oil production of India. The most important centres are Digboi, Bappapang, Hassapang and Paintola. Most oil is sent to oil refinery at Digboi.

2. ***The Naharkatiya field.*** It is located at a distance of 32 km southwest of Digboi at the left bank of Burhi Dihing river. Here oil was discovered in 1953 and production started in 1954. Oil is available at depths varying from 4,000 to 5,000 metres. Out of the 60 successful wells drilled so far, 56 are producing oil while the remaining 4 are producing natural gas. The annual production is 2.5 million tonnes of oil and one million cubic metre natural gas.

Oil from this area is sent to oil refineries at Noonamati in Assam (443 km) and Barauni in Bihar (724 km) through pipeline.

3. *The Moran-Hugrijan field.* It is located about 40 km south-west of Naharkatiya. Oil at Moran-Hugrijan field was discovered in 1953 and production started in 1956. Drilling has proved an oil bearing Barail horizon at a depth of 3,355 metre. Moran's potential may be estimated at one million tonnes per annum. As many as 20 wells have been drilled which yield oil as well as gas.

Other fields have been discovered at Rudrasagar, Sibsagar, Lakwa, Galeki, Badarpur, Barholla and Anguri.

Oilfields of Assam are relatively inaccessible and are distantly located from the main consuming areas. Oil from Assam is, therefore, refined mostly in the refineries located at Digboi, Guwahati, Bongaigaon, Barauni and Numaligarh.

Arunachal Pradesh has oil reserves at Manabhum, Kharsang and Charali. In ***Tripura***, promising oilfields have been discoverd at Mamunbhanga, Baramura-Deotamura Subhang, Manu, Ampi Bazar, Amarpur-Dambura areas. ***Nagaland*** also has some oil bearing rock strata.

ON-SHORE OIL FIELDS OF WESTERN INDIA

Gujarat. Explorations by Oil and Natural Gas Commission (ONGC) have yielded valuable findings of oil bearing rock strata over an area of about 15,360 sq km around the Gulf of Khambhat. The main oil belt extends from Surat to Amreli. Kachchh, Vadodara, Bharuch, Surat, Ahmedabad, Kheda, Mahesana, etc. are the main producing districts. In 2011-12, Gujarat produced over 5774 thousand tonnes of crude oil which accounted for over 15 per cent of the total oil production of India. Ankleshwar, Lunej, Kalol, Nawgam, Kosamba, Kathana, Barkol, Mahesana and Sanand are the important oilfields of this region.

1. *Ankleshwar.* The first major oil-find came in 1958 with the discovery of Ankleshwar field located about 80 km south of Vadodara and nearly 160 km south of Khambhat. Ankleshwar anticline is about 20 km long and 4 km wide. Oil is available at depths varying from 1,000 to 1,200 metres. It has a capacity of 2.8 million tonnes per annum. It is such a prolific oilfield that Pt. Jawahar Lal Nehru called it the *fountain of prosperity*. As many as 170 oil wells have been bored so far. It is estimated that 25 lakh tonnes per year of oil can be obtained from this field. Oil from this field is sent to refineries at Trombay and Koyali.

2. *Khambhat or Lunej field.* The oil and Natural Gas Commission drilled test wells in 1958 at Lunej near Ahmadabad and confirmed the occurrence of a commercially exploitable oil field. Oil was obtained on 4th Sept. 1959. Till 1969, a total of 62 wells were drilled out of which 19 yielded gas while 3 yielded oil. The annual production is 15 lakh tonnes of oil and 8-10 lakh cubic metres of gas. The total reserves are estimated at 3 crore tonnes.

3. *Ahmedabad and Kalol field.* It lies about 25 km north-west of Ahmedabad. This field and a part of Khambhat basin contain 'pools' of heavy crude trapped in chunks of coal. Nawgam, Kosamba, Mahesana, Sanand, Kathana, etc. are important producers.

Oil has also been struck in Olkad, Dholka, Kadi, Asjol, Sandkhurd, Siswas, Nandesan, Bandrat, Sobhasan and Vadesar areas.

Rajasthan. One of the largest inland oil discoveries was made in Barmer district of Rajasthan in 2004. The oil block covers an area of approximately 5,000 sq km. State-of-the-art technology with innovative geological modelling was used in discovering this oil field. Initial estimates of the oil in place of this discovery range from 63 to 153 million tonnes. Two important discoveries, *viz.*, Sarswati and Rajeshwari, with a total 35 million tonnes of inplace oil reserves were made earlier in 2002. The Sarswati discovery had found 14 million tonnes of in place oil reserves for which drilling upto 3,476 m was done. Mangala oil field discovered in 2004 is the largest oil discovery since 1985. It has nearly one billion barrels of recoverable oil. In the year 2011-12, Rajasthan produced 6,553 thousand tonnes of oil which accounted for over 17 per cent of the total production. Thus Rajasthan became the largest off shore oil producing state of India surpassing Assam and Gujarat in quick succession.

WESTERN COAST OFF-SHORE OILFIELDS

Extensive surveys have been conducted by ONGC in the offshore areas of Kachchh, Khambhat, Konkan, Malabar and Coromandal coasts, Krishna-Godavari delta and Sunderbans. Success on commercial scale has been achieved at Mumbai High, Bassein and Aliabet.

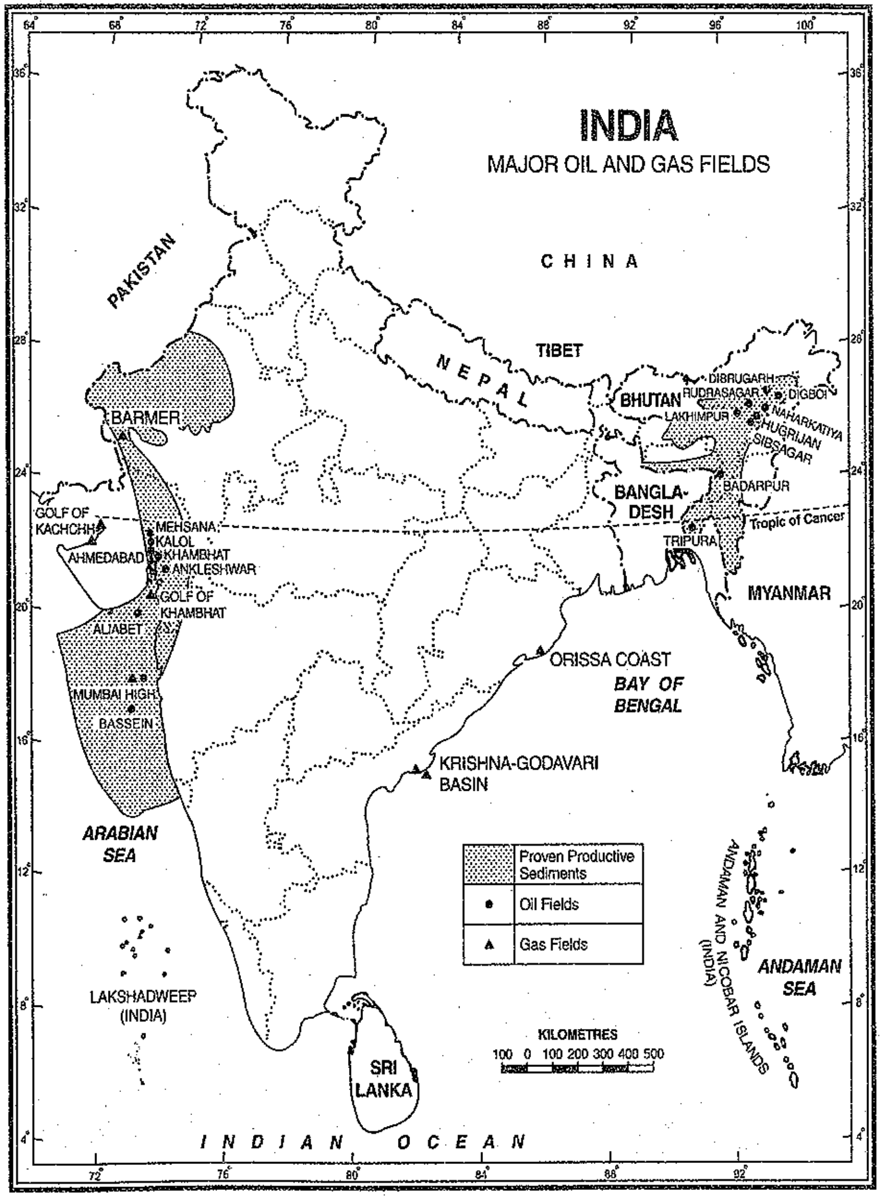

FIG. 24.5. India : Major Oil and Gas fields

1. Mumbai High. The greatest success achieved by the ONGC with respect to offshore surveys for oil was that of Mumbai High in 1974. It is located on the continental shelf off the coast of Maharashtra about 176 km north-west of Mumbai. Here the rock strata of Miocene age covers an area of 2,500 sq km with estimated reserves of about 330 million tonnes of oil and 37,000 million cubic metres of natural gas. Production on commercial scale began in 1976. Oil is taken from a depth of over 1,400 metre with the help of a specially designed platform known as ***Sagar Samrat.*** The discovery of Mumbai High has revolutionised the oil production in India. The share of Mumbai High in the total oil production of India has shot up considerably. This area produced 85 lakh tonnes of oil in 1982 which rose to over 189 lakh tonnes or over 62 per cent of all India in 1991-92. Production from this field declined between 1989-90 and 1993-94 due to over exploitation. Remedial measures have been taken to enhance the production and the declining trend has been reversed since 1994-95.

2. Bassein. Located to the south of Mumbai High, this is a recent discovery endowed with reserves which may prove to be higher than those of the Mumbai High. Huge reserves have been found at a depth of 1,900 metre. Production has started and has picked up fast.

3. Aliabet. It is located at Aliabet island in the Gulf of Khambhat about 45 km off Bhavnagar. Huge reserves have been found in this field. Commercial production is expected to start soon.

East Coast. The basin and delta regions of the Godavari, the Krishna and the Cauvery rivers hold great potential for oil and gas production. As such these are both on-shore and off-shore areas where extensive exploration has been conducted during the last few years. The Rawa field in Krishna-Godawari off-shore basin is expected to produce 1 to 3 million tonnes of crude oil annually.

Tamil Nadu produces less than the one per cent of the total oil production of India. The Narimanam and Kovilappal oilfields in the Cauvery on-shore basin are expected to produce about 4 lakh tonnes of crude oil annually. ***Andhra Pradesh*** also produces less than one per cent of the total crude oil of India. Oilfields have recently been discovered in the Krishna-Godavari basin. The oilfield near Amolpur is expected to yield 3,600 barrels of crude oil per day.

Probable Areas. There are vast possibilities of finding oil from about one lakh sq km area of sedimentary rocks in different parts of the country (see **Fig. 24.4**). Some of the outstanding areas which hold possibilities of oil are :

(*i*) Jawalamukhi, Nurpur, Dharamsala and Bilaspur in Himachal Pradesh.

(*ii*) Ludhiana, Hoshiarpur and Dasua in Punjab.

(*iii*) The Gulf of Mannar off the Tirunelveli coast.

(*iv*) The off-shore area between Point Calimere and Jaffna peninsula.

(*v*) Off-shore deep water area in Bay of Bengal between 12°N–16°N latitudes and 84°E–86°E longitudes.

(*vi*) The marine delta region of the Mahanadi, Godavari, Krishna and Cauvery rivers.

(*vii*) Stretch of sea between South Bengal and Baleshwar coast.

(*viii*) Off-shore area of the Anadaman and Nicobar Islands.

PETROLEUM REFINING

Oil extracted from the oil wells is in its crude form and contains many impurities. It is refined in oil refineries before use. After refining, various products such as kerosene, diesel, petrol, lubricants, bitumen, etc. are obtained. Although India's first oil refinery started working way back in 1901 at Digboi in Assam, it remained the only refinery in the whole of India for more than half a century. It was only in 1954 that another refinery at Tarapur (Mumbai) joined the lone refinery of Digboi. Since then oil refining in India has progressed at a rapid pace. In the recent past, Indian refining industry has done exceedingly well in establishing itself as a major player globally. India is emerging as a refinery hub and refining capacity exceeds the demand. The last decade has

seen a tremendous growth in the refining sector. The country's refining capacity has increased from a modest 62 million metric tonnes per annum (MMTPA) in 1998 to 213.66 MMTPA at present, comprising 22 refineries—17 under public sector, 3 under private sector and 2 in joint venture. The capacity-wise details of the refineries are given below :

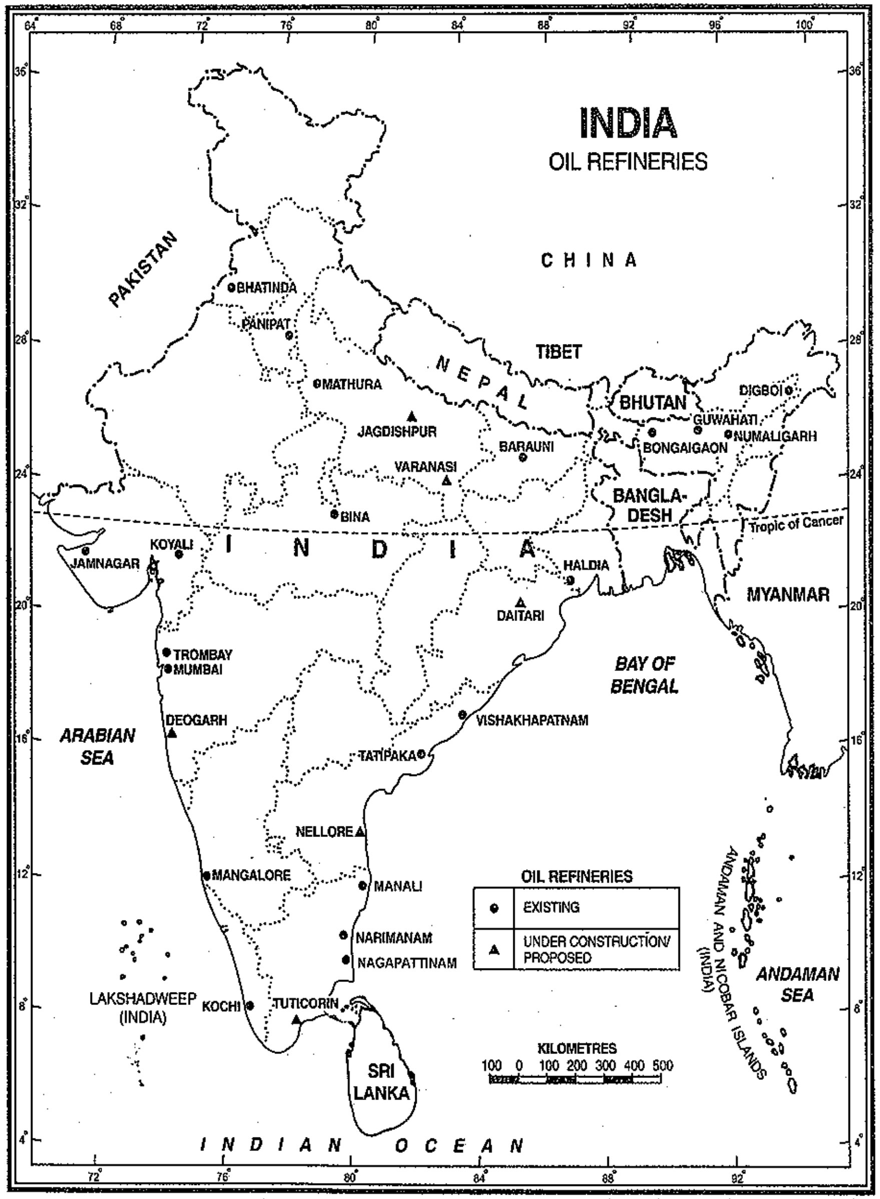

FIG. 24.6. India : Oil Refineries

TABLE 24.7. Details of Indian Refineries

Sl. No.	Refinery Location	Name of the Company	Name Plate Capacity (MMTPA)
	PSU Refineries		
1.	Guwahati		1.00
2.	Barauni		6.00
3.	Koyali		13.70
4.	Haldia		7.50
5.	Mathura	Indian Oil Corporation Ltd.	8.00
6.	Digboi		0.65
7.	Panipat		15.00
8.	Bongaigaon		2.35
9.	Mumbai	Hindusan Petroleum	6.50
10.	Visakhapatnam		8.30
11.	Mumbai	Bharat Petroleum Corporation Ltd.	12.00
12.	Kochi		9.50
13.	Manali	Chennai Petroleum	10.50
14.	Nagapattinam		1.00
15.	Numaligarh	Numaligarh Refinery Ltd.	3.00
16.	Mangalore	Mangalore Refinery Petrochemical Ltd.	15.00
17.	Tatipaka, AP	Oil & Natural Gas Corporation	0.66
		Total	**120.66**
	Jont Sector Refineries		
18.	Bina	Bharat Oman Refinery Ltd.	6.00
19.	Bathinda	HPCL Mittal Energy Ltd.	9.00
		Total	**15.00**
	Private Sector Refineries		
20.	Jamnagar	Reliance Industries Ltd.	33.00
21.	SEZ, Jamnagar		27.00
22.	Vadinar	Essar Oil Limited	18.00
		Total	**78.00**
		Grand Total	**213.66**

Source: India 2014 : A Reference Annual, p. 274.

PIPELINES

Pipelines are most convenient, efficient and economical mode of transporting liquids like petroleum, petroleum products, natural gas, water, milk, etc. Even solids can also be transported through pipelines after converting them into slurry.

Transportation by pipelines is a new development in India. Pipelines have relieved the increasing pressure on the existing surface transport system (railways and roadways).

The country had a network of about 5,035 km long pipelines in 1980 which has increased to over 7,000 km now. Pipelines have both advantages and disadvantages as described below.

Advantages of Pipeline. Pipelines have the following advantages over other means of transport :

1. They are ideally suited to transport the liquids and gases.
2. Pipelines can be laid through difficult terrains as well as under water.
3. It involves very low energy consumption.
4. It needs very little maintenance.
5. Pipelines are safe, accident-free and environmental friendly.

Disadvantages of Pipelines. Following are the main disadvantages of pipeline transport :

1. It is not flexible, *i.e.*, it can be used only for a few fixed points.
2. Its capacity cannot be increased once it is laid.
3. It is difficult to make security arrangements for pipelines.
4. Underground pipelines cannot be easily repaired and detection of leakage is also difficult.

Some of the important pipelines are briefly described as under :

1. Naharkatia-Nunmati-Barauni Pipeline. This was the first pipeline constructed in India to bring crude oil from Naharkatia oilfield to Nunmati. It was later extended to transport crude oil to refinery at Barauni in Bihar. It is 1,167 km long. It has now

extended to Kanpur in U.P. The pipeline between Naharkatia and Nunmati became operative in 1962 and that between Nunmati and Barauni in 1964. Construction work on pipeline from Barauni to Kanpur and Haldia was completed in 1966. It has a number of pumping stations and subsidiary pipelines.

(*i*) Nunmati-Siliguri pipeline transport oil from Nunmati (Guwahati) in Assam to Siliguri in West Bengal.

(*ii*) Lakwa-Rudrasagar-Barauni pipeline has been constructed to carry crude oil from Lakwa and Rudrasagar to oil refinery at Barauni.

(*iii*) Barauni-Haldia pipeline, completed in 1966, transports refined petroleum products to Haldia port and bring back crude oil to Barauni refinery.

(*iv*) Barauni-Kanpur pipeline carries refined petroleum products from Barauni to Kanpur.

(*v*) Nunmati-Bongaigaon section of this pipe is used to transport raw materials for Bongaigaon petro-chemical complex.

(*vi*) Haldia-Rajbandh-Maurigram pipeline has been constructed to meet the requirements of southern part of West Bengal.

2. Mumbai High-Mumbai-Ankleshwar-Koyali Pipeline. This pipeline connects oilfields of Mumbai High and Gujarat with oil refinery at Koyali. A 210 km long double pipeline connects Mumbai with Mumbai High. It provides facilities for transporting crude oil and natural gas. Ankleshwar-Koyali pipeline was completed in 1965. It transports crude oil from Ankleshwar oilfield to Koyali refinery.

3. Salaya-Koyali-Mathura Pipeline. An important pipeline has been laid from Salaya in Gujarat to Mathura in U.P. via Viramgram. This is 1,256 km long pipeline which supplies crude oil to refineries at Koyali and Mathura. From Mathura, it has been extended to the oil refinery at Panipat in Haryana and further to Jalandhar in Punjab. It has an off-shore terminal for imported crude oil.

4. Hajira-Bijapur-Jagdishpur (HBJ) Gas Pipeline. This pipeline has been constructed by Gas Authority of India Limited (GAIL) to transport gas. It is 1,750 km long and connects Hazira in Maharashtra to Bijapur in M.P. and Jagdishpur in U.P. It carries 18 million cubic metres of gas everyday to three power houses at Kawas (Gujarat), Anta (Rajasthan) and Auraiya (U.P.) and to six fertilizer plants at Bijapur, Sawai Madhopur, Jagdishpur, Shahjahanpur, Aonla and Babrala. Each of the fertilizer plants has a capacity of producing 1,350 tonnes of ammonia per day. The construction of this pipeline is a unique engineering feat and has been completed at an estimated cost of over ₹ 1,700 crore. The pipeline passes through 343.7 km long rocky area, 56.3 km long forest area, besides crossing 29 railway crossings and 75 big and small rivers. This is the world's largest underground pipeline and has brought about a big transformation in the economy of Gujarat, Madhya Pradesh, Rajasthan and Uttar Pradesh. It has been extended upto Delhi so that enough gas is made available to meet the growing demand of the capital city.

5. Jamnagar-Loni LPG Pipeline. This 1,269 km long pipeline has been constructed by Gas Authority of India Limited (GAIL) at the cost of ₹ 1,250 crore. It connects Jamnagar in Gujarat to Loni near Delhi in U.P. and passes through the states of Gujarat, Rajasthan, Haryana and U.P. This is the longest LPG pipeline of the world. It is like transporting 3.5 lakh LPG gas cylinders across 1,269 km every day and its capacity is being increased to 5.0 lakh cylinders per day. It will result in net saving of ₹ 500 crore per year by eliminating road tanker movement and lead to reduction of about 10,000 tonnes of pollutant emission per year. This is the first time that cross-country pipeline has been used to transport LPG adding to availability of supplies, safety in transportation and wider distribution. LPG is received at various points along the route for bottling in Ajmer and Jaipur (Rajasthan), Piyala (Haryana), Madanpur Khadar (Delhi) and Loni (U.P.). Phase-I of the pipeline was completed in 2001 and Phase-II was completed in 2003.

6. Kandla-Bhatinda Pipeline. This 1,331 km long pipeline has been constructed for transporting crude oil to the oil refinery at Bhatinda. It has been constructed by IOC at the estimated cost of ₹ 690 crore.

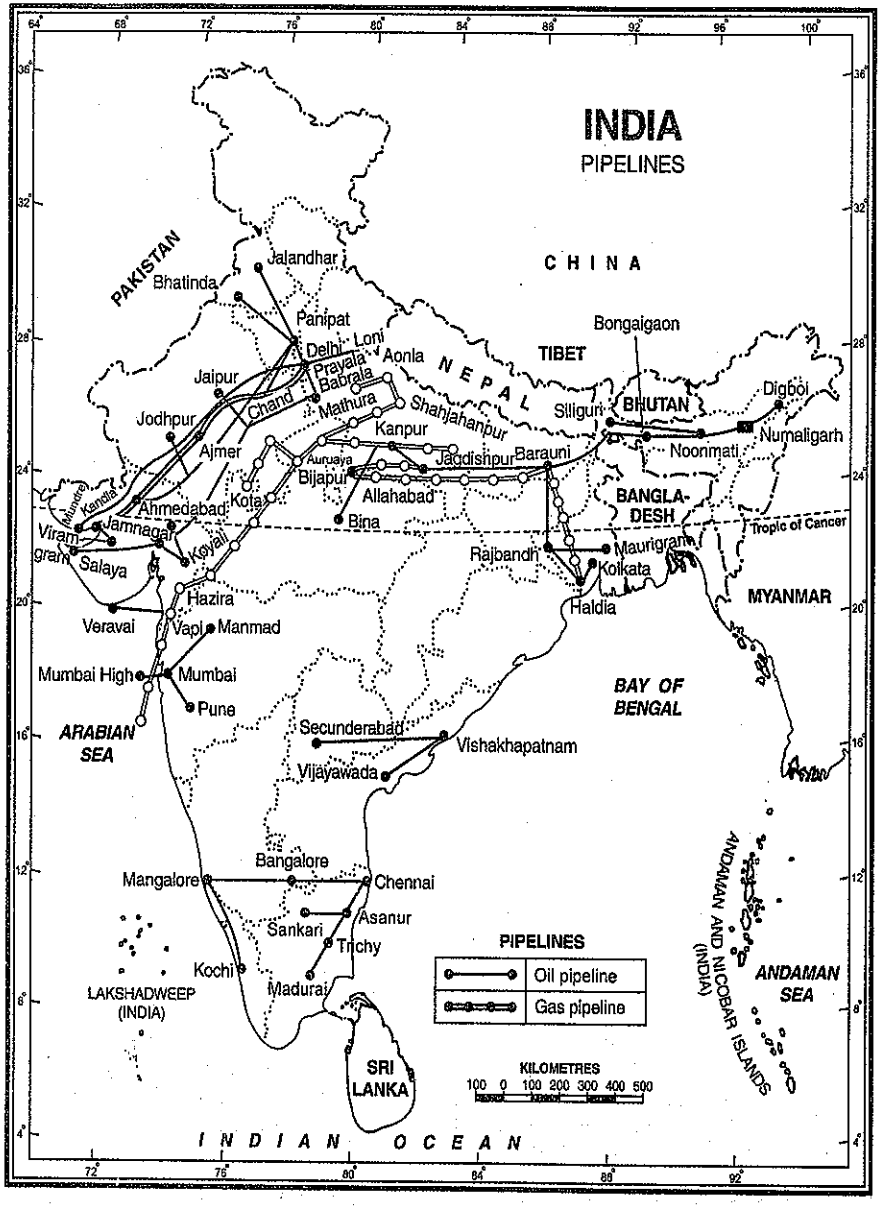

FIG. 24.7. India : Pipelines

Apart from the above mentioned important pipelines, several other pipelines have also been laid in different parts of the country. Construction of some of them has already been completed while others are at different stages of completion. In Gujarat, a number of pipelines carry crude oil, gas and refined products to refineries and markets. Important pipelines include the Kalol-Sabarmati Crude Pipeline,

the Nawgam-Kalol-Koyali Crude Pipeline, the Cambay-Dhiwaran Gas Pipeline, the Ankleshwar-Uttaran Gas Pipeline, the Ankleshwar-Vadodara Associated Gas Pipeline, and the Koyali-Ahmedabad Products Pipeline. Mumbai is an important centre for petroleum products. As such, it is joined with Pune and Manmad by pipelines. The Haldia-Kolkata pipeline caters to the needs of Kolkata and its neighbouring areas.

The Gas Authority of India Ltd. (GAIL) has drawn up an ambitious plan at the cost of ₹ 10,000 crore for the "near term" which includes projects for integrating the gas pipeline network through capacity expansion and adding new pipelines. Some of the pipelines are the Dahej-Vijaipur pipeline, 300 km north-south Gujarat pipeline, Dehej-Hazira-Uran pipeline (400 km), Kochi-Mangalore-Bangalore pipeline (900 km) and Phase III of pipeline network in Andhra Pradesh. A 600 km Vishakhapatnam-Secunderabad pipeline has 1.1 million tonnes capacity. Some of the other pipelines include the Kanpur-Bina, Mangalore-Chennai, Vijayawada-Vishakhapatnam, and Haldia-Budge Budge pipelines.

GAIL has also undertaken the construction of three important gas pipelines. The 2,050 km long **Jagdishpur-Haldia** gas pipeline is the longest and the most expensive pipeline. The approximate cost of this pipeline as ₹ 7,600 crore. The **Karanpur-Moradabad-Rudrapur** pipeline is 275 km long and its cost is ₹ 250 crore. Besides there is plan to upgrade **Bajera-Agra-Ferozabad** pipeline at the cost of ₹ 200 crore. The total length of gas pipelines belonging to GAIL is 14,800 km.

There is a proposal to build a 6,000 km long gas pipeline grid on the pattern of National Highways that will criss-cross the country. It is estimated to cost over ₹ 30,000 crores.

Chennai-Trichy-Madurai oil pipeline was dedicated to the nation on 26th June, 2006. Cairn has constructed 582 km pipeline from Barmer to Salaya. It has a capacity of 1,50,000 barrels per day. **Mundra-Delhi** oil pipeline is 1,054 km long with 18 inch (about 45 cm) diameter was dedicated to the nation on February 2, 2009. Built at the cot of ₹ 1,757 crore, it carries 5 MMTPA products which is expandable to 6 MMTPA. It has main pumping station at Mundra and intermediate pumping stations at Santhalpur and Palanpur in Gujarat and Awa and Ajmer in Rajasthan. The project also includes a storage terminal at Mundra, and tap-off marketing terminals at Palanpur, Ajmer, Jaipur and Bahadurgarh.

IMPORTS

Consumption of oil and its products has always outstripped production in India. In 1950-51, India produced only 2.7 lakh tonnes of oil against consumption of 34 lakh tonnes. With the progress in industries and transport, need for oil has increased dramatically in the post-Independent era. Consequently, India has to lean heavily on the imports of oil and its products.

It is clear from Table 24.8 that our oil bill has been rising rather disturbingly both in terms of quantity and value due to our increased demands for economic growth and because of rising prices of oil and oil products in the international market. Our oil import bill increased from less than 9 per cent of the total imports in 1960s to 30 per cent following the first oil crisis in 1973-74 and to 75 per cent in 1980s after the second oil crisis. Decline in indigenous production during 1989-90 and 1993-94 further worsened the balance between production and consumption. Our imports of oil are more than three times the indigenous production. This puts serious strain on our foreign exchange reserves. With increase in growth of industries and transport, demand for oil will increase further and make things still worse. In 2011-12, our oil bill accounted for 31.7 per cent of the total imports.

TABLE 24.8. Imports of Petroleum, Oil and Lubricants

Year	1960-61	1970-71	1980-81	1990-91	2000-01	2010-11	2011-12	2012-13	2013-14
Quantity ('000 tonnes)	800.0	1,277.0	23,537.0	29,359.0	—	—	—	—	—
Value (₹ crore)	69	136	5,264	10,816	71,497	4,82,282	7,43,075	8,91,871	10,00,064

Source : The Economic Survey 2013-14, Statistical Appendix, pp 71-73.

NATURAL GAS

Natural gas usually accompanies petroleum accumulations. Whenever a well for oil is drilled, it is natural gas which is available before oil is struck. Natural gas is fast becoming an important source of energy in India. The recoverable reserves of natural gas as on 1 April 2003 were around 700 BCM (billion cubic metre). The estimated production of natural gas was 118 million metric standard cubic metres per day in 2012-13 the major part of which came from off-shore areas. Assam, Gujarat, Andhra Pradesh and Tamil Nadu are the major on-shore producing states.

Discovery of gas made rapid strides after 1985. Oil strikes at Cauvery off-shore and at Nanda in Khambhat basin as also gas found at Talot in Jaisalmer Basin in Rajasthan were major discoveries during 1988-89. Production from South Bassein Gas Field started in September 1988. During 1989-90 oil/gas structures had been discovered in Adiyakkamanglam in Tamil Nadu, Andada in Gujarat, Khovaghat in Assam, Lingla in Andhra Pradesh, Mumbai off-shore and Kachchh offshore. Another survey conducted in 1997 in the Andamans has revealed 1,700 billion cubic feet of gas reserves which can meet the country's requirements for the next 30 years.

The face of the country's gas map has undergone a decisive change. The gas discovered by Reliance Industries in deep waters of the Krishna-Godavari off-shore basin has brought the sector into sharp focus. It is reported to be the largest discovery of natural gas in the world in the year 2002 and compares with global finding in the past in the Gulf and Sakhalin Island. The reserves are estimated to 14 trillian cubic feet. The field is 200 km into the sea from Vishakhapatnam and has blocks spread over 200,000 sq km. The wells have been drilled at depths 1350-2700 metres. This is the deepest oil exploration in India. The finding, according to a number of energy analysts, is just the tip of a 'gasberg'. However, the Krishna-Godavari basin is a very complex area because it is under the confluence of two big rivers of the peninsular India. Stratigraphy is now unraveling how sand and silt formations have taken place over the centuries. Undoubtedly the basin is rich in natural gas in its deep recesses. Hence it requires technology which goes beyond geology and geosciences and brings in engineering skill of high order. This discovery is believed to yield 60-80 million cubic metres of natural gas per day from a single field.

In June 2005, Oil and Natural Gas Corporation (ONGC) made a significant hydrocarbon find in the shallow waters of Krishna-Godawari basin, south-west of Ravva field discovered by ONGC in 1987. The new find is around 12 km from Amalpuram coast.

The above two discoveries will help in saving the precious foreign exchange and also help in transforming the economy of the Krishna-Godavari basin. The gas obtained from this basin can be used for power generation, as fuel for fertilizer plants and even for running a transport system. Since the find is equivalent to 165 million tonnes of crude oil, it will help in replacing the more polluting fuels like naphtha, fuel oil and coal.

In yet another gas discovery, the Reliance Industries struck gas off the Odisha coast in Bay of Bengal in June, 2004. Here the reserves are estimated at 4 to 5 trillion cubic feet.

In Barmer district of Rajasthan also, gas was discovered along with crude oil in 2003. It has capacity to produce 7.3 million standard cubic feet of gas per day when the production starts. Possibilities of findings gas exist in Gulf of Kachchh and Gulf of Khambhat as well as in Tripura.

About four-fifths of the total gas comes from Offshore sources. Over five per cent of the total gas of India is produced by Assam. The rest is obtained from Gujarat, Andhra Pradesh, Tamil Nadu, Tripura, and Rajasthan.

Gas is making a significant contribution towards meeting the energy requirements of the country.

Keeping in view the increasing significance of natural gas as an important source of energy, the Gas Authority of India Limited (GAIL) was incorporated in August, 1984 for transportation, processing and marketing of natural gas. The immediate task before GAIL was to complete HBJ Gas pipeline. Presently, GAIL is the largest natural gas processing, transmission and distribution company in India. It supplies gas to power plants for generation of about 5,500 MW of power, as feedstock for gas-based

fertilizer plants to produce about 10 million metric tonnes per annum (MMTPA) of urea. GAIL has seven plants for production of LPG with a total capacity of over one million tonnes per annum.

GAIL has taken major steps in Joint Venture companies, namely Mahanagar Gas Limited (with British Gas of U.K.) in Mumbai and Indraprastha Gas Limited (with Bharat Petroleum Corporation Limited) in Delhi for City Gas Distribution Schemes including CNG for transport sector. Besides GAIL has joint ventures with several other companies particularly in Gujarat and Kerala. On 29 November 2002, GAIL entered with a Joint Venture agreement with HPCL to distribute Piped Natural Gas, CNG and Auto LPG in cities of Andhra Pradesh.

TABLE 24.9. Production of Natural Gas in India (2011-12)

State/Region	Production in million cubic metres (mcm)	Percentage of total India production
1. Off-shore	37,826	81.21
2. Assam	2,726	5.85
3. Gujarat	2,097	4.50
4. Andhra Pradesh	1,362	2.93
5. Tamil Nadu	1,275	2.74
6. Others	1,290	2.77
Total	**46,576**	**100.00**

Source : Data computed from Mineral Wealth of India 2013.

Although India has made rapid strides in the discovery and production of natural gas, yet the production falls short of the demand which is increasing with each passing day. Gas in large quantities has to be imported to fill the widening gap between supply and demand. The Government of India has taken notable initiative in this direction. Negotiations are on with Iran and Pakistan for constructing 7,600 km long gas pipeline from Iran to India via Pakistan. This pipeline is expected to meet a major part of growing energy requirements particularly in north India. This gas pipeline will benefit all the three countries *viz.*, India, Pakistan and Iran. While India will get the much needed gas for its growing economy, Iran will find a ready market for its surplus gas in India. Pakistan also hopes to gain substantially from the economies of scale that jointly buying gas with India would provide as well as transit fee estimated to be about US $ 600 million per year for gas flowing through its territory. As such it behoves Pakistan to assure the security of this pipeline, even if that country has to depute regular army to mitigate chances of sabotage.

Sadly, required cooperation is not coming forward from Pakistan.

Conservation of Petroleum Products

India is fast becoming a big producer, consumer and importer of petroleum products. The demand for petroleum products is increasing at an alarmingly accelerated rate. At current rate of consumption, our known oil reserves will last only for 30-40 years. This puts heavy strain on our economic resources and calls for an urgent need to conserve petroleum products. There is a vast scope of petroleum conservation in India provided there are technological improvements, financial incentives, policy initiatives and legislative measures for implementing conservation. Transport, industry, domestic/household and agriculture are four major sectors which consume bulk of petroluem. Awareness programmes for each sector need to be developed and then extensive publicity of the measures which would bring about savings need to be undertaken to bring about the desired results.

The transport sector is one of the largest consumers of petroleum products mainly petrol and high speed diesel. This sector accounts for 50 per cent consumption of petroleum in India. Road transport alone accounts for about 37 per cent of the total oil consumption. With fast expanding transport network this consumption level is bound to increase. Oil products constitute nearly 80 per cent of total commercial energy used in transport (other sources being coal and electricity). Therefore, any energy conservation programme in transport sector is bound to strengthen our economy. This can be done largely by introducing more fuel efficient engines, operation of transport vehicles at optimum speed, improving road conditions and avoiding traffic bottlenecks, especially in urban areas. These measures can save about 30-35 per cent fuel. Provision of better roads alone can save 10 per cent petroleum. Extension of railway network has led to substantial savings in high speed diesel since a diesel loco is 7-8 times more efficient compared to diesel truck. It is, therefore, logical to switch all long distance freight movement to rail and confine road transport to short distances only. Railways have initiated several measures to achieve high degree of energy conservation. The introduction of Eastern and Western Dedicated Freight Corridors is a good initiative which will increase the freight carrying capacity of the railways and save a lot of fuel. Public transport system should be strengthened so that people are not forced to use private vehicles. This can save a lot of energy.

Industries consume about 16-20 per cent of the total oil products consumed in the country. Several industries have achieved commendable success in energy conservation by better management of energy. For example, iron and steel industry, petrochemicals, cement and paper industry have saved 21, 32, 28 and 25 per cent energy respectively between 2003 and 2013. Similar steps can be taken by other industries for saving oil and other sources of energy.

In agriculture sector, the main petroleum products consumed are high speed diesel and light diesel oil. The consumption of oil in this sector can be reduced by programmes for pump rectification, more efficient foot valves for lift irrigation, better farm machinery, use of agro residues and other non-commercial sources of energy. As regards use of petroleum for production of fertilizers, plants based on liquid oil products should be discouraged and these should be based on use of natural gas or coal as feedstocks of which the country has plentiful resources.

Kerosene and LPG are two major oil products used in the domestic sector for cooking and lighting in urban and semi-urban areas. Since there are no viable alternatives to these fuels and they are to be extended to the rural areas to check deforestation, it is imperative that their utilisation is carried out at the optimum efficiency level.

The need for conservation of petroleum products has been increasingly felt during the last few years. The Petroleum Conservation Research Association (PCRA) in 1978 under the Ministry of Petroleum and Natural Gas is doing a commendable job to promote conservation of petroleum products. PCRA's activities cover conservation of all energy sources, development, evaluation and commercialization of efficient equipment and additives, popularizing petro-crop cultivation and production of bio-fuels, environment protection etc. It has been conducting public awareness campaigns for promoting energy conservation in petroleum sector on a regular basis which includes various educational and practical sessions to a variety of consumer sectors. PCRA has also launched media campaign to promote efforts of conservation and is working in close association with Bureau of Energy Efficiency (BEE) for popularizing standards and labelling programmes for equipment using petro-based fuels such as domestic LPG stoves, diesel irrigation pump sets and diesel generating sets.

ELECTRICITY

Electricity plays a dominant role in the progress and prosperity of any country. Consumption of electricity is a barometer of a nation's economic well being and standard of living of its people. Availability of abundant electricity means unrestricted growth of industries, transport and agriculture which means freedom from hunger and poverty and the resultant economic prosperity of the masses. Although India set up its first power plant over a century ago and the electrification of Kolkata began within just a decade after that of London, power development could truly take off only after Independence. The power sector registered an impressive growth by over 100 times during 63 years from 1950-51 to 2013-14. The installed capacity rose from 2.3 thousand MW in 1950-51 to 243.0 thousand MW by 2013-14 and generation from 6.6 billion kWh to 961.5 billion kWh during the same period. However, India still lags far behind regarding consumption of electricity. The per capita consumption in India was only 393 kWh in 2011-12 as against 3,481 kWh in Britain, 6,434 kWh in Sweden and 6,550 kWh in the USA and the world average of 1,000 kWh.

Following three examples illustrate that the regional distribution of installed capacity and generated power is very uneven :

(*i*) Power is more developed in regions of heavy industries where the requirement of power is very high. Mumbai industrial region and Tamil Nadu industrial belt are such examples.

TABLE 24.10. Progress of Installed Capacity of Electricity (Utilities and Non-utilities) in Thousand MW

Year	Utilities				Non-utilities	Grand Total
	Hydro	Thermal*	Nuclear	Total		
1950-51	0.6	1.1	—	1.7	0.6	2.3
1960-61	1.9	2.7	—	4.6	1.0	5.6
1970-71	6.4	7.9	0.4	14.7	1.6	16.3
1980-81	11.8	17.6	0.9	30.3	3.1	33.4
1990-91	18.8	45.8	1.5	66.1	8.6	74.7
1995-96	21.0	60.1	2.2	83.3	11.8	95.1
2005-06	32.3	88.6	3.4	124.3	21.3	145.6
2006-07	34.7	93.7	3.9	132.3	22.3	154.6
2007-08	35.9	103.0	4.1	143.0	25.0	168.0
2008-09	36.9	107.0	4.1	148.0	27.0	175.0
2009-10	36.9	118.0	4.6	159.4	31.5	190.9
2010-11	37.6	131.3	4.8	173.7	34.4	208.1
2011-12	39.0	156.1	4.8	199.9	36.5	236.4
2012-13	39.6	179.2	4.8	223.6	NA	223.6
2013-14	40.5	197.7	4.8	243.0	NA	243.0

*Including Renewable Energy Source.
NA = not available.
Source : Economic Survey 2013-14, Statistical Appendix, p. 27.

(*ii*) It is also more developed in those regions where possibilities of developing power are comparatively more. Such regions are located near coalfields (such as the Damodar valley, Singrauli coalfield etc.) or multipurpose projects like Bharkra-Nangal, Koyna etc.

(*iii*) Power is comparatively less developed in industrially backward or sparsely populated regions. Desert area of western Rajasthan, interior parts of the peninsular India, Assam and other mountainous states are examples of low level of power development.

Following types of electricity are recognised depending upon the raw material used and mode of its production.

1. Hydroelectricity.
2. Thermal Electricity (including steam, gas and oil).
3. Nuclear Electricity.

Their relative importance and temporal growth has been shown in **Table 24.10**.

HYDROELECTRICITY

The future prosperity of India depends to a great extent on our ability to produce and use hydroelectricity. The other two sources of energy, coal and petroleum, are exhaustible and will not be available to us for ever. Therefore, we should reduce our dependence on coal and petroleum and develop hydroelectricity as far as possible. Currently, hydroelectricity accounts for about 16 per cent of the total installed capacity. This has to be increased so that increasing demand for energy is met and at the same time, precious and scarce coal and petroleum resources are saved from over exploitation. Hydroelectricity is a renewable, cheap, clean and environmentally benign source of energy and will be available to us for all times to come. River water, if not properly used, will wastefully drain into the sea.

India is blessed with huge water resources and there are vast possibilities of producing hydroelectricity. However, India has developed only a small percentage of the total potential available. India's exploitable hydro-electric potential in terms of installed capacity is estimated to be about 1,48,700 MW out of which a capacity of 39.0 thousand MW (26.2%) has been developed so far. This is due to certain geographical factors as well as because of developing stage of economy. Most of the river regimes in India are extremely erratic because they are fed by monsoon rains which are highly seasonal and whimsical. Further, many rivers do not have natural waterfalls and huge capital has to be invested for constructing dams.

Most of the sites suitable for generating hydroelectricity are located away from the consuming centres as a result of which a lot of energy is wasted in transmission. Under normal circumstances, there is loss of 8 per cent energy for transmitting it through a distance of 160 km and 21 per cent loss for 800 km. Thus if hydroelectricity generated at Bhakhra Nangal dam is to be consumed at Delhi, the average loss is about 15 per cent.

The hydroelectric power generation in India made a humble start at the end of the 19th century with the commissioning of a hydroelectric power plant in 1897 to supply electricity to Darjeeling. Another hydroelectric power plant was set up at Shivasamundram waterfall on the Cauvery river in Karnataka in the year 1902. At a later stage some hydroelectric power plants were erected in the Western Ghats. These were designed to meet the growing demands of Mumbai. In 1930s, a number of hydropower plants were commissioned in Himachal Pradesh, Uttar Pradesh, Tamil Nadu and Karnataka. The total generation capacity was 508 MW at the time of independence in 1947. Planned period started immediately after independence and several multipurpose projects were undertaken during the Five Year Plans. The National Hydroelectric Power Corporation (NHPC) was set up in 1975. Till now, it has completed the construction of eight hydroelectric projects with the total installed capacity of 2,193 MW. Total installed capacity of hydroelectricity increased from 0.6 thousand MW in 1950-51 to 40.5 thousand MW in 2013-14 (**Table 24.10**). This was nearly one-fourth of the total installed capacity of electricity.

Hydroelectric power can play a significant role in view of the energy crisis which India is currently facing. Indian rivers drain 1,677 billion cubic metres of water to the sea every year. The Central Water and Power Commission estimated the potential of hydroelectric power at about 40 million kW at 60% load factor from these rivers. Central Electricity Authority re-estimated this potential at 84,000 MW at 60% load factor. It is equivalent to about 450 billion units of annual energy generation. Basin-wise distribution of the potential is given in **Table 24.11**.

TABLE 24.11. India : Basin-wise Estimated Potential of Hydropower (Potential in thousand MW at 60 per cent load factor)

Basin	Potential	% of Total
Indus	20.0	23.8
Brahmaputra	35.0	41.7
Ganga	11.0	13.1
Central Indian basins	3.0	3.6
West flowing rivers	6.0	7.1
East flowering rivers	9.0	10.7
Total	**84.0**	**100.0**

Following influence the development of Hydroelectric Power (HEP) in India :

(*i*) There should be perennial flow of large volume of water which depends upon the amount of rainfall.

(*ii*) The water should fall from a sufficient height. This height may be in the form of a natural waterfall or a fall obtained by constructing a dam across the river. It may also be obtained by diverting the water from one river basin to another.

(*iii*) A readily available market is an essential requirement for generating HEP as electricity cannot be stored.

(*iv*) The generation of HEP requires huge capital investment as it is capital intensive activity.

(*v*) It also requires technological advancement because production, distribution and utilisation are closely related to the technological level of the concerned area.

The rivers originating from the northern mountainous region and the peninsular rivers differ markedly with respect to their suitability for hydroelectric production. Some outstanding facts are explained as under :

1. Northern Rivers. These rivers are very useful for hydroelectric generation due to a large number of factors. Major factors are :

(*i*) Himalayan rivers originate from the mountainous region and have their sources in glaciers and snowfields. Therefore, they receive water both from rain in rainy season and snowmelt in hot season and have enough flow of water throughout the year. As such they are known as perennial rivers and supply water for hydroelectric production all the year round.

(*ii*) Velocity of water flow is high because of dissected terrain and steep slope. This helps in generation of hydroelectric power.

(*iii*) Low competition for use of water for other purposes makes water available for HEP production. Water used in hydroelectric generation can be gainfully used for irrigation.

(*iv*) About three-fourth of the total potential is confined to the river basins originating from the northern mountainous region. The major rivers are the Indus, the Ganga and the Brahmaputra.

2. Peninsular Rivers. The peninsular rivers are comparatively poor with respect to hydroelectric power potential and production due to following reasons :

(*i*) The peninsular rivers are purely dependent on rainfall as a result of which flow of water in these rivers is very erratic. They have exceptionally high flow during the rainy season which is followed by a prolonged dry season of lean flow. They are thus not perennial rivers and are not much suited to hydroelectric production.

TABLE 24.12. Progress of Electricity Generated (Utilities and Non-utilities) in Billion kWh

Year	Utilities				Non-tilities	Grand Total
	Hydro	Thermal*	Nuclear	Total		
1950-51	2.5	2.6	—	5.1	1.5	6.6
1960-61	7.8	9.1	—	16.9	3.2	20.1
1970-71	25.2	28.2	2.4	55.8	5.4	61.2
1980-81	56.5	61.3	3.0	120.8	8.4	129.2
1990-91	71.7	186.5	6.1	264.3	25.1	289.4
1995-96	72.6	299.3	8.0	379.9	38.2	418.0
2000-01	74.5	408.1	16.9	499.5	55.0	554.5
2005-06	101.5	506.0	17.3	623.8	73.6	697.4
2006-07	113.5	538.1	18.8	670.7	81.8	752.5
2007-08	120.4	585.3	16.9	722.6	90.5	813.1
2008.09	110.1	616.2	14.9	741.2	99.7	840.9
2009-10	104.1	677.1	18.6	799.8	106.1	906.0
2010-11	114.4	704.3	26.3	844.8	120.9	965.7
2011-12	130.5	759.4	33.3	923.2	128.2	1051.4
2012-13	113.7	760.7	32.9	907.3	NA	907.3
2013-14	134.8	792.5	34.2	961.5	NA	961.5

*Includes Renewable Energy Sources.

NA = not available

Source : Economic Survey 2013-14, Statistical Appendix, p. 28.

(*ii*) Storage of water is essential to regulate the flow.

(*iii*) The bulk of potential is confined to hilly regions.

However there are some factors which favour the development of hydroelectric power in the peninsular India.

(*i*) The topographical features in upper reaches of the major rivers are seldom favourable for development of irrigation. Consequently, development of hydroelectric sites would not clash with other priority uses of water. The Western Ghats, north-western Karnataka, Nilgiri and Anamalai hills and upper Narmada basin are major areas of concentration of potential in peninsular India.

(*ii*) Most of the areas in the southern states, especially the western part of the peninsula, are far away from the coal deposits of north-eastern part of the peninsular plateau. As such they have to depend upon the hydroelectric power to meet their energy requirements.

Generation of hydroelectricity registered a gradual increase from 2.5 billion kWh in 1950-51 to 82.9 billion kWh in 1998-99. After that juncture,

TABLE 24.13. Important Hydroelectric Plants in Different States of India

States	Name of Hydroelectric Plants
Jammu and Kashmir	Lower Jhelum, Salal on Chenab, Dool Hasti, Karrah and Banihar.
Punjab and Himachal Pradesh	Bhakra-Nangal on Satluj, Dehar on Beas, Giri Bata, Andhra, Binwa, Rukti, Rongtong, Bhabanagar, Bassi, Baira Siul, Chamera, Nathpa-Jhakri on Satluj (biggest hydel power project in India).
Uttar Pradesh	Rihand, Khodri, Chibro on Tons.
Uttarakhand	Tehri dam on Bhagirathi.
Rajasthan	Ranapratap Sagar and Jawahar Sagar on Chambal.
Madhya Pradesh	Gandhi Sagar on Chambal, Pench, Bargi on Narmada, Bansagar-Tons.
Bihar	Kosi.
Jharkhand	Subarnarekha, Maithon, Panchet, Tilaiya (all three under DVC).
West Bengal	Panchet.
Odisha	Hirakud on Mahanadi, Balimela.
North-eastern states	Dikhu, Doyang (both in Nagaland), Gomuti (Tripura), Loktak (Manipur), Kopili (Assam), Khandong and Kyrdemkulai (Meghalaya), Serlui and Barabi (Mizoram), Ranganadi (Arunachal Pradesh).
Gujarat	Ukai (Tapi), Kadana (Mahi).
Maharashtra	Koyana, Bhivpuri (Tata Hydroelectric Works), Khopoli, Bhola, Bhira, Purna, Vaiterna, Paithon, Bhatnagar Beed.
Andhra Pradesh and Telangana	Lower Sileru, Upper Sileru, Machkund, Nizam Sagar, Nagarjun Sagar, Srisailam (Krishna).
Karnataka	Tungabhadra, Saravati, Kalinadi, Mahatma Gandhi (Jog fall), Bhadra, Sivasamudram (Kaveri), Shimasapura, Munirabad, Lungnamakki.
Kerala	Iddikki (Periyar), Sabarigiri, Kuttiaddy, Sholayar, Sengulum, Pallivasal, Kallada, Neriamangalam, Parambikulum Aliyar, Poringal, Ponniar.
Tamil Nadu	Pykara, Mettur, Kodayar, Sholayar, Aliayar, Sakarpathi, Moyar, Suruliyar, Papanasam.

downward trend started and continued till 2002-03, when the electricity generation was 64 billion kWh only. This downward trend was reversed in 2004-05 and the electricity generated increased to 134.8 billion kWh in 2013-14.

Hydroelectric power plants are scattered in different parts of the country. Following **Table 24.12** gives the list of important hydroelectric power plants in different states.

Figure 24.8 shows the areal distribution of major hydel power stations in India.

Although hydroelectricity accounts for about 16 per cent of the total installed capacity of electricity in India, it is the single largest source of energy for some states. For example, Himachal Pradesh, Meghalaya, Nagaland, Sikkim and Uttarakhand wholly depend upon hydroelectricity for their energy requirements. All these states are located in hilly and mountainous areas where geographical conditions like terrain, drainage, etc. are congenial to hydroelectric generation. The other states where energy supply scene is dominated by hydroelectricity are Jammu and Kashmir, Kerala, Mizoram and Odisha. So far as total installed capacity of hydroelectricity is concerned, Andhra Pradesh (including Telangana), Karanataka, Kerala, Maharashtra, Odisha, Punjab, Rajasthan and Tamil Nadu are the outstanding states. Some of the important hydroelectric power projects are briefly discussed here.

1. Andhra Pradesh (including Telangana). Andhra Pradesh and Telangana have 3,272 MW installed capacity of hydroelectricity which is the highest capacity attained by any state in India. This capacity accounts for about 43 per cent of the total installed capacity of these two states. Nagarjun Sagar, Lower Sileru, Upper Sileru, Mechkund, Nizam Sagar, Srisailam, Inchampalli and Polavaram are the main producers.

2. Karnataka. Mahatama Gandhi Project on Jog Fall of the Sharavati river, Shivasamudram and Krishnaraja Sagar on Cauvery, Shimsha on Shishma river (a tributary of the Cauvery) are some of the outstanding power projects of Karnataka. Karnataka's installed capacity is 2,944 MW which is the second highest after Andhra's 3,272 MW. Hydroelectricity accounts for about 56.6 per cent of the total installed capacity of the state.

3. Tamil Nadu. Mettur, Pykara, Papanasam, Kadamparai, Pandiyar, Kodayar, Kundah and Periyar are the main hydroelectric producing stations in Tamil Nadu. Most of the power stations are located in hilly districts and have been connected by the electric grid system to regulate the supply of hydro power.

4. Punjab. Two power stations at Bhakhra dam on the Satluj along with Ganguwal and Kotla power projects are the main producers of hydroelectricity. Pong dam on the Beas and the Upper Bari Canal system are the other producers.

5. Uttar Pradesh. The Ganga Electric Grid System is very important for production and distribution of hydroelectricity. The Upper Ganga Canal forms 12 falls between Haridwar and Meerut and most of them have been used to produce hydroelectricity. The power stations are situated at Bahadurabad, Mohammadpur, Nirghni, Chitaura, Salwa, Bhola, Plara and Sumera. The stretch of the Upper Ganga Canal and the power stations in this area are shared by Uttarakhand and Uttar Pradesh. Matatila dam on Betwa river near Jhansi and Rihand project at Pipri in Mirzapur district are the other important producers of hydroelectricity.

6. Kerala. The state is located away from the main coal producing areas of the country and is blessed with several small but swift streams descending from the Western Ghats. Many of them form waterfalls which provide ideal sites for the generation of hydroelectricity. The state has 1,807 MW installed capacity. Idduki, Kuttiyadi, Sabargiri, Sholayar, Mananthavadi, Chalakudy, Puyankutty, Lower Periyar and Pallivasal are important projects.

7. Maharashtra. Most of the hydro-power potential is in the Sahyadris where geographical conditions are favourable for its production. Tata Hydro-electric grid at Lonavala comprises of three power houses at Khopoli (capacity 72 MW), Bivpuri (capacity 72 MW) and Bhira (capacity 137 MW). These stations supply electricity to Mumbai and its surroundings over a distance of 112 km. The Koyna project located about 240 km away from Mumbai on Koyna river (a tributary of the Krishna river) is another major landmark in Maharashtra. Purna and Vaitarna are other important projects.

8. Odisha. Over four-fifths of the total available capacity in the state is contributed by hydroelectricity.

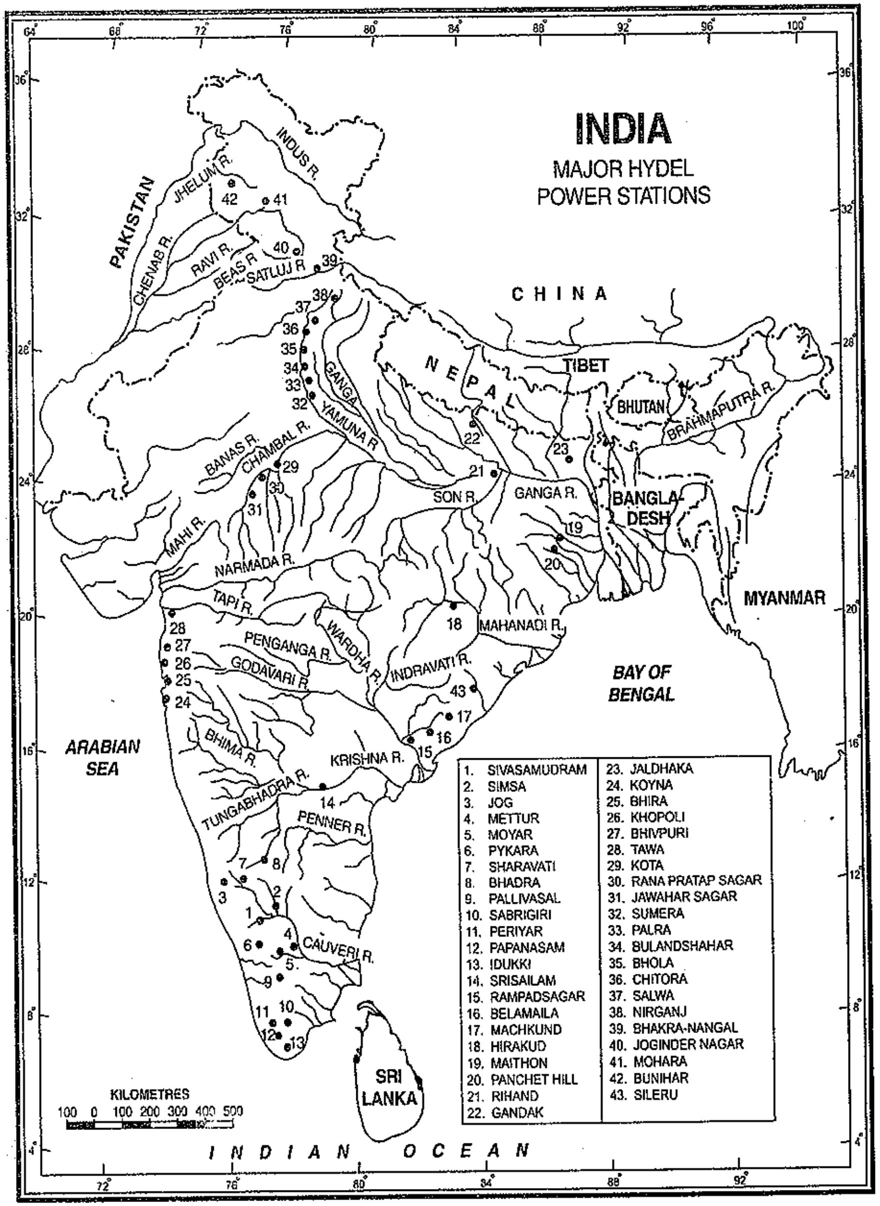

FIG. 24.8. India : Major Hydel Power Stations

Hirakud, Bhimkud, Balimela and Rengali are the main projects producing hydroelectricity.

9. Himachal Pradesh. Mandi Project at Joginder Nagar, Pandoh project on Beas river and the Shimla project produce bulk of the hydroelectricity in the state.

10. Jammu and Kashmir. The hill terrain of the state provides several suitable sites for hydroelectric

generation. Chenani, Sind, Jhelum, Dool Hasti and Salal are the main producing projects.

THERMAL ELECTRICITY

This type of electricity is generated by using fossil fuels like coal, diesel and natural gas. Obviously, thermal power is influenced by the availability of these fuels.

Thermal electricity has recorded a much faster rate of growth, both with respect to installed capacity and actual generation, than its hydro and nuclear counterparts. In 1950-51 the installed capacity of thermal electricity was 1.1 thousand MW as compared to 0.6 thousand MW hydroelectricity. In 2013-14, the installed capacity of thermal electricity reached a level of 197.7 thousand MW against only 40.5 installed capacity of hydroelectricity (*see* **Table 24.10**). Thus installed capacity of thermal electricity rose by 179 times as compared to 67 times increase in hydroelectricity. Generation of hydro and thermal electricity was almost about the same level in 1950-51. But thermal power generation reached a level of 792.5 billion kWh in 2013-14 from an insignificant level of only 2.6 billion kWh in 1950-51 (*see* **Table 24.12**). The thermal power generation recorded more than 304 times increase from 1950-51 to 2013-14 whereas hydroelectricity increased from 2.5 billion kWh in 1950-51 to 134.8 billion kWh in 2013-14 (Table 24.12) thus recording only 54-fold increase during the same period. In the year 2013-14, thermal power accounted for over 82 per cent of the total power generation as compared to only 51 per cent in 1950-51.

National Thermal Power Corporation (NTPC) was established in 1975, after which the share of thermal electricity increased considerably. At present, NTPC has 13 coal-based super thermal power projects and seven gas/liquid fuel based combined cycle projects. It has an installed capacity of 19,435 MW.

Thermal electricity has special significance in those areas where geographical conditions are not very favourable for generating hydroelectricity. It accounts for more than half of the installed capacity in 14 states. In the states of Assam, Bihar, Jharkhand, Chhattisgarh, Gujarat, Mizoram and West Bengal it accounts for over 90 per cent of the installed capacity. In Madhya Pradesh, Maharashtra, Manipur and Uttar Pradesh it accounts for about three-fourths of the total installed capacity. Statewise distribution of thermal electricity is briefly described as under :

1. Maharashtra. Maharashtra is the largest producer of thermal electricity and accounts for about 16 per cent of the total thermal electricity produced in India. Chola and Trombay steam power plants, Kolhapur Diesel Turbine, Uran Gas Turbine, Chandrapur, Bhusawal, Khaparkeda, Parli, Dhobal and Ujjaini are the main thermal power producing plants.

2. Gujarat. Gujarat does not have any major river flowing through its territory which can offer suitable sites for producing hydroelectricity in appreciable measure. Therefore, 91 per cent of the installed capacity of the state comprises thermal electricity. The main plants producing thermal electricity in the state are located at Banas, Gandhinagar, Kachchh, Sabarmati, Wanakbari, Kawas, Sikka, Mahuva, Utran, Shahpur, Porbandar, Kandla, Ahmedabad, Dhuvaram, etc.

3. Andhra Pradesh. Andhra Pradesh has some coal deposits as a result of which the state has developed thermal electricity. Thermal energy account's for about 90 per cent of the total energy produced in the state. The main thermal power stations in the state are at Ramagudam, Kothagudam, Nellore, Vijayawada, Bhadrachalam, Manuguru, etc.

4. West Bengal. West Bengal has large reserves of low grade steam coal which is quite suitable for generation of thermal power. Consequently, thermal electricity comprises 97.7 per cent of the total installed capacity of the state. The major power projects of the state are Bundel, Kolkata, Durgapur, Farakka, Murshidabad, Birbhum, Kalaghat, Titagarh, Mejia, Santaldih, etc.

5. Tamil Nadu. Thermal power accounts for about 72.1% of the installed capacity of Tamil Nadu. The state produces about 5 per cent of the total thermal electricity produced in India. Neyveli, Mettur, Ennore (Chennai), etc. are important projects of Tamil Nadu.

6. Uttar Pradesh. Although Uttar Pradesh has mighty rivers flowing through its territory, the hydro-potential has not been properly harnessed. The result is that hydroelectricity forms only 6.4 per cent of the

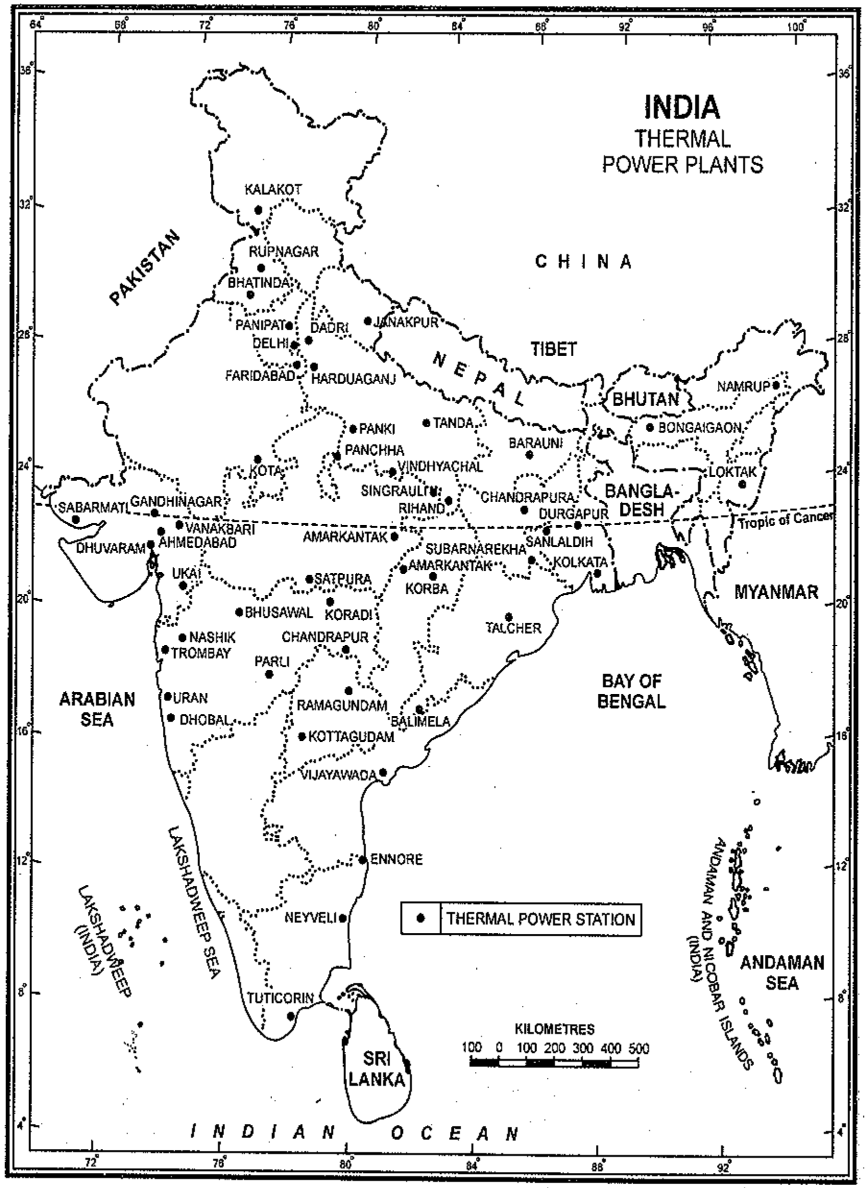

FIG. 24.9. Thermal Power Plants

total installed capacity and the remaining 93.6 per cent is constituted by thermal electricity. Most of the coal used in generating thermal electricity is brought from the neighbouring states of Jharkhand, Chhattisgarh and Madhya Pradesh. Obra (Mirzapur), Harduaganj (Aligarh), Renusagar, Rosa, Jawaharpur, Unchahar, Rihand, Kanpur, Mau (Azamgarh), Gorakhpur, Dohrighat, Moradabad, Tundla, Bahraich, etc. are important thermal power stations in Uttar Pradesh.

TABLE 24.14. Major Thermal Power Stations in India

State	Thermal Power Stations
Maharashtra	Karadi, Nashik, Kaparkheda, Paras, Bhusawal, Parli, Uran, Ballarshah, Chola, Trombay, Kolhapur, Dhobal, Ujjaini.
Gujarat	Banas, Gandhinagar, Kachchh, Sabarmati, Wanskbori, Kawas, Sikka, Mahuva, Utran, Shapur, Porbandar, Kandla, Ahmedabad, Dhuvaram, Ukai.
Andhra Pradesh	Nellore, Vijayawada, Bhadrachalam, Manuguru.
Telangana	Ramagudam, Kottagudam
West Bengal	Bundel, Kolkata, Durgapur, Farakka, Murshidabad, Birbhum, Kalaghat, Titagarh, Mejia, Santaldih, Gauripur.
Tamil Nadu	Neyveli, Methur, Ennore, Tuticorin.
Uttar Pradesh	Obra, Harduaganj, Renusgar, Rosa, Jawaharpur, Unchohar, Rihand, Kanpur, Mau, Gorakhpur, Dohrighat, Moradabad, Tundla, Bahraich
Madhya Pradesh	Singrauli, Satpura, Amarkantak.
Jharkhand	Durgapur, Subarnarekha, Chandrapura.
Chhattisgarh	Korba.
Haryana	Faridabad, Panipat, Yamunanagar.
Punjab	Bhatinda, Roopnagar.
Delhi	Indraprastha, Rajghat, Badarpur.
Rajasthan	Kota, Polana, Sawai Modhiopur, Banswara, Anta.
Assam	Namrup, Bongaigaon, Chandarpur.
Odisha	Talcher, Balimela.
Bihar	Barauni, Kahalgaon.

Other producers. Among the other producers are *Madhya Pradesh* (Singrauli, Amarkantak, Satpura), *Jharkhand* (Subarnarekha, Chadrapura), *Chhattisgarh* (Korba), *Punjab* (Bhatinda and Rupnagar), *Haryana* (Faridabad, Panipat and Yamunanagar), *Rajasthan* (Kota, Palana, Sawai Madhopur, Banswara); *Karnataka* (Raichur), *Assam* (Namrup, Bongaigaon, Chandarpur), *Odisha* (IB Valley, Talcher), and *Delhi* (Badarpur, Indraprastha, Rajghat).

Table 24.14 gives a list of major thermal power stations in India. Areal distribution of thermal power plants is shown in **Figure 24.9**.

NUCLEAR ENERGY

Nuclear energy is obtained from uranium and thorium. India has vast untapped uranium resources and there is urgent need to make use of these resources if India really wants to get out of the present scenario of power shortages and energy crisis.

Although nuclear power contributes a little over 3 per cent of our total power generation at present, it has vast potential for future development. It requires quite higher technology to develop nuclear power which India has fortunately attained now. India is one of the few countries which have developed the capability of designing, constructing, commissioning and operating a nuclear power station without any help from outside.

Most of the nuclear power stations in India have been constructed near sources of water because it is required in great quantity for cooling purposes.

Nuclear power programme was initiated in 1940s when 'Tata Atomic Research Commission' was incorporated in August, 1948. However, the real progress was made only after the establishment of the Atomic Energy Institution at Trombay in 1954. This was renamed as the 'Bhabha Atomic Research Centre' (BARC) in 1967. The first nuclear power station with 320 MW capacity was set up at Tarapur near Mumbai in 1969. Later, atomic reactors were installed at Rawatbhata (300 MW) near Kota in Rajasthan, Kalpakkam (440 MW) in Tamil Nadu, and Narora in Uttar Pradesh. Kaiga in Karnataka and Kakarapara in Gujarat also have nuclear energy plants. Nuclear power plants are proposed to be set up at Kumharia (Haryana), Bargi (M.P.) Haripur (West Bengal), Jailapur (Maharashtra) Mithi Viridi (Gujarat) and Kovvada (Andhra Pradesh).

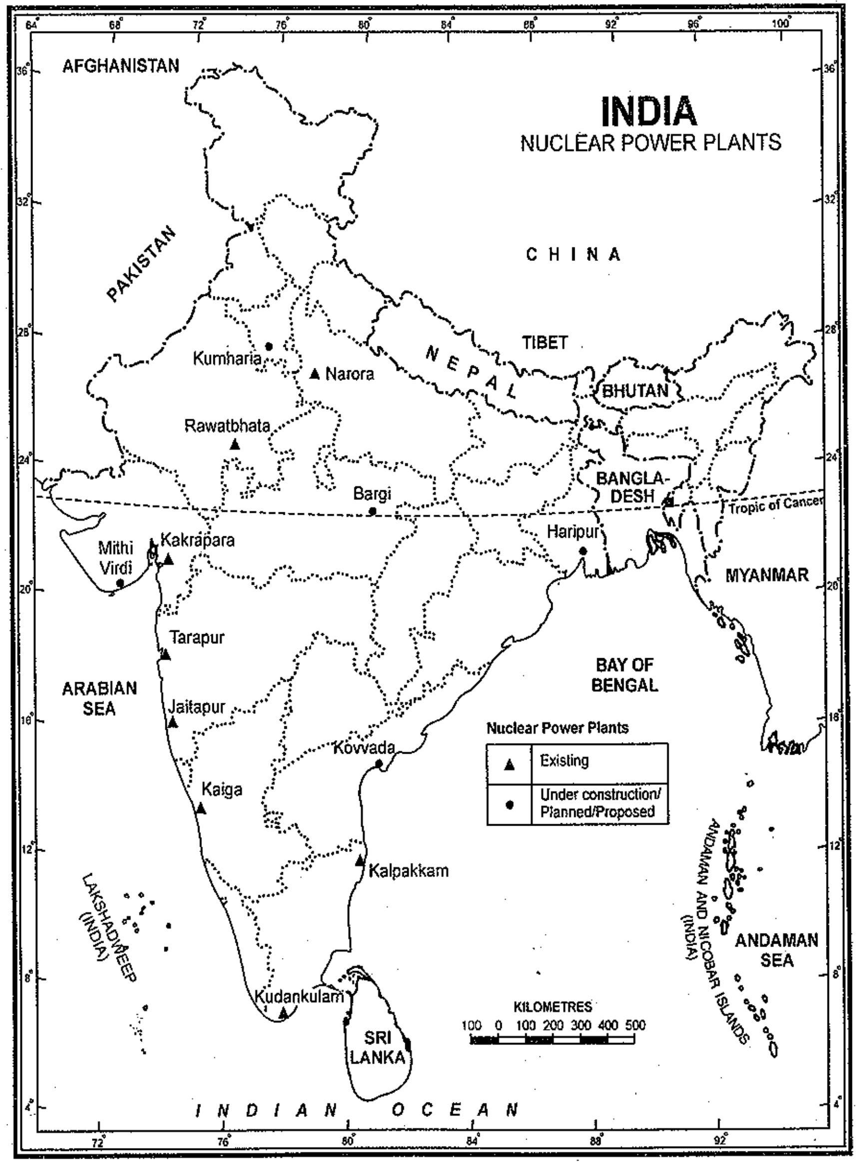

FIG. 24.10. India : Nuclear Power Plants

Nuclear Power Programme

A three stage Nuclear Power Programme was drafted by the Department of Atomic Energy (DAE) in 1954. This programme aimed at meeting the growing demand for energy in the country by utilizing natural resources of uranium and thorium. The programme involves pressurized heavy water reactors (PHWREs) in the first stage, fast breeder reactors (FBRs) in the second stage and thorium-based advanced heavy water reactors (AHWRs) in the third stage. Development of technology relating to spent-fuel reprocessing, waste management, safety and environment were also included in this programme.

Nuclear Power Programme, Stage-I. This programme was initiated in 1960s with PHWR reactor as the initial choice. It was aimed at gaining experience with two boiling water reactors (BWRs) imported from the U.S.A. installed at Tarapur Atomic Power Station (TAPs) about 110 km north of Mumbai and commissioned in 1969. In 1972, the PHWR of Candou design nuclear power plant was commissioned at Rawatbhata near Kota in Rajasthan in technical collaboration with the Atomic Energy Canada Ltd. (AECL).

The U.S.A. and Canada ceased their nuclear collaboration with India following nuclear explosion made by India at Pokran in 1974 and Indian engineers engaged themselves in developing indigenous technology. Thus the next reactor was established in 1980 after a long gap of 8 years. The indigenous technology reached its commercial maturity with the commissioning of a 2X22. PHWR at Kakarapara (Gujarat) in 1992. The state-of-the-art 2X22. PHWRs were commissioned one each at Kakarapara, Kaiga (Karnataka) and Rawatbhata (Rajasthan) in 1995, 1999 and 2000 respectively.

The Nuclear Power Corporation of India (NPCIL) a public sector undertaking of the DAE is responsible for designing, constructing and operating the nuclear power stations in India. **Table 24.15** gives details of nuclear power plants run by the NPCIL.

Nuclear fuel fabrication for nuclear reactors and research reactors is done at Nuclear Fuel Complex, Hyderabad and Bhabha Atomic Research Centre (BARC), Mumbai. The BARC and Indira Gandhi Centre for Atomic Research (ICAR) are also engaged in developing new fuels to be used in future.

TABLE 24.15. Details of nuclear power plants in India

Reactor	Type	Commercial Operation
Tarapur 1 and 2	BWR	1969
Tarapur 3 and 4	PHWR	2005-06
Kaiga 1 and 2	PHWR	1999-2000
Kaiga 3 and 4	PHWR	2007
Kakarapara 1 and 2	PMWR	1993-95
Kakarapara 3 and 4	PHWR	2012
Kalpakkam 1 and 2	PHWR	1984-86
Kalpakkam PFBR	FBR	2010
Narora 1 and 2	PHWR	1991-92
Rawatbhata 1	PHWR	1973
Rawatbhata 2	PHWR	1981
Rawatbhata 3 and 4	PHWR	1999-2000
Rawatbhata 5 and 6	PHWR	2007-08
Rawatbhata 7 and 7	PHWR	2012
Kudankulam 1 and 2	PWR	2007-08
Kudankulam 3 and 4	PWR	2012
Jaitapur 1 and 2	PWR	2012

Notes : BWR = Boiling Water Reactors.
PHWR = Pressurised Heavy Water Reactors
PWR = Pressurised Water Reactor,
FBR = Fast Breeder Reactor

Source **:** World Nuclear Association.

Nuclear Power Programme Stage-II. This stage envisages setting up of Fast Breeder Reactors (FBRs) heated by reprocessing plants and plutonium based fuel fabrication plants. These fast breeder systems produce more fuel than consumed by them. FBRs can increase the utilization of fuel by about 60 times than PHWRs. India is vigorously pursuing the FBRs programme to tide over the current power problem faced by the country. To manage the FBRs programme, a new PSU named Bhartiya Nabhikaiya Vidhyut Nigam (BHAVIN) was set-up in 2003.

Nuclear Power Programme, Stage-III. This stage is concerned with setting up of thorium-based reactors and associated fuel cycle facilities. Since thorium is only a fertile material, no reactor can be started using thorium directly as a fuel. Thorium is converted into uranium-233 through irradiation with neutrons in a reactor whether PHWR or FBR.

Nuclear Energy; India and the World. It has already been mentioned that only a little over 3 per cent of India's energy needs are met from nuclear sources. This is much less when compared with some of the developed and even the developing countries. For instance, France gets more than three-fourths of the energy from nuclear power and Sweden's 48% energy is received from nuclear sources (Table 24.16).

TABLE 24.16. Dependence on Nuclear Power

Country	Percentage of electricity production supplied by nuclear plants	No. of nuclear reactors
1. France	78.1	59
2. Sweden	48.2	10
3. South Korea	38.6	20
4. Hungary	37.7	4
5. Germany	31.8	17
6. Japan	30.0	55
7. U.S.A.	19.4	103
8. U.K.	18.4	19
9. Russia	15.9	31
10. Canada	15.8	18
11. Argentina	6.9	2
12. Brazil	3.3	2
13. India	3.1	17
14. Pakistan	2.7	2
15. China	1.9	10

Source : Department of Atomic Energy, International Atomic Energy Agency.

The above description brings us to the conclusion that there is vast scope for developing nuclear energy in India. However, nuclear energy development programme has to face very tough resistance from environmentalists and those who fear the occurrence of nuclear mishaps either due to natural disasters like earthquakes, tsunamis, cyclones etc. or because of human failure. Damage to Fukushima nuclear power plant in Japan caused by tsunami of March 11, 2011 is an eye opener. Several protests have been noticed against Jaitapur and Kudankulam nuclear power plants. These fears are not totally unfounded as several mishaps have taken place in different parts of the country. Some of the serious mishaps in nuclear power plants in India are detailed below.

NUCLEAR MISHAPS IN INDIA

- **May 4, 1987 (Kalpakkam).** Refueling accident damages reactor core.
- **September 10, 1989 (Tarapur).** Radioactive iodine leaks at above normal levels.
- **May 13, 1992 (Tarapur).** A malfunctioning tube causes plant to release 12 Curies of radioactivity.
- **March 31, 1993 (Narora).** Plant suffers a fire at its steam turbine blades. Shutdown lasted a year.
- **May 13, 1994 (Kaiga).** During construction, an inner containment dome meant to contain radiation collapses.
- **February 2, 1995 (Kota).** Plant leaks radioactive helium and heavy water into the Rana Pratap Sagar river.
- **Dec. 26, 2004 (Kalpakkam).** During the tsunami, sea water enters intake tunnel of plant. Plant shut down.
- **November 25, 2009 (Kaiga).** Employees fall ill. Tests show tritium content in urine of 92 employees who drank water from cooler. A disgruntled staff had poured radioactive heavy water into it.

Pattern of Electricity Consumption

Pattern of electricity consumption has undergone wide ranging changes during the last few decades. For example, the consumption of electricity in industrial sector had drastically reduced from 62.6 per cent in 1950-51 to 33.3 in 2001-02. However, a slight recovery was made in the subsequent years and the share of industrial sector in electricity consumption stood at 37.6 per cent in 2007-08 to fall again to 36.5 per cent in 2010-11. In contrast to this, consumption of electricity in agriculture had increased considerably from 3.9 per cent in 1950-51 to 31.4 in 1998-99. It appears that a stage of saturation was reached with respect to percentage of electricity consumption in agriculture in 1998-99 and downward trend has been observed afterwards. The percentage share of agricultural sector in electricity consumption came down to 20.5 in 2010-11. Consumption of electricity for domestic purposes showed varying trends from 1950-51 to 1980-81 after which there has been a regular rise in the percentage of electricity consumption for domestic purposes. The percentage of electricity consumption in domestic sector decreased from 12.6 in 1950-51 to 8.8 in 1970-71. It reached 11.2 per cent in 1980-81 after which it consistently rose to reach a level of 25.9 per cent in 2010-11. Percentage of electricity consumed for traction declined from 7.4 in 1950-51 to 2.2 in 2010-11 inspite of large scale electrification of railways. This is due to increased use of electricity in other fields like agriculture and domestic (see **Table 24.17**).

TABLE 24.17. Pattern of Electricity Consumption (Utilities) in per cent

Year	Domestic	Commercial	Industry	Traction	Agriculture	Others
1950-51	12.6	7.5	62.6	7.4	3.9	4.0
1960-61	10.7	6.1	69.4	3.3	6.0	4.5
1970-71	8.8	5.9	67.6	3.2	10.2	4.3
1980-81	11.2	5.7	58.4	2.7	17.6	4.4
1990-91	16.8	5.9	44.2	2.2	26.4	4.5
2000-01	23.9	7.1	34.0	2.6	26.8	5.6
2005-06	24.3	8.7	36.8	2.4	21.9	5.9
2006-07	24.4	8.8	37.6	2.4	21.9	5.1
2007-08	24.0	9.2	37.5	2.2	20.6	6.5
2008-09	24.7	10.2	37.1	2.2	20.4	5.4
2009-10	24.9	10.4	36.7	2.2	21.0	4.8
2010-11	25.2	10.4	36.5	2.2	20.5	5.4

Source : Economic Survey 2012-13, p. A-27.

NON-CONVENTIONAL ENERGY SOURCES

With increasing demand for energy and with fast depleting conventional sources of energy such as coal, petroleum, natural gas, etc. the non-conventional sources of energy such as energy from sun, wind, biomass, tidal energy, geo-thermal energy and even energy from waste material are gaining importance. This energy is abundant, renewable, pollution free and eco-friendly. It can be more conveniently supplied to urban, rural and even remote areas. Thus it is capable of solving the twin problems of energy supply in a decentralised manner and helping in sustaining cleaner environment. *It is the energy of the future. No wonder, non-conventional energy is fast catching the imagination of the people in India.*

The importance of renewable energy was recognised in the country in the early 1970s. The renewable energy programme started with the establishment of the Department of Non-conventional Energy Sources (DNES) in 1982. Indian Renewable Energy Development Agency (IREDA) was set up in 1987. It was later renamed as Ministry of New and Renewable Energy (MNRE) In 1992, DNES was converted into Ministry of Non-conventional Energy Sources (MNES) which has taken several steps to create a suitable atmosphere for harnessing non-conventional sources of energy. India has today one of the largest programmes for renewable energy. The activities cover all major renewable energy sources, such as biogas, biomass, solar, wind, small hydropower and other emerging technologies. Several renewable energy systems and devices are commercially available. The renewable energy programmes cover the entire gamut of technologies, including improved wood stoves, biogas plant, biomass gasifier, solar thermal and solar photovoltaic systems, wind mill, co-generation, small hydropower, energy recovery from urban/municipal and industrial wastes, geothermal energy, hydrogen energy, electric vehicles and bio-fuels, etc. According to energy experts, India's non-conventional energy potential is estimated at about 1,95,000 MW. An estimate of 31 per cent of this potential comes from sun, 30 per cent from ocean-thermal, 26 per cent from bio-fuel and 13 per cent from wind.

During the last two decades, several renewable energy technologies have been developed and deployed in villages and cities. Some of the achievements are given in Table 24.18 alongwith the estimated potential :

TABLE 24.18. Details of estimated renewable energy and cumulative achievements under different programmes as on 31 March, 2010

Sl. No.	Programmes/Systems	Estimated Potential	Achievement during (2010-11)	Cumulative Achievement
I.	**Power from Renewables**			
	A. Grid-Interactive renewable power			
	Biomass Power (Agro residues and Plantations)	16,881	143.50 MW	997.10 MW
	Wind Power	45,195	2,330.00 MW	14,155 MW
	Small Hydro Power (upto 25 MW)	15,000	307.21 MW	3,042.63 MW
	Cogeneration-bagasse	5,000	321.50 MW	1,667.53 MW
	Waste to Energy (Urban and Industrial)	2,700	7.50 MW	72.46 MW
	Solar Power	50 MW/sq km	26.59 MW	37.66 MW
	Total		**3,136.30 MW**	**19,972.38 MW**
	B. Off-Grid/Distributed Renewable Power including Captive/CHP Plants			
	Biomass/Cogeneration (non-Bagasse)		80.73 MW	301.61 MW
	Biomass Gasifier		10.73 MWeq	131.81 MWeq
	Energy Recovery from Wast		23.70 MWeq	70.42 Meq
	Solar PV Power Plants		4.28 MWp	8.16 MWp
	Aero-generator Hybrid Systems		177.00 kW	1.25 MW
	Total		**119.617 MWeq**	**513.25 MWeq**
II.	**Decentralized Renewable Energy Systems**			
	Family Type Biogas Plants (nos.)	120 lakh	1.51 lakh	44.04 lakh
	Solar Photovoltaic Systems			
	(*i*) Street Lighting Systems (nos.)		26,472	1,82,200
	(*ii*) Home Lighting Systems (nos.)		1,13,817	7,33,245
	(*iii*) Solar Lanterns (nos).		18,224	8,31,604
	(*iv*) Solar Photovoltaic Pumps (nos.)		106	7,334
	Solar Thermal Program			
	(*i*) Solar Water Heating Systems—			
	Collector area (m^2)	140 million	1.00 million sq m	4.47 million sq m
III.	**Remote Village Electrification**		1,537 villages and hamlets	8104 villages and hamlets
IV.	**Other Programmes**			
	Energy Parks		3 nos	514
	Aditya Solar Shops		9 nos	302

MWeq = MegaWatt equipment; MW = MegaWatt; KWp = KiloWatt Peak; sq m = Square Metre

Source : India 2012, A Reference Annual, p. 362.

In the past ten years in from 2004 to 2014, the installation of renewable energy for electricity has grown at an annual rate of 25 per cent. It has reached 30,000 MW as of January 2014. During this period, wind power installation has grown ten times and solar energy has grown from nothing to 2,500 MW. Currently renewable energy accounts for 12 per cent of total electricity generation capacity and contributes about 6 per cent of the electricity produced in the country. Renewables, therefore, produce twice the

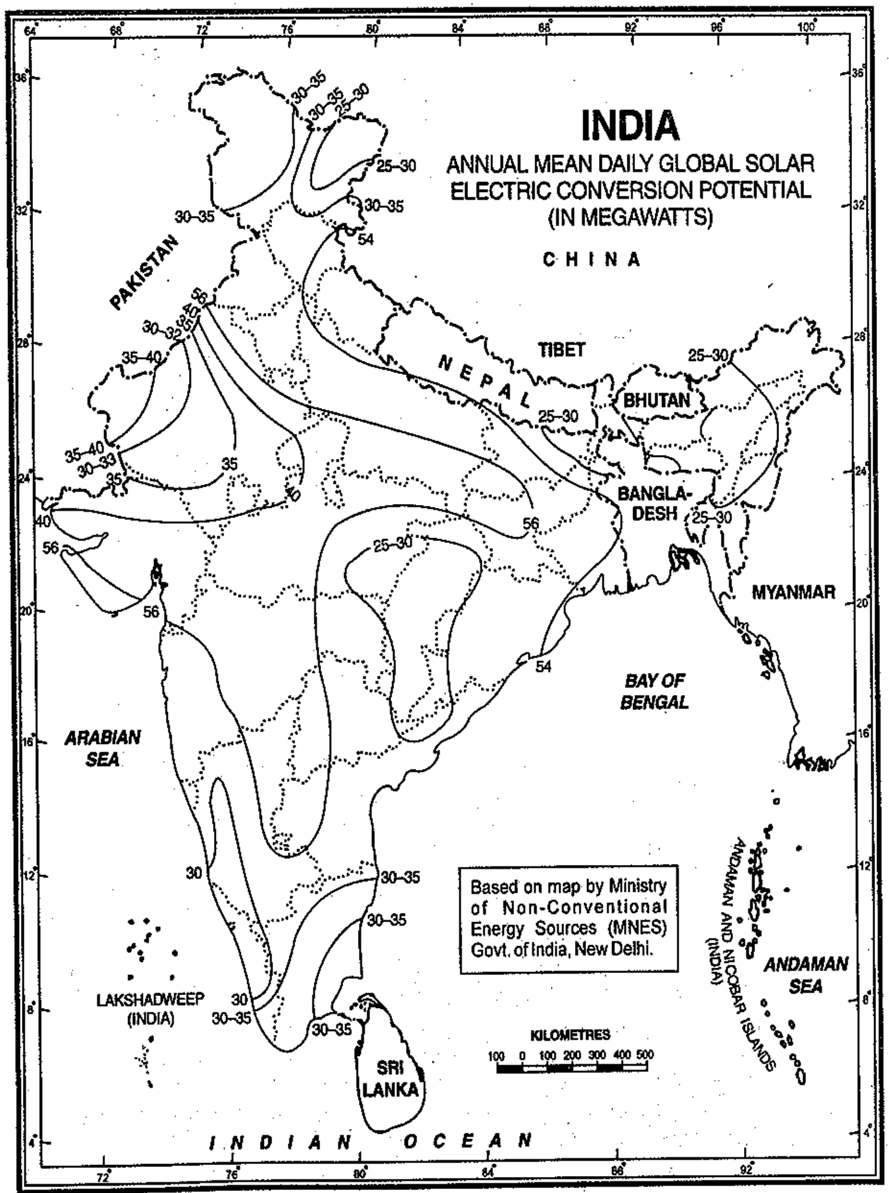

FIG. 24.11. India : Annual mean daily global solar electric conversion potential (in MW) and Solar Energy centres

amount of electricity produced in by all nuclear power plants in the country. In 2012-13 the electricity produced by renewables was equivalent to meeting per capita annual electricity requirement of above 60 million people. More than a million households in the country, today, depend solely on solar energy for their basic electricity needs (State of Renewable Energy in India, A Citizen's Report, 2014, Centre for Science and Environment).

SOLAR ENERGY

Sun is the source of all energy on the earth. India, being a tropical country, is well endowed with plenty of solar energy. Most parts of the country have bright sun-shine throughout the year except a brief monsoon period. As our country is literally soaked in sunshine, exploitation of solar energy is an extremely important component of renewable energy sector through both the thermal and photovoltaic routes for a variety of applications like cooking, water heating, drying of farm produce, water pumping, home and street lighting, power generation for meeting decentralised requirements in villages, schools, hospitals, etc. India receives nearly 3,000 hours of sunshine every year which is equivalent to over 5,000 trillion kWh per year. This is far more than the total energy consumption of the country. The daily average of solar energy incident over India varies from 4 to 7 kWh/m^2 depending upon the location. Solar water heaters, solar refrigeration, solar drying, street lighting, cooking, pumping, power generation, photo-voltaic solar cells, solar ponds, etc. are becoming very popular in different parts of the country.

Although solar energy can be gainfully used in any part of the country except some higher areas in the Himalayan ranges, the Thar Desert of Rajasthan holds great promise in this direction. Scientists are of the opinion that the vast expanse of the Thar Desert could well earn the distinction of being the *biggest solar power house of the world*. The 35,000 sq km expanse of Thar Desert is sufficient to generate anything between 700 gigawatts to 2,100 gigawatts. A major chunk of the desert has been declared as 'Solar Energy Enterprise Zone' like the one in Nevada (USA). Parts of Kathiawar peninsula. Maharashtra, Karnataka, Andhra Pradesh, Telangana, Madhya Pradesh, West Bengal, Jharkhand, Bihar, Uttar Pradesh, Haryana and Punjab also hold great possibilities of harnessing solar energy. Map in Figure 24.11 shows annual mean daily global solar electric conversion potential in India.

Solar radiant energy can be used through thermal as well as photovoltaic routes. Both solar, thermal and photovoltaic applications have large potential in the country.

Solar Thermal Energy

Soaked in abundant sunshine, India offers an excellent opportunity for converting solar energy to thermal energy. Several solar thermal technologies have been developed. These include solar water heaters, solar cookers, solar heaters, solar distillation systems, etc. Research and development in the field of solar thermal energy is continuously being pursued in the country for about four decades. As a result, several products have been developed indigenously. To promote these products, a subsidy-based thermal extension programme was launched in 1984 and continued upto 1993. This initiative had resulted in disseminating the solar thermal products in different parts of the country. The main objectives of the Solar Thermal Energy Programme, being implemented by the Ministry of Non-conventional Energy Source (MNES), are market development, commercialization and utilization of solar thermal systems for the fulfilment of heat energy requirements of different applications in domestic, institutional and industrial sectors. It has five components *viz*. Solar Thermal Extension Programme, Solar Cooker Programme, Solar Buildings Programme, Research and Development (R&D) Programme and Aditya Solar Shops.

Solar Water heating is one of the main technologies being promoted by MNES. Water heating technology for low temperature range is mainly based on flat plate collectors, which absorb solar radiation and raise the temperature of water upto 80°C. This hot water can be used for various applications in homes, hotels, hostels, restaurants and hospitals. Hot water at this temperature is used in a number of industries also. Solar water systems (solar geysers) of capacities ranging from 100 to 300 litres per day are suited for domestic applications. Larger systems from hundreds to thousands of litres are used in commercial and industrial establishments.

Due to the efforts made by MNES during the last several years both the technology and the manufacturing base for solar water heating is now well established. Although the initial cost of solar water heating system is rather high, the system pays back the investment within 3 to 6 years depending on the fuels substituted. The technical potential of solar water heaters in the country has been estimated to be 140 million sq metres of collector area. There is an enormous possibility for harvesting solar energy through this technology. With the increasing acceptability in the residential sector, solar water heaters can be set up in multistoreyed residential flats for meeting the hot water requirement.

The use of solar water heaters saves electricity and contributes to a reduction in peak load demand. It has been estimated that the use of 1,000 domestic solar water heating systems of 100 litres capacity each can contribute to a peak load shaving of 1 MW.

Solar air heaters and dryers can conveniently be used both in industry and agriculture. Already a number of solar drying systems have been installed in the country and these are helping to save significant amounts of conventional fuels. Among the industries using these are tea, food processing, *dal* mills and spice manufacturers. Solar air heaters are also being used for space heating in the cold regions. Various types of collectors have been fabricated and are currently under use.

Solar cooker is a simple device which cooks food with the help of solar energy and saves conventional fuels to a significant extent. On clear sunny days, it is possible to cook both noon and evening meals with a solar cooking device. Different types of solar cookers have been developed in the past, which include box solar cooker, steam cooker, solar meal maker with heat storage and concentrating type community cooker. The Ministry of Non-Conventional Energy Sources (MNES) had been promoting the box solar cooker in the country till 1993-94 due to its various advantages over the others. Thereafter, different designs of solar cooker have been propagated under its market-oriented and demonstration programmes. Currently two types of cookers, *viz*, box solar cooker and concentration type cooker are popular among the users. *Box solar* cooker can cook meals for a family of 4 to 5 members and saves 3 to 4 LPG cylinders in a year on full use. If provided with electrical back-up, it can be used during non-sunshine hours also within the kitchen with nominal consumption of electricity. *Concentrating* type solar cooker is of three broad types, *viz*., dish solar cooker, community solar cooker and solar steam cooking system. Dish solar cooker is a fast cooking device which can cook food for 10 to 15 people under sun. It saves upto 10 LPG cylinders per year on full use in small establishments. Community solar cooker (Schefler) can cook food for around 40 people inside the kitchen and saves 35 LPG cylinders per year on full use in community kitchens. Solar steam cooking system can cook food for thousands of people using steam inside the kitchen in very short time. It is useful for installation at ashrams, temples, churches, gurudwaras, etc. A solar cooking system has been installed in Shirdi to cater to 3,000 devotees every day. World's largest system with a capacity to prepare food for 15,000 pilgrims was also set up by the Tirumala Tirupathi Devasthanam in October, 2002.

Solar cooking has been picking up fast with a number of households and institutions, especially those attracting large number of visitors, evincing interest in installing different solar cooking systems depending upon the number of persons for whom they have to prepare food everyday.

Solar Photovoltaic (SPV) technology enables direct conversion of sunlight into electricity without any moving parts and without causing pollution. Photovoltaic systems and power plants have emerged as viable power sources for applications such as lighting, water pumping and telecommunication and are being increasingly used for meeting the electrical energy needs in remote villages, hamlets and hospitals, besides households in the hilly, forest, and desert areas as well in islands. During the past few years, many organisations have started using SPV systems for a variety of applications on commercial basis as these are found to be economically viable as compared to other alternatives. Recently a programme on the deployment of SPV water pumping systems for agriculture and related uses has been implemented.

Upto 2010-11, the cumulative achievement under solar photovoltaic systems was 1,82,200 street-lighting systems, 7,33,245 home lighting systems, 8,31,604 solar lanterns and 7,334 solar photovoltaic pumps.

Efforts are being made to popularise the use of solar greenhouse for growing vegetables during off-season in cold and dry areas of Leh and Kargil. Solarised huts are being designed in cold areas of Jammu and Kashmir and Himachal Pradesh to keep the buildings warm.

Installed Capacity. Solar power has grown exponentially in India during the last few years. The country's cumulative installed capacity grew from a meager 2.12 MW in 2007-08 to 2208.36 in January 2014 (**Table 24.19**).

The Jawaharlal Nehru National Solar Missing (JNNSM) was launched on 11th January 2010 as part of National Action Plan as Climate Change to increase penetration of solar energy in India. The policy initiatives have been focussed on encouragement to set up commercial projects by providing generation based incentives for the power fed to the grid through the mechanism of renewable purchase obligation by utilities backed with preferential tariff and at the same time pursuing research and development efforts to develop indigenous technologies and capacity as well as capabilities in this sector. It aims to create and enabling policy framework for development of following solar energy applications.

Some of the states are better placed with respect to solar installed capacity than others. Maximum solar installed capacity of 860.4 MW has been reported in Gujarat, followed by Rajasthan (666.75 MW), Maharashtra (237.25 MW), Madhya Pradesh (195.32 MW) and Andhra Pradesh (92.50 MW). Tamil Nadu, Karnataka, Uttar Pradesh, Odisha, Punjab, Haryana and Chhattisgarh have less than 35 MW solar installed capacity. Other states and union territories have negligibly small solar installed capacity. Solar installed capacity of some important states is given in **table 24.21**.

Ultra Mega Solar Power Plants. On January 29, 2014, the Ministry of New and Renewable Energy (MNRE) announced the setting up of the Ultra Mega Solar Power Project in Sambhar (Rajasthan). This is the first of the four such 4,000 MW projects the MNRE plans to be installed. The other three would

TABLE 24.19. Solar installed capacity in India

Year	Installed Capacity in MW
2008-09	2.10
2009-10	9.13
2010-11	32.00
2011-12	481.48
2012-13	1446.76
January 2014	2208.36

Source : Ministry of new and renewable energy (Displayed in State of Renewable Energy in India, A Citizen's Report, Centre for Science and Environment, New Delhi 2014, p. 3)

TABLE 24.21. Solar Installed Capacity of some Important States, as on January 31, 2014

State	Solar installed capacity (MW)
1. Gujarat	860.40
2. Rajasthan	666.75
3. Maharashtra	237.25
4. Madhya Pradesh	195.32
5. Andhra Pradesh	92.90
6. Tamil Nadu	31.82
7. Karnataka	31.00

Source : Ministry of New and Renewable Energy (Displayed in State of Renewable Energy in India, A Citizen's Report (2014), p. 172.

TABLE 24.20. Jawaharlal Nehru National Solar Mission

Sr. No.	Application Segment	Phase I (2010-13)	Phase II (2013-17)	Phase III (2017-22)
1.	Solar Thermal Collectors	7 million sq meter	15 million sq metre	20 million sq metre
2.	Off Grid Solar Applications	200 MW	1,000 MW	2,000 MW
3.	Grid-Power including Roof-Top and Small Plants	1,100 MW	4,000—10,000 MW	20,000 MW

Source : India 2012, A Reference Annual, p. 352.

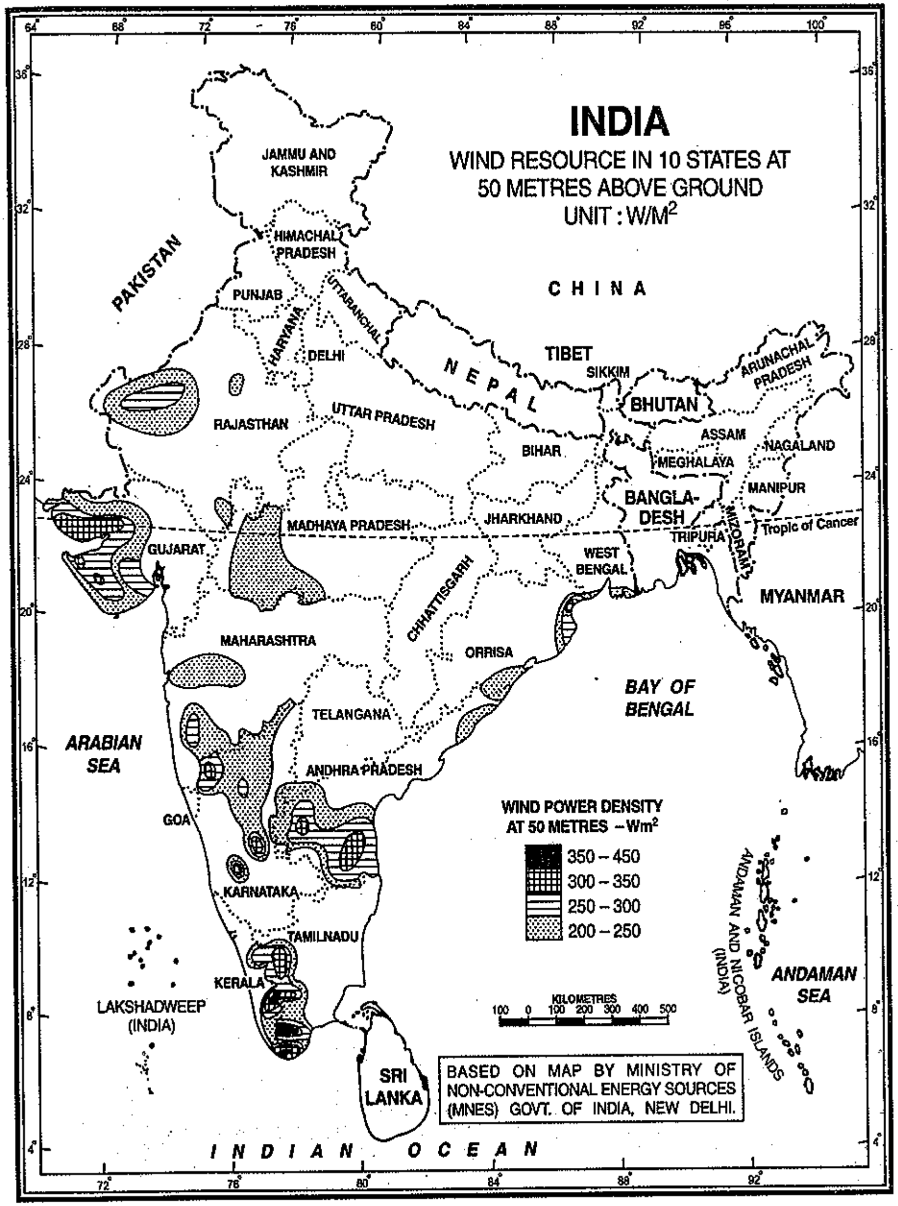

FIG. 24.12. India : Wind Resource in 10 states at 50 m above ground

come up in Khargoda (Gujarat) and Ladakh and Kargil (Jammu and Kashmir). These projects are expected to cost ₹ 1.2 lakh crore (State of Renewable Energy in India, A Citizen's Report, 2014, p. 6).

WIND ENERGY

Wind is another important source of non-conventional energy. The cost inputs are only at the initial stage and the power immediately after commissioning. Once the generation starts, cost-free power is available for about 20 years because there is no recurring cost on fuel.

India has vast wind potential and windfarms have emerged as a viable option with the advancement of wind technology in the country.

Since 1985, the MNES has carried out an extensive wind monitoring and mapping programme to identify better sites and to assess the resource potential. The programme has been implemented in a very systematic manner. The compiled data has been analysed and is being published with the ultimate objective of preparing a wind atlas of the country. This data has been utilised in identifying some excellent sites for windfarms. Map in **Figure 24.2** shows that coastal areas in Gujarat, Tamil Nadu, Andhra Pradesh, Odisha and West Bengal as well as vast areas of Maharashtra, Madhya Pradesh and Rajasthan are in a much better position with respect to wind power resources. The map shows wind resources in 10 states as detailed data are available for these states only.

Wind Power Potential in India : Discovering more out of the thin air. Advances in turbine technology and studies exploring wind resources have opened up the immense potential of wind power in the Indian subcontinent. Centre for Wind Energy Technology (C-WET) has assessed India's wind power potential as 102,778 MW at 80 metres height considering 2 per cent land availability. This is up from the earlier estimate of approximate 49,130 MW at 50 metres with the same land availability. According to C-WET, Gujarat has the highest wind potential in the country followed by three southern coastal states, Andhra Pradesh, Tamil Nadu and Karnataka (*see* **Fig. 24.13**). Wind potential in different states).

In the past few years, other research organisations have estimated wind power potential using different models for mapping the country's wind resource. In one such study, the Lawrence Berkeley National Laboratory (LBNL), USA assumed a turbine density of 9 MW per sq km and a capacity utilisation factor of 20 per cent to estimate the country's wind potential. The study reckoned the wind potential of the country to be 2 million MW at 80 metre hub-height or 3.1 million MW at 120 metre hub-height (State of Renewable Energy in India, Citizen's Report, 2014, pp. 28, 29)

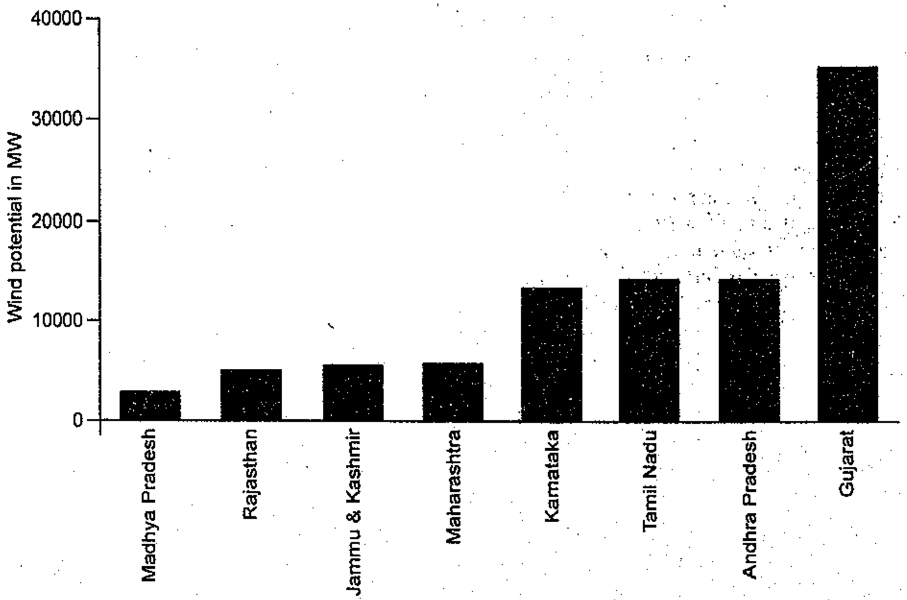

FIG. 24.13. Wind Potential in different states (upto December, 2013)

Wind Power Installation. Wind-energy accounts for about 67 per cent of the total renewable energy capacity installed in India. At the end of December 2013, the total installed capacity of wind power was 20,149.5 MW. At present, India stands fifth in terms of cumulative wind power capacity after China, the U.S.A., Germany and Spain. In 2012, India accounted for about 7 per cent of the world total installed capacity. **Table 24.22** gives details of state-wise year-wise wind power installed capacity.

Growth of Wind Power : A Rollercoaster Ride. Wind power in India has grown at a cumulative annual growth rate of 26 per cent from 2002-03 to 2013-14. The installation of wind power has always

TABLE 24.22. State-wise and Year-wise Wind Power Installed Capacity (MW)

State	Upto to March 2002	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	Total
Andhra Pradesh	93.2	0	6.2	21.8	0.45	0.8	0	0	13.6	55.4	54.1	202.15	447.7
Gujarat	181.4	6.2	28.9	51.5	84.6	283.95	616.36	313.6	297.1	312.8	789.9	208.28	3074.59
Karnataka	69.3	55.6	84.9	201.5	143.8	265.95	190.3	316	145.4	254.1	206.7	201.65	2135.2
Kerala	2	0	0	0	0	0	8.5	16.5	0.8	7.4	0	0	35.2
Madhya Pradesh	23.2	0	0	6.3	11.4	16.4	130.39	25.1	16.6	46.5	100.5	9.6	385.99
Maharashtra	400.3	2	6.2	48.8	545.1	485.3	268.15	183	138.9	239.1	416.5	288.55	3,021.9
Rajasthan	16.1	44.6	117.8	106.3	73.27	111.75	68.95	199.6	350	436.7	545.7	613.95	2684.72
Tamil Nadu	877	133.6	371.2	675.5	857.55	577.9	380.67	431.1	602.2	997.4	1083.5	174.58	7162.2
Others	32	0	0	0	0	0	0	0	0	0	0	1.1	4.3
Total	1665.7	242	615.2	1111.7	1716.17	1742.05	1663.32	1484.9	1564.6	2349.2	3196.7	1699.86	19052

Source **:** Ministry of New and Renewable Energy, http://mnre.gov.in/file-manager/UserFiles/wp_installed.htm. (State of Renewable Energy in India, A Citizen's Report, 2014, Centre for Science and Environment, New Delhi, p. 177)

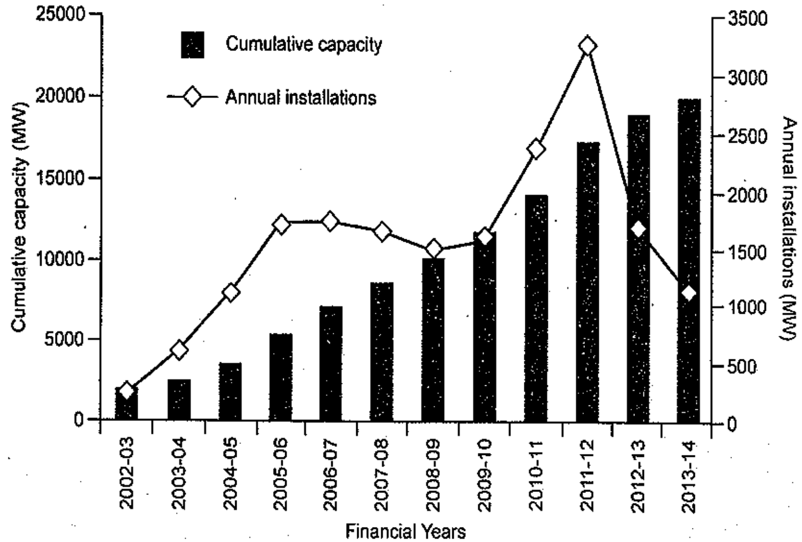

FIG. 24.14. Growth of wind power.

Source **:** MNRE (http://mnre.gov.in/file-manager/UserFiles/Presentations-MWM-0912014/Alok-Srivastava-JS-MNRE.pdf) (State of Renewable Energy in India, A Citizen's Report, 2014, Centre for Science and Environment, New Delhi, p. 29) exceeded government targets. In the 10th (2002-07) and 11th (2007-12) Five-Year Plans (FYP), against targets of 1,500 MW and 9,000 MW, 5,427 MW and 10,260 MW of wind power was installed. This prompted the government to set ambitious plans for growth of wind power in the 12th FYP (2012-17). The plan set a target of 15,000 MW. However, growth was sluggish in 2012-13 and 2013-14 mainly due to withdrawal of subsidies by the government in the beginning of the 12th Five Year Plan. This has prompted MNRE to go into the mission mode. A Wind Mission has been inaugurated to develop a long-term sustainable policy framework to accelerate the wind sector's growth.

Table 24.23 shows that Tamil Nadu has recorded a maximum of 59.675 Billion kWh cumulative wind energy from 2005-06 to 2011-12. This is followed by Maharashtra, Karnataka, Gujarat, Rajasthan, Andhra Pradesh, Madhya Pradesh and Kerala.

Offshore Possibilities. India's 7,517 km long coastline offers vast wind power potential. To harness this potential, India released its offshore wind draft policy in May, 2013 which proposed an Offshore Wind Energy Steering Committee (OWSC) to frame the policy for offshore wind energy development. It also proposed formation of a National Offshore Wind Energy Authority (NOWA) to act as the nodal agency for offshore projects in the country. Although various studies have suggest immense wind energy potential along the Indian coasts, none of them has come out with concrete and reliable data. A MNRE presentation uses the study by World Institute of Sustainable Energy (WISE) to estimate Tamil Nadu's wind energy potential at 1,27,000 MW at 80 metre height. This gives us an idea of vastness of wind energy potential along our coasts. However, absorbitant cost of production will be big hindrance in the way of exploiting this huge potential. It has been estimated that the cost of offshore wind is currently ₹ 12-18 crore per MW as compared to ₹ 6 crore per MW for on-shore wind energy.

Biogas

Biogas is based upon the use of dung to produce gas which is used as domestic fuel especially in the rural areas. This technique is based on the decomposition of organic matter in the absence of air to yield gas consisting of methane (55%) and carbon dioxide (45%) which can be used as a source of energy. This energy is piped for use as cooking and lighting fuel in specially designed stoves and lamps respectively. It can also be used for replacing diesel oil in dual fuel engines for generation of motive power and electricity. The left-over digested slurry serves as an enriched manure. Biogas technology is taking deep roots in rural India because of certain inherent advantages. Biogas has higher thermal efficiency when compared with kerosene, firewood, dung and charcoal. It is observed that the thermal efficiency of gobar gas is 60 per cent while dung, which is commonly used in villages for cooking, has only 11 per cent thermal efficiency. Thus the use of gobar gas fuel is advantageous from the point of view of not only fuel efficiency but also fuel saving.

TABLE 24.23. State-wise Cumulative Wind Power Generation in Billion kWh

State	Upto 2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	Cumulative
Andhra Pradesh	0.8	0.111	0.101	0.333	0.106	0.9076	0.122	1.65
Gujarat	1.618	0.455	0.851	2.104	2.988	2.881	4.181	15.077
Karnataka	2.344	1.397	1.84	1.723	2.895	2.825	3.279	16.303
Kerala	0.047	0	0	0	0.065	0.065	0.07	0.246
Madhya Pradesh	0.33	0.07	0.069	0.003	01982	0.09	0.13	0.775
Maharashtra	3.44	1.714	1.804	2.207	2.779	2.692	3.296	17.931
Rajasthan	0.921	0.532	0.682	0.758	1.127	1.387	2.42	7.826
Tamil Nadu	15.414	5.268	6.066	6,206	8.146	8.72	9.855	59.675
Total	24.914	9.547	11.413	13.334	18.188	18.735	23.353	119.483

Source: Ministry of New and Renewable Energy, http://mnre.gov.in/file-manager/UserFiles/wp8.htm (State of Renewable Energy and India, A Citizen's Report 2014, Centre for Science and Environment, p. 177.)

Biogas technology has a bright future in India. It has been estimated that 1 to 1.5 billion tonnes of waste dung is available per annum in the country. If two-third of this quantity is used to produce biogas, it could yield 22,425 million cubic metre of biogas which could save 33,904 million litres of kerosene. Currently, it saves about 70 lakh tonnes of fuel wood annually. Further, it could yield manure equivalent to 14 million tonnes of nitrogen, 13 million tonnes of phosphate and 0.9 million tonnes of potash. The success of biogas technology has brought about a sort of *Brown Revolution* in rural India.

Although biogas plants and improved *chullahs* have been disseminated in India since 1940s, they picked up only in early 1980s. The National Project on Biogas Development (NPBD) was taken up in Central Sector during 1981-82 on country wide basis. It seeks to provide clean and convenient fuel for cooking and lighting purposes in rural areas, produce enriched organic manure, improve sanitation and hygiene by way of linking household biogas plants with toilets and reduce the drudgery of women.

Besides family size biogas plants, the Ministry of Non-conventional Energy Sources is also promoting the setting up of community, institutional and nightsoil based biogas plants. The Community and Institutional Biogas Plants (CBP/IBP) Programme was initiated in 1982-83. Under this programme, the biogas is generally used for motive power and generation of electricity, besides meeting the cooking fuel requirements. A component on biogas plants linked with community toilet complexes was added in the year 1993-94 to facilitate on site treatment of human waste. During the financial year 2010-11, 1,51,138 family type biogas plants were installed across the country, taking the cumulative installations to over 44 million biogas fertilizer plants.

National Programme on Improved Chulhas

The National Programme on Improved Chulhas (NPIC) was initiated in 1986-87 with the following objectives :

- fuel wood conservation;
- elimination/reduction of smoke;
- reduction in drudgery of women and children from cooking in smoky kitchen and collection of fuel wood;
- environmental upgradation and check on deforestation; and
- employment generation in rural areas.

Improved chullahs that do not emit smoke and use less wood, are fast replacing traditional cookstoves in rural areas ushering in what is described as *smokeless revolution* in different parts of the country. While the traditional chullahs have thermal efficiency of 8-10 per cent, the improved chullahs have minimum efficiency of 20-25 per cent. An improved chullah saves on an average about 375 kg of bio-fuel and 3 litres of kerosene per year under field conditions. Besides, an improved chullah results in a saving of 45 minutes to one hour per family which would otherwise be spent on collecting and processing the fuel material, cleaning of utensils and cooking. The improved chullah also helps in making the environment inside the kitchen smoke-free, thereby reducing the incidences of eye and lung diseases amongst women and children. The NPIC is also generating employment in rural areas for women at the rate of 0.3 person day per chullah.

A pilot project has been launched to test the efficiency and marketability of improved cook-stoves, so that the consumption of fire wood is reduced. Under the National Business Cookstoves, initiative, a pilot scale project for deployment for 5,500 biomass community cookstoves in Anganwadis, Mid-day meal scheme in schools, Tribal Hostels etc. and demonstration for 15,000 of family sized/portable cookstoves has been taken up.

The world's largest system for cooking in community kitchen has been installed at Shirdi to cook food for 20,000 people per day and is saving around 60,000 kg of LPG every year. All institutions including large institutions with hostels, hospitals/medical colleges military/paramilitary establishments, industrial organisations, academies wherever large number of meals is cooked, are the targets.

Biomass Power. Agricultural and agro-industrial residues are collectively known as biomass. Biomass gasification is a thermochemical process in which fuel gas is formed as a result of partial combustion of biomass, such as wood waste, crop residues, agro-industrial wastes, etc. (or any organic material). The main advantage of the gasification technique is that it enables solid biomass to be converted into a more convenient and versatile fuel. The produced gas could either be burnt directly for thermal applications or be used for replacing diesel oil in dual-fuel engines for mechanical and electrical applications. Its relevance in today's world is greater than in the past as it provides an option to reduce Green House gas emissions because biomass can be CO_2 neutral in terms of emission. Gasification has vast potential for rural lighting purposes. The social and environmental benefits of biomass power for long-term sustainability have been accepted. The gasifier programme in India was launched in 1986 by the Ministry of New and Renewable Energy (MNRE) based on 3.7 kW wood based gasifiers.

MNRE reckons that over 500 million tonnes of biomass generated every year in the country has energy potential equivalent to 175 million tonnes of oil. It is also estimated that 150-200 million tonnes of biomass goes waste. This waste can generate 15,000 upto 25,000 MW of electrical power at typically prevalent plant factor load. A recent report from the Central Statistics Office estimates the potential of biomass power as 17,538 MW. MNRE also believes that more than 70,000 MW electricity can be generated from biomass grown on wastelands, road sides and on plantations along railway tracks. It has been estimated that vast stretches a wasteland would be able to produce 400 million tonnes of fuel wood per year equivalent to 60,000 MW of power. The total electricity generation potential from biomass in India had been estimated at about 1,00,000 MW. The MNRE has initiated biomass programme with a view to increase fast growing short rotation fuel wood species, suitable for plantation under the given set of agro-climatic conditions. This aims at increasing the productivity to about 40 tonnes per hectare per year as compared to the average forest tree production rate of 0.5 tonne per hectare per year. Biomass yields ranging from 12 to 37 tonnes per hectare per year have been achieved by established Biomass Research Centres.

Biomass gasifier systems of upto 500 kW capacity based on fuel-wood have been developed indigenously and are being manufactured in the country. Similarly, the technology for producing biomass briquettes from agricultural residues and forest litter at both household and industrial levels has been developed. The exploitable potential for power generation from agro residues, agro-industrial residues (excluding bagasse) and forestry residues has been estimated at 16,000 MW on a conservative basis.

Be it a small-scale unit or a remote island, the biomass gasifier has come as a saviour cutting down on the consumption of precious fossil fuels on the one hand and bringing about economic development on the other. Thanks to the initiatives and programmes of the MNES, techno-economic viability of biomass gasifiers has been demonstrated and gasifier systems for varied applications have been deployed in different parts of the country. In the process India has emerged a world leader in the development and deployment of gasifier technology and systems.

Gasifier plants have been set up in Gujarat, Uttar Pradesh, Andhra Pradesh, Tamil Nadu, West Bengal, Nagaland and some other states. In certain areas gasifier plants have played a vital role for meeting the energy requirements of the people living in remote and inaccessible areas. It is difficult to extend grid electricity to Chhottomallakhali Island in the Sunderbans area of South 24 Parganas district of West Bengal due to prohibitive cost involved in crossing various rivers and creeks. The switching on of the 4 × 125 KW power plant based on biomass gasifier on 29th June, 2001 has completely changed the lives of inhabitants of this remote island. The plant is catering to the electricity needs of domestic, commercial and industrial users, drinking water supply, hospital, ice factory, etc.

The MNRE has planned to initiate the National Bioenergy Mission in association with state governments and other stakeholders to promote biomass related projects in the country. The mission sets targets for scaling up biomass energy in the country. Its overall target is 20,000 MW biomass projects by 2022. Satewise installed capacity and potential are given in **table 24.24**.

Cogeneration

Cogeneration is the simultaneous production of power either electrical or mechanical and useful thermal energy from a single fuel source. A cogeneration system is an integration of various components (energy conversion system, balance-of-plant system, heat source, heat pump, etc.) into a total system which provides the electrical and thermal requirements of a specific industrial process.

TABLE 24.24. Biomass potential and installed capacity in India (2014)

State	Potential (MW)	Installed Capacity (MW)
1. Andhra Pradesh	578	380.75
2. Bihar	619	43.3
3. Chhattisgarh	236	219.9
4. Gujarat	1,221	30.5
5. Haryana	1,333	45.3
6. Jharkhand	90	0.0
7. Karnataka	1,131	491.38
8. Kerala	1,044	0.0
9. Maharashtra	1,887	756.9
10. Madhya Pradesh	1,364	16
11. Odisha	246	20.0
12. Punjab	3,172	124.5
13. Rajasthan	1,039	91.3
14. Tamil Nadu	1,070	538.7
15. Uttarakhand	24	10.0
16. Uttar Pradesh	1,617	776.5
17. West Bengal	396	26.0
18. Total	17,067	3,601.03

Source : Ministry of New and Renewable Energy, Data Portal of India (Displayed in State of Renewable Energy in India, A Citizen's Report (2014) Centre for Science and Environment, New Delhi, p. 182.)

There have been very few studies undertaken to estimate the potential for cogeneration in India. However, some surveys conducted in different industries have revealed some interesting facts. For example, nearly 30 per cent of the electricity used in the pulp and paper industry is cogenerated with steam production in paper mills. In fertilizer industry, almost all the energy requirements of the ammonia and urea plants are met with steam generated through high pressure waste heat-boilers. According to a survey of 300 industrial units, conducted by Tata Energy Research Institute (TERI) in 1993, there exists a cogeneration potential of 7,574 MW in the country (*see* **Table 24.25**) Further, TERI has estimated that cogeneration in India will increase to 61,621 MW in the year 2021.

TABLE 24.25. Cogeneration Potential Estimates by TERI

Industry	Potential	Per cent
Alumia	59	0.8
Caustic soda	394	5.2
Cement	78	1.0
Cotton textile	506	6.7
Iron & steel	362	4.8
Man-made fibre	144	1.9
Paper	594	7.8
Refineries	232	3.1
Sugar	5,131	67.7
Sulfuric Acid	74	1.0
Total	**7,574**	**100**

Source : Planning for the Indian Power Sector (1995), TERI, p. 117.

It is clear from the table that over two-thirds of the cogeneration potential is accounted for by sugar industry alone. Bagasse based cogeneration programme, launched in January 1994, envisaged creation of 300 MW power generation capacity during the Eighth Plan. According to a report from the Central Statistics Office, 5,000 MW power can be obtained from bagasse based cogneration. The Tata Energy Research Institution has estimated the cogeneration power potential based on bagasse at 5,100 MW. The programme is targeted at around 420 existing and around 90 new sugar mills. Already ten mills have commissioned co-generation projects having total exploitable power to the tune of 29 MW. This brings out the extent of untapped potential. As of January 2014, the installed capacity of bagasse base cogeneration was 2,513 MW. The potential is also significant in paper and textile industries. Considering the gains from cogeneration, the Government of India is giving several incentives for its development.

Small Hydropower

There is no globally accepted definition of a small hydropower plant (SHP) because different countries use different capacity limits for defining

SHP. For example developed countries have a range of 1.5 to 2.0 MW for defining SHP whereas in developing countries this limit varies from 25 to 50 MW. The capacity limit for SHP is 50 MW in China, 30 MW in Brazil, 20 MW in Australia and European Union, 10 MW in Norway, 5 MW in UK and only 1.5 MW in Sweden. In India, however, hydropower projects with a capacity upto 25 MW are considered as SHP. Interestingly, in India, hydropower plants with a capacity of less than 25 MW are considered renewable power source; there is no justification available why hydropower plants with more than 25 MW are not considered renewable.

Generation of electricity from small sized hydropower sources is a low cost, environment friendly and renewable source of energy. Small and mini hydel projects have the potential to provide energy in remote and hilly areas where extension of grid system is un-economical. Although SHPs have become very popular and an important source of hydropower in India, this is one of the oldest form of harnessing power in the country. The first SHP of 130 KW was installed at Darjeeling in 1897. This was followed by SHP of 2 MW at Mysore in 1902, 3 MW plant at Mussoorie in 1907 and 1.75 MW plant at Chaba and 50 MW plant at Jubbal (Near Shima) in 1930. Some of the plants are still working and contributing to hydropower generation of the country.

MNRE has estimated the potential of SHP at about 19,750 MW in 6474 sites spread all over the country. Arunachal Pradesh, Chhattisgarh, Himachal Pradesh, Jammu and Kashmir, Karnataka and Uttarakhand have maximum potential. As of January 2014, the installed capacity of SHP was 3474.15 MW and the projects of another 1076 MW were under different stages of implementation (**Fig. 24.15**).

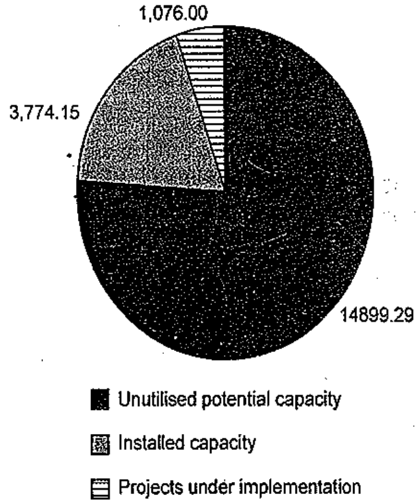

FIG. 24.15. India : Small Hydro Plants SHPs (2014)

The total installed capacity in India increased from 1,905 MW in 2006 to 3,456 MW in 2012. Similarly, the number of projects increased from 573 in 2006 to 939 in 2012 (**Fig. 24.16**).

A brief description of state-wise potential and installed capacity is given below.

Himachal Pradesh. This state has a potential of 2,398 MW in 531 sites. However, only a quarter has been utilised till March 2013.

Karnataka. Karnataka has the highest untapped potential of 3,177 MW in the country. This high potential is spread over 694 sites in different parts of the state. Sixty five projects worth 201 MW are currently under implementation. Keeping in view the environmental impact of SHPs, Karnataka Renewable Energy Policy (KREP) permits these project with less

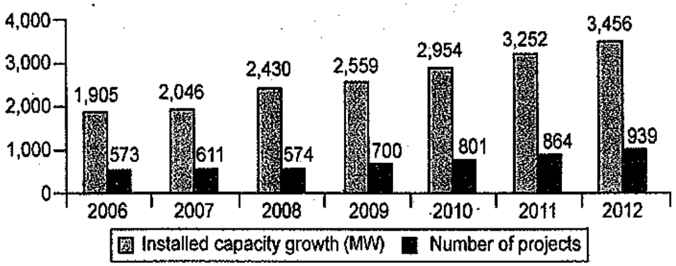

FIG. 24.16. Growth in SHP installed capacity and number of projects 2006 to 2012

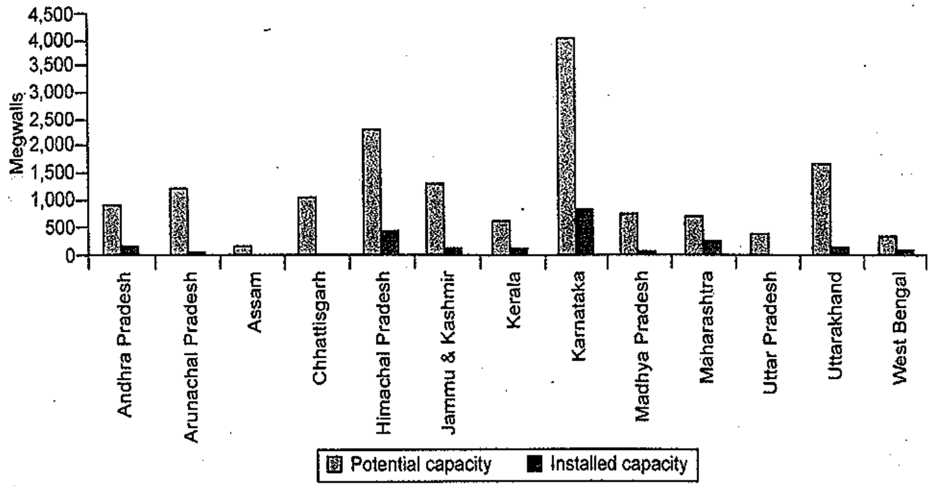

FIG. 24.17. Major states with potential and install capacity of SHP

Source **:** Ministry of new and renewable energy annual report 2012-13.

than 5 MW only in the Western Ghats/forest areas. KREP policy 2009-14 further says, "Mini-hydro project proposals which do not involve diversion water flow resulting in drying up the stream/river stretch will be considered for development.

Uttarakhand. This state has huge SHP untapped potential of 1,500 MW. The renewable energy policy of the state released in 2008 aimed to achieve 1,000 MW electricity form renewable sources of which 600 MW were to be achieved through SHP.

Jammu and Kashmir. This state has a potential of 1,500 MW of SHP but has developed only 150 MW. Jammu and Kashmir released a "Policy for Development of Micro/Mini-Hydro Power Projects" in 2011 which governs the establishment of SHPs.

Chhattisgarh. Chhattisgarh has an untapped potential of 1,100 MW but has an installed capacity of only 27 MW. This state has taken many steps to promote non-conventional energy in different forms.

Arunachal Pradesh. This state has 1,300 MW of SHP potential but only 100 MW has been tapped so far. Arunachal Pradesh released its SHP policy on January 24, 2008 which aimed at encouraging private operators. Projects are allocated on Build Own Operate Transfer (BOOT) basis for a period of 50 years. Till December, 2012, out of the 1,483 unelectrified villages in the state, only 425 have been electrified through SHP.

The other states with reasonable potential and SHP development are Andhra Pradesh, Assam, Kerala, Madhya Pradesh, Maharashtra, Uttar Pradesh and West Bengal (**Fig. 24.17**).

Geothermal Energy

There are vast possibilities of developing and exploiting geothermal energy in India. About 340 hot spring localities have been identified; many of them have temperature nearing boiling point. Extensive surveys are being conducted to develop geothermal energy for direct heat and power generation. Assessment of Geothermal energy potential of selected sites in Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Jharkhand and Chhattisgarh has been/is being undertaken. A five kW geothermal pilot power plant has been commissioned at Manikaran in Kullu district of Himachal Pradesh. A potential of 4-5 MW geo-thermal power has been estimated in Puga Valley of Ladakh in J&K. Plan to exploit this potential has been finalised. Sanction for installation of a geothermal power plant at Tattapani geothermal fields in Chhattisgarh has been granted. A project on mushroom cultivation and poultry farming using geothermal power is under implementation at Regional Research Laboratory, Jorhat.

Tidal Energy

It is estimated that India possesses 8,000-9,000 MW of tidal energy potential. The Gulf of Khambhat is the best suited area with about 7,000 MW potential of tidal energy. This is followed by Gulf of Kachchh (1,000 MW) and Sunderbans (100 MW). A 900 MW tidal power plant is proposed to be set up in the Gulf of Kachchh.

Wave Energy

Wave energy potential in India is estimated at about 40,000 MW. Coastal areas can get special benefit from this energy. One wave energy power plant of 150 kW (maximum) has been installed at Vzhinjam near Thiruvananthapuram. Another one MW wave energy plant has been set up in the Andaman and Nicobar Islands.

Ocean Thermal Energy Conversion

India's ocean thermal energy is estimated at 50,000 MW. The first ever plant for ocean thermal energy conversion with a capacity of 100 MW is proposed to be set up off the coast of Tamil Nadu.

Energy from Waste

Generation of waste is inevitable in many human activities. In nature, a balance is maintained as the waste generated by animals and human beings serve as nourishment for the plant life. So long as this natural cycle is maintained, the question of pollution due to waste does not arise. However, with increasing industrialisation, urbanisation and changes in the pattern of life, which are inevitable in any process of economic growth, waste causes damage to environment unless it is very carefully managed. According to 2011 census figures, nearly 377 million people live in urban areas and generate 110,000 – 150,000 tonnes per day (TPD) of municipal solid waste (MSW). In 2012 the Ministry of New and Renewal Energy (MNRE) estimated 4,000 MW of potential. However, not much headway has been made due to environmental issues and financial constraints. Power potential of some of the large cities generating more than one thousand tonnes per day (TPD) of MSW is given in **Table 24.26**.

Energy Crisis

India is passing through a critical phase of energy crisis as demand for energy has always outpaced its supply. Demand for energy is increasing at an accelerated rate due to rapid increase in population, industrialization, urbanization and unprecedented increase in means of transport. Rise in living standard of the common man has further complicated the matter. The prevailing scenario of energy crisis is reflected in frequent power failures, declared and undeclared power cuts, low and fluctuating voltage and closure of power plants in different parts of the country. Most the power plants are working at below the installed capacity due to short supply of fuels like coal and gas and mismanagement of the production process. Large scale electric thefts and inefficient distribution system are other causes of energy crisis.

Peak demand, peak demand met and storage of energy are depicted in **table 24.27**. It shows that we are suffering from energy shortage varying from 11 to 15 per cent which is quite high considering our plans for rapid economic growth.

According to the Twelfth Plan projections, total domestic energy production will read 669.6 million tonne oil equivalent (MTOE) by 2016-17 and 844 MTOE by 2021-22. This will meet around 71 per cent and 69 per cent of expected energy consumption with the balance to be met from imports of oil and coal putting heavy strain on our meager foreign exchange sources.

Our per capita energy consumption is very low at 998 kWh as compared to 1378 kWh in China, 1934 kWh in Brazil, 6231 kWh in UK, 7,816 kWh in Japan and 13,066 kWh in U.S.A. Energy crisis is likely to deepen as the per capita energy consumption will increase with the rise in living standard of the masses.

The only way out to solve the problem of energy crisis is to increase production and conserve energy.

TABLE 24.26. Energy from Waste

City	MSW generated (TPD)	Calorific Value (MJ/kg)	Power Potential (MW)
1. Greater Kolkata	11,520	5.0	129.2
2. Greater Mumbai	11,124	7.5	186.6
3. Delhi	11,040	7.5	186.8
4. Chennai	6,118	10.9	149.0
5. Greater Hyderabad	4,923	8.2	91.0
6. Greater Bengaluru	3,344	10.0	74.9
7. Pune	2,602	10.6	61.8
8. Ahmedabad	2,518	4.9	27.9
9. Kanpur	1,756	4.1	25.9
10. Surat	1,734	6.6	16.1
11. Kochi	1,366	2.5	7.6
12. Jaipur	1,362	3.5	10.7
13. Coimbatore	1,253	10.0	28.0
14. Greater Vishakhapatnam	1,194	6.7	18.0
15. Ludhiana	1,115	10.7	26.8
16. Agra	1,021	2.2	5.0

Source: R.K. Annepu, Sustainable solid waste management in India, Columbia University, New York, January, 2012.

TABLE 24.27. Power demand-supply gap (Figures in MW)

Year	Peak Demand	Peak demand met	Shortage (%)
2001	65,628	74,872	12
2002	69,189	78,441	12
2003	71,547	81,492	11
2004	75,066	84,574	12
2005	77,836	88,667	12
2006	81,370	92,968	12.5
2014	19,625	2,25,633	15.0

Source: Planning Commission.

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CHAPTER 25

Manufacturing Industries

Manufacturing is the processing of primary products into more refined and usable products. Many of the natural resources cannot be utilised directly without processing. It is because of this reason that we manufacture cloth from cotton, sugar from sugarcane, paper from wood pulp, and petro-chemicals from mineral oil. By doing so, we make the primary products more valuable and usable. In other words, *manufacturing means transformation of natural material endowments into commodities of utility by processing, assembling and repairing.*

Manufacturing is vital for our very existence. It is an activity that works as an *engine of economic growth,* helps in removing poverty, and unemployment and transforms a traditional society into a modern society. The economic strength of a country is judged by the development of its industries. All the developed countries of the world are highly industrialised.

HISTORICAL PERSPECTIVE OF INDIAN INDUSTRIES

Early Times

History of Industry in India dates back to the history of mankind. India's handicrafts manufactured in village huts and houses all over the country were prized in foreign countries. Working on the locally available raw materials and with the skills and tools handed over to them by their forefathers, the village artisans produced products of high aesthetic quality with ease and efficiency. Generations of such workers provided India with a long and glorious tradition of artistic handicrafts of a varied nature. Among all the industries of early times, the textiles, especially the cotton textile industry, had the place of pride both in India and in the outside world. There is enough evidence to show that the Indians knew weaving some 1,500 years before Christ, when the Europeans were still covering themselves with animal skins. Pyrard, the 17th century Portuguese writer has recorded that every one from the Cape of Good Hope to China was clothed from head to foot in Indian made garments. The fine Dhaka muslin was the envy of the world for centuries together. Iron and Steel industry was also in advanced stage at that time. The iron column near Qutab Minar in Delhi is standing in the open and is exposed to sun, rain and weathering over 1,500 years, and it still looks fresh. It seems that this column will continue to stand there till eternity. This rare monument is a testimony to the forging and fabricating ingenuity of ancient India. It is believed that the famous Damascus swords were made from steel imported from India. In addition to cotton textiles and steel industries; wood, stone and ivory carvings, silk textiles, pottery, bronze, brass, silver and copper works, dyeing and calico printing were also famous throughout the world.

Industrial Revolution in Europe resulted in modern factories. With this the scale of manufacturing goods increased tremendously leading to mechanisation. As a result migration of workers occurred from villages to cities. The barter system of goods with goods came to an end, exchange of goods with money started. It is correct that a revolution occurred in the manufacturing sphere but the traditional village handicrafts and cottage industries witnessed their death toll. Thousands of artisans were rendered jobless as their manufactures could not compete with the fine and low cost goods manufactured in modern industries. A near chaos prevailed in villages. Goldsmiths, blacksmiths and weavers began to starve. Thus, modern industry eroded the strong traditional industrial base.

The Rise of Modern Industry

The decline of the traditional industry and the rise of the modern industry in India were neither simultaneous nor casually connected. The beginning of modern large scale industry in India dates back to 1830 when the first charcoal fired iron making was attempted in Tamil Nadu. However, this venture collapsed in 1866. Therefore, the real beginning of the modern industry in India is recognised with the establishment of cotton textile industry at Mumbai in 1854. This industry grew tremendously in 1870s due to a spurt in demand in the wake of the American Civil War. By 1875-76, the number of cotton textile mills rose to 47. The first jute mill was set up at Rishra near Kolkata in 1855. Since the geographical conditions were very much favourable for jute industry in the Hugli basin, this industry flourished well and there were 64 mills in 1913-14, providing employment to over two lakh persons. Among the other industries which appeared on the industrial scene of India before the outbreak of World War I in 1914 were woollen textiles, paper and breweries. The main industrial centres were port cities of Mumbai, Kolkata and Chennai. This pattern of industrial location was conceived by the British rulers to facilitate imports and exports. The sole inland industrial centre of any consequence was Kanpur, the base of military equipment production.

Inter War Period. Indian industries made rapid strides during the First World War (1914-18) due to rise in demand for industrial goods by the Armed Forces. However, the real spurt was provided by the Indian Fiscal Commission set up in 1921-22. This gave the much needed protection to industries like iron and steel, textiles, cement, sugar, paper and metals. One of the most prominent feature of Indian industrial scene during this period was the dispersal of cotton textile industry away from Mumbai. In 1875-76, 61.7 per cent of cotton textile mills were located in Mumbai and by 1938-39 only 17.5% per cent of the mills remained in Mumbai. In fact this industry gained a lot as a result of war. On the eve of the war, India had emerged as the fourth largest cotton manufacturing country next to the USA, the U.K. and Japan in that order. Jute industry on the other hand, continued to concentrate in the Hugli basin only. However, the number of jute mills rose from 64 in 1913-14 to 107 in 1938-39.

World War II. While Indian industry prospered during World War I, the Second World War created problems for Indian industry. India became an active participant in war and the entry of Japan in the hostilities brought war to India's doorstep. However, the impact of war was shortlived and the industry was quick to recover from the initial shock and exploited the opportunities offered by the war. A programme costing ₹4 crore for the manufacture of armaments and explosives was launched in 1941 to meet the immediate requirements of war. The ordinance factories started producing 700 varieties of ammunition. There were pressing demands to meet the civilian requirements too. With this object in view, heavy chemical industry was started in 1941 and the production of sulphuric acid, synthetic ammonia, caustic soda, chlorine and bleaching powder commenced. The Hindustan Aircraft Company, also assembled its first aircraft in 1941. Metal fabricating industries such as copper were also initiated. A wide variety of engineering industries like machine tools, machinery manufacture in respect of cotton, tea, and oil processing industries, electrical equipment, vanaspati manufacturing, power, alcohol,

TABLE 25.1. Industrial Growth in India (1937 = 100)

Year	General	Cotton Textile	Jute Textile	Steel	Chemicals	Sugar	Cement	Paper
1939	105.4	104.3	90.3	108.0	84.4	88.7	124.8	121.0
1945	120.0	120.0	84.4	142.9	134.1	85.5	196.6	196.5

Source : M.R. Kulkarni, Industrial Development (2013), p. 136.

synthetic resin and plastic industries also flourished. However, some other industries including diesel engines, pumps, sewing machines and electric fans suffered a setback. By and large, the performance of individual industries varied considerably as is indicated in the **Table 25.1**.

It is clear from the table that the overall performance of industry was satisfactory. Steel, chemicals, cement and paper industries recorded impressive gains. Cotton textile industry also showed considerable improvement. However, jute and sugar industries suffered decline.

Post World War II Period and Partition. The post war period was characterised by many ups and downs and by the overall decline in industrial products. Several factors contributed to this state of affairs, the most prominent among them being fall in demand, overworked machinery, labour trouble and bottlenecks of transport and distributions till 1946. Cotton textiles, sugar, cement and steel industries were the worst sufferers. Partition of the country in 1947 threw everything out of gear and dealt a severe blow to industry in India. While Pakistan accounted for only 23 per cent of the area and 18 per cent of the population of pre-partition India, that country got 40 per cent of the cotton and 81 per cent of the jute output. Obviously, jute and cotton industries were the worst sufferers. Further India suffered losses in terms of markets as well as skilled labour that migrated to Pakistan. However, India retained most of the basic and important industries. (**Table 25.2**).

TABLE 25.2. Consequences of Partition (1947)

Item	Share in percentage	
	India	Pakistan
Area	77	23
Population	82	18
Industrial Establishments	91	9
Mineral Production	97	3
Jute output	19	81
Cotton Mills	96	4
Cotton output	60	40
Railway mileage	83	17

Source : M.R. Kulkarni, Industries Development (1998), p. 126.

The situation improved in 1948 following three year truce on labour front, tax concessions and active state help by setting up the Industrial Finance Corporation. The industrial policy of 1948 indicated the direction of industrial development in India.

Industrial Development in the Planning Era

Immediately after independence, need to take solid steps for improving industrial scene was badly felt. It was realised that industrialisation was the only vehicle which could lead the shattered economy of the country on the path of progress and prosperity. Consequently, industry attracted special attention of plans and planners.

The First Five Year Plan (1951-56). This plan became operational only four years after Independence. The main thrust of the plan was on agriculture because the country was facing shortage of foodgrains at that time. Therefore, the emphasis was on increasing capacity of existing industries rather than starting new ones. Cotton textile, sugar, vanaspati, cement, paper, chemical and engineering industries showed some progress. Some of the new industries that emerged during this plan were newsprint, power looms, medicines, paints and varnishes and transport equipment. In spite of the top priority given to agriculture, irrigation and power generation in the first five year plan, industrial production showed 40 per cent increase as compared to 30 per cent increase recorded by grain production. As a matter of fact, the First Five Year Plan laid down the basis for future progress of industri

The Second Five Year Plan (1956-61). This plan laid emphasis on the development of basic and heavy industries and defined the key-role which the public sector was to play in the economic development of the country. A comprehensive Industrial Policy Resolution was announced on 20th April 1956. This resolution had industrial development as major thrust. Iron and steel, heavy engineering, lignite projects and fertilizer industries formed the basis of industrial planning. In addition to the expansion of pre-existing steel plants at Jamshedpur, Kulti-Burnpur and Bhadravati, three new state owned plants at Durgapur, Rourkela and Bhilai were either initiated or completed. The Chittaranjan Locomotive Workshop, The Hindustan Shipbuilding Yard (Vishakhapatnam), The Sindri Fertilizer Factory and the Hindustan Machine Tools Limited (HMT) plant at Bangalore were expanded. A heavy electrical equipment manufacturing plant was established at Bhopal. Two new fertilizer plants at Nangal and Rourkela were set up.

The Third Five Year Plan (1961-66). This plan laid stress on the expansion of basic industries like steel, chemicals, fuel, power and machine building. The basic philosophy behind this plan was to lay foundation for a 'self-generating' economy. The Hindustan Machine Tools Limited had only one factory in the Second Plan and this number rose to five in the Third Plan. Heavy Machine Tools plant at Ranchi was also completed. Machine building, locomotive and railway coach making, shipbuilding, aircraft manufacturing, chemical, drugs and fertilizers industries also made significant achievement.

However, the achievement fell short of the target to a great extent due to the following reasons :

(*i*) Untimely monsoon rains, severe drought in 1965 and bad weather conditions.

(*ii*) India's war with China in 1962 and with Pakistan in 1965.

(*iii*) Non-availability of foreign credit.

(*iv*) Inability of rigid administrative rules to cope with such abnormal situations.

The Annual Plans (1966-69)

The Fourth Five Year Plan was deferred and Annual plans were adopted for a period of three years (1966-69). Not much headway was made due to resource crunch. The index of industrial production increased only by 1.7 per cent and 0.3 per cent in 1966-67 and 1967-68 respectively. However, things improved in 1968-69 and the industrial production rose by 7 per cent.

The Fourth Five-Year Plan (1969-74). Indian Economy started recovering from recession at the beginning of the Fourth Five Year Plan. But the growth rate showed wide yearly fluctuations from peak of 7.3 per cent in 1969-70 to zero growth in 1973-74 as against the stipulated annual growth rate of 8-10 per cent. Agro-based industries such as sugar, cotton, jute, vanaspati showed uneven growth due to shortage of raw materials and difficult power situation. Metal-based industries and chemical industries also suffered setbacks. However, a significant progress was reported by some other industries like alloys and special steels, aluminium, automobile tyres, petroleum refining, electronic goods, machine tools, tractors and heavy electrical equipment. Public sector undertakings also showed good progress. Efforts were made to accentuate the process of industrial dispersal through regional and local planning process.

The Fifth Five Year Plan (1974-79). The main emphasis of this plan was on rapid growth of core sector industries and increase the production of export oriented articles and articles of mass consumption. The average annual rate of growth was 8.21 per cent. The public sector had assumed much importance. Steel plants at Salem, Vijaynagar and Vishakhapatnam were proposed to create additional capacity. Steel Authority of India (SAIL) was constituted. Drug manufacturing, oil refining, chemical fertilizers and heavy engineering industry made good progress.

The Sixth Five Year Plan (1980-85). This plan marked a watershed in the development process which was initiated three decades ago with the commencement of the first plan. Although considerable growth was achieved during the earlier five plans, much thought could not be given to quality, cost competitiveness or needs of modernisation. Thus high cost, low quality production structure had emerged. The period 1950-80 marked the first phase of industrialisation. The second phase started with the commencement of the Sixth Five Year Plan. It was felt that large domestic and foreign market remained to be exploited for industrial growth. This was possible only if our industries were efficient, globally competitive, cost effective and modernised. For this purpose liberalisation was initiated. The average annual growth rate was 5.5 per cent which fell short of the initial target of 8 per cent.

Targets of capacity creation had been achieved for industries like aluminium, zinc, lead, thermoplastics, petro-chemicals, electrical equipment, automobiles and consumer durables. Production targets were achieved in industries like petroleum, machine tools, automobiles, T.V. receivers, etc. Shortfall in production was reported for coal, steel, cement, non-ferrous metals, drugs and pharmaceuticals, textiles, jute manufacture, commercial vehicles, railway wagons, sugar, etc.

Seventh Five Year Plan (1985-1990). This plan registered an annual growth rate of 8.5 per cent as against the target of 8.7 per cent. The plan aimed at developing a 'high tech' and electronics industrial service base. Industrial dispersal, self employment, improving the exploitation of the local resources, proper training were the main planks of the plan.

Annual Plans (1990-91 and 1991-92)

Eighth five year plan (1990-95) could not take off due to fast-changing political situation at the centre. The new Government which assumed power at the Centre in June, 1991, decided that the Eighth Five-year Plan would commence on 1 April 1992 and that 1990-91 and 1991-92 should be treated as separate Annual Plans. The impact of liberalisation was felt on industries, along with other sectors of economy.

Eighth Five Year Plan (1992-97). The major policy changes initiated in the industrial sector in 1991 included removal of entry barriers, reduction of areas reserved exclusively for public sector, rationalisation of approach towards monopolistic and restrictive practices, liberalization of foreign investment policy and import policy, removing regional imbalances and encouraging the growth of employment intensive small and tiny sector. The period immediately following the reforms was marked by low growth rates and even stagnations in the major industrial sectors. However, the growth quickly recovered and the index of industrial production increased by 6 per cent. The general annual growth rate in major sectors of industry was 12 per cent in 1995-96.

Ninth Five Year Plan (1997-2002). Industrial growth improved marginally to 6.6 per cent in 1997-98 but fell to 4.1 per cent in 1998-99. This decline was probably caused by poor performance in mining and manufacturing sectors. The overall industrial output grew by 6.7 per cent in 1999-2000, which again fell to 4.9 per cent in 2000-01 mainly due to fall in manufacturing sector. The growth rate of consumer goods including durables and non-durables accelerated to 7.9 per cent during 2000-01. The growth rate of basic goods, capital goods and intermediate goods declined drastically and it was estimated at 3.8 per cent, 1.4 per cent and 4.5 per cent respectively during the year 2000-01. Six core and infrastructure industries, *viz.*, electricity, crude oil, refinery, coal, steel and cement, having a weightage of 26.7 per cent in the average Index of Industrial Production (IIP) grew by 5.3 in 2000-01 compared to 9.1 per cent in 1999-2000. The main factors responsible for slowdown of industrial growth during the year 2000-01 were lack of domestic demand for immediate goods, low inventory demand for capital goods, high oil prices, existence of excess capacity in some sectors, business cycle, inherent adjustment lacks in industrial restructuring and calamity like Gujarat earthquake, and high interest rate with an adverse impact on private investment, and slow down in the world economy.

Tenth Five Year Plan (2002-07). This plan targeted a Gross Domestic Product (GDP) growth rate of eight per cent and the growth target for industrial sector had been set at ten per cent. Indian Industry, especially the manufacturing sector, was recording a consistently high growth rate which showed robustness of Indian Industry, particularly automobile/auto components and pharmaceutical sub-sectors.

For sustaining pace of growth and investment, several initiatives had been launched for modernising, technology upgradation, reducing transaction costs, increased export thrust, so as to enhance its global competitiveness and achieve balanced regional development. Further, in order to give export thrust, Department of Commerce had launched major initiatives such as Assistances to States for Infrastructure Development for Exports (ASIDE)

TABLE 25.3. Index of Industrial Production (IIP) Growth Rates (Base : 2004-05)

Group/Year	2007-08	2008-09	2009-10	2010-11	2011-12
Mining and Quarrying	4.6	2.6	7.9	5.2	–2.0
Manufacturing	18.4	2.5	4.8	8.9	3.0
Electricity	6.3	2.7	6.1	5.5	8.2
General Index	15.5	2.5	5.3	8.2	2.9
Use Based Classification					
Basic good	8.9	1.7	4.7	6.0	5.5
Capital goods	48.5	11.3	1.0	14.8	–4.0
Intermediate goods	7.3	0.0	6.0	7.4	–0.6
Consumer goods	17.6	0.9	7.7	8.5	4.4
(*i*) Consumer Durables	33.1	11.1	17	14.2	2.6
(*ii*) Consumer Non-Durables	10.2	–5.0	1.4	4.2	5.9

Source : India 2014 : A Reference Annual, p. 472.

Market Access Initiatives (MAI), Special Economic Zones (SEZs) Policy, Modernisation of Director General of Foreign Trade (DGFT), etc. For a balanced industrial development, industrial policy packages had been announced for special category states of Uttarakhand, Himachal Pradesh, Jammu and Kashmir and North East states. Social scarcity issues had been addressed through insurance cover for workers in handloom, agro and rural industrial and processed marine product sector. Textile industry is a major employment intensive sector for which special schemes/packages were introduced. Technology Upgrading Funds Scheme (TUFS) was one such scheme which was expected to improve the access for decentralized powerloom sector. Textile Center Infrastructure Development Scheme (TCIDS) was to take care of infrastructure development aspect of textile industry.

Manufacturing sector had a share of 79.36 per cent in the Index of Industrial Production (IIP). During the year 2002-03, the IIP grew at the rate of 5.8 per cent as compared to 2.1 per cent in 2001-02. Manufacturing sector registered a growth rate of 6.0 per cent as against 2.8 per cent during 2001-02. As per the use-based classification, production of basic foods, capital goods, intermediate goods and consumer goods exhibited higher increase during 2002-03 as compared to 2001-02.

Eleventh Five Year Plan (2007-12). A new series of Index of Industrial Production (IIP) with 2004-05 as its base was adopted which covered the broad sectors of industry, *viz.*, mining, manufacturing and electricity. The IIP was also categorized by Use Based Classification. **Table 25.3** shows the sectoral and use-based growth during the 11th Five Year Plan.

This table makes it clear that industrial growth measured in terms of IIP register a robust growth of 15.5 per cent in 2007-08. Thereafter, the global economic crisis led to a severe reduction in growth rate to 2.5 per cent in 2008-09. However, the industrial sector showed a quick recovery from the global showdown and registered growth rates and 5.3 per cent and 8.2 per cent respectively in 2009-10 and 2010-11. But the growth rate again fell to 2.9 in 2011-12. This decelaration of growth has been registered across almost all sectors of industry and was primarily caused by negative growth of 2.0 per cent in mining and quarrying.

Similarly use based industries also suffered a lot due to global economic crisis in 2008-09 but made some recovery in the subsequent years.

FACTORS INFLUENCING THE LOCATION OF INDUSTRIES

Many important geographical factors involved in the location of individual industries are of relative significance, *e.g.*, availability of raw materials, power resources, water, labour, markets and the transport facilities. But besides such purely geographical

factors influencing industrial location, there are factors of historical, human, political and economic nature which are now tending to surpass the force of geographical advantages. Consequently, the factors influencing the location of industry can be divided into two broad categories *i.e.*

(I) Geographical factors, and
(II) Non-geographical factors.

I. Geographical Factors

Following are the important geographical factors influencing the location of industries.

1. Raw Materials. The significance of raw materials in manufacturing industry is so fundamental that it needs no emphasising. Indeed, the location of industrial enterprises is sometimes determined simply by location of the raw materials. Modern industry is so complex that a wide range of raw materials is necessary for its growth. Further we should bear in mind that finished product of one industry may well be the raw material of another. For example, pig iron, produced by smelting industry, serves as the raw material for steel making industry. Industries which use heavy and bulky raw materials in their primary stage in large quantities are usually located near the supply of the raw materials. It is true in the case of raw materials which lose weight in the process of manufacture or which cannot bear high transport cost or cannot be transported over long distances because of their perishable nature. This has been recognised since 1909 when **Alfred Weber** published his theory of location of industry. The jute mills in West Bengal, sugar mills in Uttar Pradesh, cotton textile mills in Maharashtra and Gujarat are concentrated close to the sources of raw materials for this very reason. Industries like iron and steel, which use very large quantities of coal and iron ore, losing lot of weight in the process of manufacture, are generally located near the sources of coal and iron ore.

Some of the industries, like watch and electronics industries, use very wide range of light raw materials and the attractive influence of each separate material diminishes. The result is that such industries are often located with no reference to raw materials and are sometimes referred to as *'footloose industries'* because a wide range of locations is possible within an area of sufficient population density.

2. Power. Regular supply of power is a pre-requisite for the localisation of industries. Coal, mineral oil and hydro-electricity are the three important conventional sources of power. Most of the industries tend to concentrate at the source of power. The iron and steel industry which mainly depends on large quantities of coking coal as source of power are frequently tied to coal fields. Others like the electro-metallurgical and electro-chemical industries, which are great users of cheap hydro-electric power, are generally found in the areas of hydro-power production, for instance, aluminium industry.

As petroleum can be easily piped and electricity can be transmitted over long distances by wires, it is possible to disperse the industry over a larger area. Industries moved to southern states only when hydro-power could be developed in these coal-deficient areas. Thus, more than all other factors affecting the location of large and heavy industries, quite often they are established at a point which has the best economic advantage in obtaining power and raw materials. Tata Iron and Steel Plant at Jamshedpur, the new aluminium producing units at Korba (Chhattisgarh) and Renukoot (Uttar Pradesh), the copper smelting plant at Khetri (Rajasthan) and the fertilizer factory at Nangal (Punjab) are near the sources of power and raw material deposits, although other factors have also played their role.

3. Labour. No one can deny that the prior existence of a labour force is attractive to industry unless there are strong reasons to the contrary. Labour supply is important in two respects (*a*) workers in large numbers are often required; (*b*) people with skill or technical expertise are needed. **Estall and Buchanan** showed in 1961 that labour costs can vary between 62 per cent in clothing and related industries to 29 per cent in the chemical industry; in the fabricated metal products industries they work out at 43 per cent.

In our country, modern industry still requires a large number of workers in spite of increasing mechanisation. There is no problem in securing unskilled labour by locating such industries in large urban centres. Although, the location of any industrial unit is determined after a careful balancing of all relevant factors, yet the light consumer goods and agro-based industries generally require a plentiful of labour supply.

4. Transport. Transport by land or water is necessary for the assembly of raw materials and for the marketing of the finished products. The development of railways in India, connecting the port towns with their hinterlands determined the location of many industries around Kolkata, Mumbai and Chennai. As industrial development also furthers the improvement of transport facilities, it is difficult to estimate how much a particular industry owes to original transport facilities available in a particular area.

5. Market. The entire process of manufacturing is useless until the finished goods reach the market. Nearness to market is essential for quick disposal of manufactured goods. It helps in reducing the transport cost and enables the consumer to get things at cheaper rates. It is becoming more and more true that industries are seeking locations as near as possible to their markets; it has been remarked that market attractions are now so great that a market location is being increasingly regarded as the normal one, and that a location elsewhere needs very strong justification. Ready market is most essential for perishable and heavy commodities. Sometimes, there is a considerable material increase in weight, bulk or fragility during the process of manufacture and in such cases industry tends to be market oriented.

6. Water. Water is another important requirement for industries. Many industries are established near rivers, canals and lakes, because of this reason. Iron and steel industry, textile industries and chemical industries require large quantities of water, for their proper functioning. Significance of water in industry is evident from **Table 25.4.** Also it requires 36,400 litres of water to produce one kwh of thermal electricity. Further, it is worth noting that water used in industries often gets polluted and is therefore not available for any other purpose.

TABLE 25.4. Requirement of Water in Industry

Name of the industry	Amount of water required in litres/tonne
Steel	300,000
Sulphite paper	290,000
Oil refining	25,600
Rayon	1,000,000
Paper from wood	173,000

Source : H.R. Jarrett, A Geography of Manufacturing (1977).

7. Site. Site requirements for industrial development are of considerable significance. Sites, generally, should be flat and well served by adequate transport facilities. Large areas are required to build factories. Now, there is a tendency to set up industries in rural areas because the cost of land has shot up in urban centres.

8. Climate. Climate plays an important role in the establishment of industries at a place. Harsh climate is not much suitable for the establishment of industries. There can be no industrial development in extremely hot, humid, dry or cold climate. The extreme type of climate of north-west India hinders the development of industries. In contrast to this, the moderate climate of west coastal area is quite congenial to the development of industries. Because of this reason, about 24 per cent of India's modern industries and 30 per cent of India's industrial labour is concentrated in Maharashtra-Gujarat region alone. Cotton textile industry requires humid climate because thread breaks in dry climate. Consequently, majority of cotton textile mills are concentrated in Maharashtra and Gujarat. Artificial humidifiers are used in dry areas these days, but it increases the cost of production.

II. Non-Geographical Factors

Now-a-days alternative raw materials are also being used because of modern scientific and technological developments. Availability of electric power supply over wider areas and the increasing mobility of labour have reduced the influence of geographical factors on the location of industries. The non-geographical factors are those including economic, political, historical and social factors. These factors influence our modern industries to a great extent. Following are some of the important non-geographical factors influencing the location of industries.

1. Capital. Modern industries are capital-intensive and require huge investments. Capital is usually available in urban centres. Big cities like Mumbai, Kolkata, Delhi, Chennai are big industrial centres, because the required capital is available in these cities.

2. Government Policies. Government activity in planning the future distribution of industries, for reducing regional disparities, elimination of pollution of air and water and for avoiding their heavy clustering in big cities, has become no less an important locational factor. There is an increasing trend to set up all types of industries in an area, where they derive common advantage of water and power and supply to each other the products they turn out. The latest example in our country is the establishment of a large number of industrial estates all over India even in the small-scale industrial sector.

It is of relevance to examine the influence of India's Five Year plans on industrial location in the country. The emergence of suitable industries in south India around new nuclei of public sector plants and their dispersal to backward potential areas has taken place due to Government policies.

The state policy of industrial location has a greater hand in the establishment of a number of fertiliser factories, iron and steel plants, engineering works and machine tool factories including railway, shipping, aircraft and defence installations and oil refineries in various parts in the new planning era in free India. We may conclude by noting that the traditional explanation of a location of industry at a geographically favourable point is no longer true. Location of oil refinery at Mathura, coach factory at Kapurthala and fertiliser plant at Jagdishpur are some of the results of government policies.

3. Industrial Inertia. Industries tend to develop at the place of their original establishment, though the original cause may have disappeared. This phenomenon is referred to as inertia, sometimes as *geographical inertia* and sometimes *industrial inertia.* The lock industry at Aligarh is such an example.

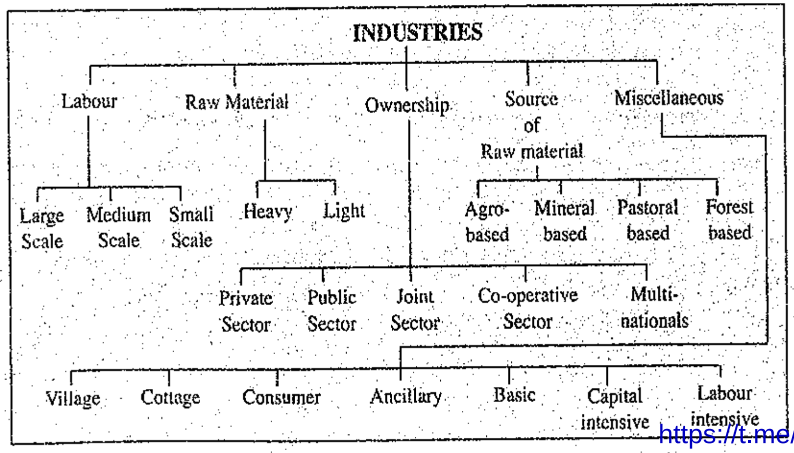
4. Efficient Organisation. Efficient and enterprising organisation and management is essential for running modern industry successfully. Bad management, sometimes squanders away the capital and puts the industry in financial trouble leading to industrial ruin. Bad management does not handle the labour force efficiently and tactfully, resulting in labour unrest. It is detrimental to the interest of the industry. Strikes and lock-outs lead to the closure of industries. Hence, there is an imperative need of effective management and organisation to run the industries.

5. Banking Facilities. Establishment of industries involves daily exchange of crores of rupees which is possible through banking facilities only. So the area with better banking facilities are better suited to the establishment of industries.

6. Insurance. There is a constant fear of damage to man, machines and materials in industries for which insurance facilities are badly needed.

CLASSIFICATION OF INDUSTRIES

Industries can be classified into several groups. The following table gives an understanding about them.



I. On the Basis of Strength of Labour

1. Large Scale Industry. Industries which employ a large number of labourers in each unit are called large-scale industries. Cotton and jute textile industries are large scale industries.

2. Medium Scale Industries. The industries which employ neither very large nor very small number of labourers are put in the category of medium scale industries. Cycle industry, radio and television industries are some examples of medium scale industries

3. Small Scale Industries. Industries which are owned and run by individuals and which employ a small number of labourers are called small scale industries.

II. On the Basis of Raw-Material and Finished Goods

Industries classified on the basis of raw materials and finished goods are :

1. Heavy Industries. Industries which use heavy and bulky raw-materials and produce products of the same category are called *heavy* industries. Iron and steel industry presents a good example of heavy industries.

2. Light Industries. The light industries use light raw-materials and produce light finished products. Electric fans, sewing machines are light industries.

III. On the basis of Ownership

Since the start of the planned development of Indian economy in 1951, industries are divided in the following four classes :

1. Private Sector Industries. Industries owned by individuals or firms such as Bajaj Auto or TISCO situated at Jamshedpur are called private sector industries.

2. Public Sector Industries. Industries owned by the State and its agencies like Bharat Heavy Electricals Ltd., or Bhilai Steel Plant or Durgapur Steel Plant are public sector industries.

3. Joint Sector Industries. Industries owned jointly by the private firms and the state or its agencies such as Gujarat Alkalies Ltd., or Oil India Ltd. fall in the group of joint sector industries.

4. Co-operative Sector Industries. Industries owned and run co-operatively by a group of people who are generally producers of raw materials of the given industry such as a sugar mill owned and run by farmers are called co-operative sector industries.

IV. On the Basis of Source of Raw Material

On the basis of source of raw materials, industries are classified as under :

1. Agro Based Industries. Agro based industries are those industries which obtain raw-material from agriculture. Cotton textile, jute textile, sugar and vegetable oil are representative industries of agro-based group of industries

2. Mineral Based Industries. The industries that receive raw materials primarily from minerals such as iron and steel, aluminium and cement industries fall in this category.

3. Pastoral-Based Industries. These industries depend upon animals for their raw material. Hides, skins, bones, horns, shoes, dairy, etc. are some of the pastoral-based industries.

4. Forest Based Industries. Paper card-board, lac, rayon, resin, tanning of leather, leave-utensils, basket industries are included in this type of industries.

V. Miscellaneous Industries

Industries are also classified into the following miscellaneous categories.

1. Village Industries. Village industries are located in villages and primarily cater to the needs of the rural people. They usually employ local machinery such as oil extraction, grain grinding and agricultural implements.

2. Cottage Industries. Industries which artisans set-up in their own houses, work with wood, cane, brass, stone, etc. are called cottage industries. Handloom, khadi and leather work at the artisans' house fall in this category.

3. Consumer Goods Industries. Consumer industries convert raw materials or primary products into commodities directly used by the people. Textiles, bakery products, sugar, etc. are some of the consumer goods industries.

4. Ancillary Industries. The industries which manufacture parts and components to be used by big industries for manufacturing heavy articles like trucks, buses, railway engines, tractors, etc. are called ancillary industries.

5. Basic Industries. Industries on which depend many other industries for their manufacturing processes are called basic industries. Iron and steel industry and power generating industry are included in this category.

6. Capital-Intensive Industries. Industries requiring huge investments are called capital-intensive industries. Iron and steel, cement and aluminium are outstanding examples of capital-intensive industries.

7. Labour-Intensive Industries. Industries which require huge labour force for running them are called labour-intensive industries. In these industries, labour is more important than capital. Shoe-making and bidi-manufacturing, etc. are included in these industries.

TEXTILE INDUSTRIES

Textile is a broad term which includes cotton, jute, wool, silk and synthetic fibre textiles. The textile sector occupies an important place in terms of employment generation. The sectors like handloom, handicrafts, powerloom, and readymade garments are specially known for their employment potential. Textile industries contribute about 12 per cent industrial production, 4 per cent to the GDP and provides employment to about 45 million persons which includes a substantial number of SC/ST and women. The contribution of the industry to the gross export earnings of the country is 11 per cent while adding only 2 to 3 per cent to the gross import bills of the country. It is the only industry which is self-reliant from raw material to the highest value added products, *viz.*, garments/made ups. Currently India is the third largest producer of cotton, second largest producer of silk, fifth largest producer of synthetic fibres and has the largest loomage and ring spindles in the world.

COTTON TEXTILE INDUSTRY

Growth and Development

India held world monopoly in the manufacturing of cotton textiles for about 3,000 years from about B.C. 1500 to A.D. 1500. In the middle ages, Indian cotton textile products were in great demand in the Eastern and European markets. The muslins of Dhaka, chintzes of Masulipatnam, calicos of Calicut, baftas of Cambay and gold-wrought cotton piece goods of Burhanpur, Surat and Vadodara acquired a worldwide celebrity by virtue of their quality and design. This industry could not survive in the face of strong competition from the modern mill industry of Britain which provided cheap and better goods as a result of Industrial Revolution in that country. Moreover, the British textile industry enjoyed political advantage at that time.

The first modern cotton textile mill was set up in 1818 at Fort Glaster near Kolkata. But this mill could not survive and had to be closed down. The first successful modern cotton textile mill was established at Mumbai in 1854 by a local Parsi entrepreneur **C.N. Dewar**. Shahpur mill in 1861 and Calico mill in 1863 at Ahmedabad were other landmarks in the development of Indian cotton textile industry. The real expansion of cotton textile industry took place in 1870's. By 1875-76 the number of mills rose to 47 of which over 60 per cent were located in Mumbai city alone. The industry continued to progress till the outbreak of the First World War in 1914. The total number of mills reached 271 providing employment to about 2.6 lakh persons. The First World War, the Swadeshi Movement and the grant of fiscal protection favoured the growth of this industry at a rapid pace. Demand for cloth during the Second World War led to further progress of the industry. Consequently, the number of mills increased from 334 in 1926 to 389 in 1939 and 417 in 1945. Production of cloth also increased from 4,012 million yards in 1939-40 to 4,726 million yards in 1945-46.

The industry suffered a serious setback in 1947 when most of the long staple cotton growing areas went to Pakistan as a result of partition. However, most of the cotton mills remained in India. Under such circumstances, India faced a severe crisis of obtaining raw cotton. The country had, therefore, to resort to large-scale imports of long staple cotton which was an extremely difficult task in view of the limited foreign exchange reserves. The only solution to this problem was to increase production of long staple cotton within the country. This goal was achieved to a great extent in the post partition era.

Present Position

At present, cotton textile industry is the largest organised modern industry of India. There has been a phenomenal growth of this industry during the last five decades. About 16 per cent of the industrial capital, 14 per cent of indutrial production and over 20 per cent of the industrial labour of the country is engaged in this industry. The total employment in this industry is well over 25 million workers. There are at present 1,719 textile mills in the country, out of which 188 mills are in public sector, 147 in cooperative sector and 1,384 in private sector. About three-fourths are spinning mills and the remaining one-fourth composite mills. Apart from the mill sector, there are several thousand small factories comprising 5 to 10 looms. Some of them have just one loom. These are based on conventional handloom in the form of cottage industry and comprise decentralised sector of this industry. **Table 25.5** shows that the contribution of decentralised sector is much more than the organised sector. It has increased rapidly from a mere 19.31 per cent in 1950-51 to 58.96 per cent in 1980-81 and made a sudden jump to 87.95 per cent in 1990-91. It gradually improved during the first half of 1990s and stood at all time peak of 95.41 per cent in 2007-08 after which slight fall in this percentage has been observed (**Table 25.5**)

Production. Cotton cloth is produced in three different sectors *viz.* 1. Mills, 2. Power-looms and 3. Handlooms.

1. *Mills.* The mill sector played a dominant role in cotton textile industry at the initial stage. But its importance was reduced drastically with the growth of powerlooms and handlooms. The share of mill sector in cotton cloth production came down from 80.69 per cent in 1950-51 to only 5.64 per cent in 2011-12.

2. Powerloom Sector. The decentralized powerloom sector is one of the most important segments of the textiles industry in terms of fabric production and employment generation. India had nearly 5.28 lakh powerloom units with 23.33 lakh powerlooms as in March, 2011. However, the number of modern shuttleless looms is only 1.15 lakh which accounts for only 5 per cent of the total powerlooms in the country. This sector of textile industry provides direct/indirect employment to 57.29 lakh persons and contributes about 62 per cent to the total cloth production. The cloth output from this sector increased from 30.63 billion square metres in 2005-056 to 37.52 billion square meter in 2010-11. This sector produces almost all varieties of cloth including technical textiles. More than 60 per cent of the fabric meant for export is also sourced from powerlooms sector. The ready-made garments and home textile sectors are heavily dependent on this sector to meet their fabric requirements. The major powerloom clusters are at Bhiwandi, Erode, Salem, Madurai, Ichalkaranji, Solapur, Burchanpur, Bhilwara, Kishangarh, Ludhiana, Amritsar and Panipat. The Government is also developing four handloom clusters, *i.e.*, Bhiwandi, Erude, Bhilwara and Ichalkaranji. The Government has also set-up 44 Powerloom Service Centres in different clusters for solving the problems of the weavers and for improving the technology level, skill development, design development, etc. The main emphasis is on Technology Upgradation Fund Scheme (TUFS) which has given much needed impetus to this sector.

4. Handlooms. Handloom symbolizes rich heritage and ethos of vibrant Indian culture. Due to the uniqueness and exclusivity of designs, capability to produce small batch sizes and having eco-friendly fabric, handloom products are in the high demand both in the domestic and international markets. This sector has made significant progress in the recent past with respect to quantity, quality and variety of its products. With about 15 per cent share of handlooms in textile production and major contribution to export earnings, this sector provides employment to 43.31 lakh persons engaged on 23.77 handlooms across the country. The fabric production which was witnessing downward trend due to economic slowdown in 2008 made a quick recovery in the post-slowdown period, and the production increased from 6,667 million square metres in 2008-09 to 6,936 million square metres in 2012-13. The export of handloom fabric also staged a smart recovery in the same period. Five Indian Institutes of Handloom Technology (IIHTs) at Varanasi, Salem, Guwahati, Jodhpur and Bargarh and 25 Weavers' Service Centres (WSCs) across the country are working to impart technical knowledge to weavers.

TABLE 25.5. Progress of Cotton Textile Industry in India

Year	Spun yarn (by cotton textile mills) in million kg	Cotton Cloth (Million Sq. Metres)			
		Mill sector	Decentr-alised sector	Total	Percentage of decentralised sector to total
1950-51	533	3,401	814	4,215	19.31
1960-61	788	4,649	2,089	6,738	31.00
1970-71	929	4,055	3,547	7,602	46.66
1980-81	1,087	3,434	4,934	8,368	58.96
1990-91	1,510	1,859	13,572	15,431	87.95
2000-01	2,267	1,106	18,612	19,718	94.39
2005-06	2,521	1,192	22,681	23,873	95.01
2006-07	2,824	1,305	24,933	26,238	95.03
2007-08	2,948	1,249	25,947	27,196	95.41
2008-09	2,896	1,259	25,639	26,898	95.32
2009-10	3,079	1,465	27,449	28,914	94.93
2010-11	3,490	1,604	30,114	31,718	94.94
2011-12	3,126	1,724	28,846	30,570	94.36

Source: Data Computed from Economic Survey 2012-13, pp. A-32-33.

Locational Factors

Several factors, like availability of raw cotton, market, transport, etc. play a key role in the localisation of cotton textile industry. The significance of raw cotton is evident from the fact that 80 per cent of the industry is coterminous with the cotton growing tracts of the country. Some of the important centres such as Ahmedabad, Solapur, Nagpur, Coimbatore and Indore are located in the areas of large scale cotton cultivation. Mumbai is also not far away from the cotton producing areas of Maharashtra and Gujarat which have contributed a good deal in the localisation and growth of cotton textile industry here. It is equally important to note that cotton is a **pure raw material**, in the sense that it does not lose much of its weight in the process of manufacturing and the slight loss in weight is more than compensated by the use of sizing materials. There is not much of difference between the cost of transporting raw cotton and finished cloth. Both can be transported with equal ease and without adding much to the total cost of production. Hence, this industry normally tends to be located at such centres which have favourable transport facilities with respect to market. In other words, it is primarily a market oriented industry. With tropical and sub-tropical climate, all parts of India provide vast market potential for cotton textile industry. West Bengal, Bihar, Uttar Pradesh, Kerala and Odisha do not grow cotton and still have large number of big centres where cotton textile industry has flourished well. Thus although in earlier stages of industrialisation, cotton textile manufacturing was concentrated in Mumbai, it has witnessed great spatial spread and now covers almost the entire country. Since, it was a traditional cottage industry, cheap and skilled labour was readily available. The most notable feature of the distribution of the industry is that even within a state, the industry is localised within particular areas and regions, almost to the complete exclusion of others.

Dispersal of industry from the old nuclei started after 1921 with railway lines penetrating into the peninsular region. New centres like Coimbatore, Madurai, Bengaluru, Nagpur, Indore, Solapur and Vadodara were more favourably located in respect to raw material, market and labour than places of original locations. This industry also reached some places with some additional advantages, such as

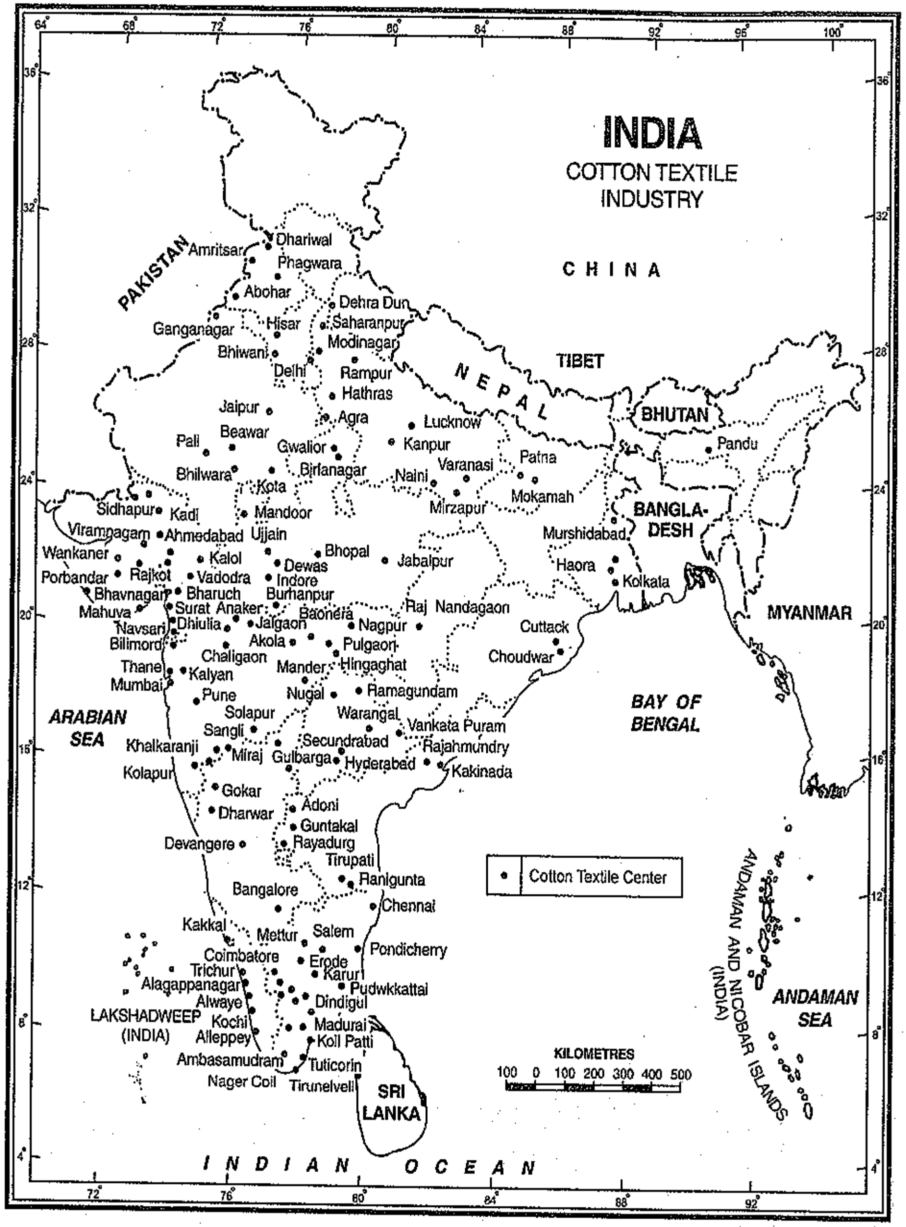


FIG. 25.1. India : Cotton Textile Industry

nearness to coal (Nagpur), financial facilities (Kanpur) and wide market with port facilities (Kolkata).

Dispersal of cotton textile industry was further boosted with the development of hydroelectricity. The growth of this industry in Coimbatore, Madurai and

Tirunelveli is largely due to the availability of hydroelectricity from Pykara dam. The industry also tended to shift from areas of high labour cost to those with low labour cost. The labour cost factor played a crucial role in establishing this industry at Madurai, Turunelveli, Coimbatore.

Distribution

Although cotton textile mills are located in over 80 towns and cities of India, yet its larger concentration is found in Maharashtra, Gujarat, West Bengal and Uttar Pradesh. **Figure 25.1** shows the spatial distribution of cotton textile industry in India.

Maharashtra. Maharashtra excels all other states in the development of cotton textile industry. It produces 39.38 per cent mill cloth and 10.79 per cent yarn of India. About three lakh workers are engaged in this industry in Maharashtra. Mumbai is the largest centre in India having 63 mills out of Maharashtra's total of 122 mills. Mumbai is rightly called the ***Cottonopolis*** of India. Following are the main reasons of phenomenal growth of cotton textile industry in and around Mumbai.

(*i*) Mumbai enjoys humid climate which is helpful for this industry because thread does not break so frequently.

(*ii*) Mumbai is a very important port which helps in import of machinery and long staple cotton and export of cloth.

(*iii*) Cheap hydro-electricity is readily available from the nearby areas.

(*iv*) The black-cotton soil in the hinterland of Mumbai provides cotton as the basic raw material.

(*v*) Cheap labour can be drawn from the surrounding areas.

(*vi*) There is ready market for Mumbai products both in India and abroad.

(*vii*) Mumbai is well-connected by a network of roads and railways which help in easy transportation of raw material and finished goods.

(*viii*) Facilities for washing and dyeing also exist here.

(*ix*) There is no dearth of capital inputs.

(*x*) Mumbai has the advantage of an early start.

Apart from Mumbai, Solapur, Pune, Kolhapur, Satara, Wardha, Nagpur, Aurangabad, Amravati, Akola, Sangli, Chaligaon, Miraz, Mander, Jalgaon, etc. are other centres of cotton textile industry in Maharashtra.

Gujarat. Gujarat is the second largest producer of cotton textiles. This state accounts for over 33 per cent of the mill cloth and over 8 per cent of the yarn production of the country. Ahmedabad is the largest centre where 73 out of 118 mills of Gujarat are located. Ahmedabad is the second largest centre of cotton textile industry after Mumbai. Following facilities are available to Ahmedabad :

(*i*) Ahmedabad lies near the main cotton belt of India and there is no problem of obtaining raw cotton.

(*ii*) Climate is humid and is suited to this industry.

(*iii*) Cheap power is readily available.

(*iv*) Cheap and skilled labour is drawn from the nearby areas.

(*v*) Ahmedabad is served by a network of railways and roadways.

(*vi*) Land at Ahmedabad is much cheaper as compared to that in Mumbai.

(*vii*) Most of Ahmedabad mills produce cheap cloth which finds a ready market among the poor masses of India.

The other important centres of Gujarat are Vadodara, Bharuch, Surat, Rajkot, Porbandar, Maurvi, Bhavnagar, Viramgam, Sidhpur, Kelot, Kadi, etc.

Madhya Pradesh. Cotton is locally grown. Coal provides necessary energy. Abundant cheap labour is available due to backward economy of the masses. Gwalior, Ujjain, Indore, Dewas, Ratlam, Jabalpur, Bhopal, etc. are important centres.

Tamil Nadu. Among the southern states, Tamil Nadu is an important cotton textile producer. Although Tamil Nadu produces only about 6 per cent of the mill cloth of India, the state excels all other states in the production of yarn and accounts for over 44% of the total yarn production of the country. Coimbatore is the most important centre having 200 mills out of Tamil Nadu's 439 mills and is known as ***Manchester of South India***. But Tamil Nadu's mills are of smaller size and give comparatively less production. Other important centres are Chennai (10 mills), Madurai, Tirunelveli, Tirucchchirappalli, Salem, Perambur, Tuticorin, etc.

West Bengal. *Kolkata is the most important* centre of West Bengal. It enjoys facilities of a port, humid climate, coal from Raniganj, local labour due to high density of population and those of dyeing and washing. But Kolkata suffers from the disadvantage of being away from the main cotton-producing areas of India. The other important centres are Haora, Murshidabad, Hugli, Sirampur, Shiampur and Panihar.

Uttar Pradesh. Most of cotton textile industry has developed in the western part of Uttar Pradesh. Kanpur is the largest centre and is known as ***Manchester of Uttar Pradesh***. This city has 10 out of 52 cotton textile mills of the state. Other important centres are Moradabad, Varanasi, Agra, Bareilly, Aligarh, Modinagar, Saharanpur, Rampur, Etawah, Lucknow, Mirzapur, etc.

Other producers are detailed as below:

Andhra Pradesh. Guntur, East Godavari and Udayagiri.

Kerala. Thiruvananthapuram, Alleppey, Kollam, Trichur, Alwaye.

Bihar. Gaya, Patna, Bhagalpur

Rajasthan. Pali, Beawar, Vijayanagar, Kishangarh, Ganganagar, Bhilwara, Udaipur, Jaipur, Kota, Ajmer.

Punjab. Amritsar, Ludhiana, Phagwara.

Haryana. Bhiwani, Hissar, Rohtak.

Karnataka. Bangalore, Belgaum, Mangalore, Chitradurga, Devangera, Gulbarga, Chennapatnam, Mysore.

Telangana. Hyderabad, Secunderabad.

Problems of Cotton Textile Industry

Although cotton textile is one of the most important industries of India, it suffers from many problems. Some of the burning problems are briefly described as under :

1. Scarcity of Raw Cotton. Indian cotton textile industry suffered a lot as a result of partition because most of the long staple cotton growing areas went to Pakistan. Although much headway has been made to improve the production of raw cotton, its supply has always fallen short of the demand. Consequently, much of the long staple cotton requirements are met by resorting to imports.

2. Obsolete Machinery. Most of the textile mills are old with obsolete machinery. This results in low productivity and inferior quality. In the developed countries, the textile machinery installed even 10-15 years ago has become outdated and obsolete, whereas in India about 60-75 per cent machinery is 25-30 years old. Only 18-20 per cent of the looms in India are automatic whereas percentage of such looms ranges from cent per cent in Hong Kong and the USA. to 99 per cent in Canada, 92 per cent in Sweden, 83 per cent in Norway, 76 per cent in Denmark, 70 per cent in Australia, 60 per cent in Pakistan and 45 per cent in China.

3. Erratic Power Supply. Power supply to most cotton textile mills is erratic and inadequate which adversely affects the production.

4. Low Productivity of Labour. Labour productivity in India is extremely low as compared to some of the advanced countries. On an average a worker in India handles about 2 looms as compared to 30 looms in Japan and 60 looms in the USA. If the productivity of an American worker is taken as 100, the corresponding figure is 51 for U.K. 33 for Japan and only 13 for India.

5. Strikes. Labour strikes are common in the industrial sector but cotton textile industry suffers a lot due to frequent strikes by a labour force. The long drawn strike in 1980 dealt a severe below to the organised sector. It took almost 23 years for the Government to realise this and introduce legislation for encouraging the organised sector.

6. Stiff Competition. Indian cotton mill industry has to face stiff competition from powerloom and handloom sector, synthetic fibres and from products of other countries.

7. Sick Mills. The above factors acting singly or in association with one another have resulted in many sick mills. As many as 177 mills have been declared as sick mills. The National Textile Corporation set up in 1968 has been striving to avoid sick mills and has taken over the administration of 125 sick mills. What is alarming is 483 mills have already been closed.

TABLE 25.6. Mega Cluster

Handlooms (4 Mega Cluster)	Handicrafts (5 Mega Clusters)	Powerloom (3 Mega clusters)
1. Varanasi (U.P.)	5. Moradabad (U.P.)	10. Bhiwandi (Maharashtra)
2. Sivasagar (Assam)	6. Nasarpur (Andhra Pradesh)	11. Erode (Tamil Nadu)
3. Murshidabad (West Bengal)	7. Bhdohi-Mirzapur (U.P.)	12. Bhilwara (Rajasthan)
4. Virudhnagar (Tamil Nadu)	8. Srinagar (Jammu & Kashmir)	
	9. Jodhpur (Rajasthan)	

Source : India 2012, A Reference Annual, p. 715.

Technical Textiles

Technical textiles are materials and products used for their technical performance and functional properties. These products are used in different fields such as aerospace, shipping, sports, agriculture, defence, medicine/health, manufacturing, etc. This sector of textile industry has huge potential and a bright future. The global size of technical textiles was about $ 136 billion and is growing at an average annual rate of 3.5 per cent. Domestic market for these textiles was ₹ 70,151 crore in 2012-13 and is growing at an average annual rate of 11 per cent. The Government of India launched an ambitious scheme known as Scheme for Growth and Development of Technical Textiles (SGDTT) during 2007-08 to exploit the vast potential of Technical Textiles.

Mega Cluster

The schemes for mega cluster support weavers/artisans, both in and outside the cooperative fold, including those in Self Help Groups (SHGs), Non-Governmental Organizations (NGOs) etc. The schemes provide for development of all the facets of selected clusters like raw material support, design inputs, upgradation of technology, infrastructure development, marketing support, welfare of weavers etc. At present, following 12 centres are being developed as Mega Cluster (**Table 25.6**).

Exports. India is a major exporter of cotton textiles. Cotton yarn, cloth and ready-made garments form important items of Indian exports. Indian garments are well known throughout the world for their quality and design and are readily accepted in the world of fashion. **Table 25.7** shows the export trends of cotton textile products from India. It is clear that export of ready-made garments has increased tremendously since 1960-61. In 2013-14, more than 62 per cent of the total export of cotton textiles consisted of ready-made garments.

India's textiles including handlooms and handicrafts are exported to more than hundred countries. However, the USA and the European Union account for about two-thirds of India's textile exports. The other major textile destinations are China, U.A.E. Sri Lanka, Saudi Arabia, Republic of Korea, Bangladesh, Turkey, Pakistan, Brazil, Hong-Kong, Canada and Egypt.

JUTE TEXTILES

This is the second important textile industry of India after cotton textile industry. This industry occupies a significant place in our economy and is one of the major industries in the eastern region, particularly in West Bengal. Jute the *golden fibre* meets all the standards of safe packaging in view of being a natural, renewable, biodegradable and

TABLE 25.7. Value of Cotton Textile Exports (₹ Crore)

Year	1960-61	1970-71	1980-81	1990-91	2000-01	2010-11	2003-04	2012-13	2013-14
Cotton Yarn, Fabrics, made ups, etc.	65	142	408	2,100	16,030	13,160	21,624	40,947	53,914
Readymade Garments	1	29	550	4,012	25,478	52,861	65,613	70,343	90,402
Total	**66**	**171**	**958**	**6,112**	**41,508**	**66,021**	**87,237**	**1,11,290**	**1,44,316**

Source : The Economic Survey 2013-14, Statistical Appendix, pp. 75-77.

eco-friendly product. Globally, India is the largest producer of jute goods and this sector supports livelihood of about 40 lakh farm families and provides direct and indirect employment to 4 lakh workers.

Many of the sick and inefficient mills had to be closed down due to shortage of raw material. A relentless campaign to increase the production of raw jute by increasing area under jute cultivation in the Brahmaputra valley, West Bengal, Tarai and in East coastal areas and by increasing yield per hectare eased the situation to a great extent. The production of raw jute increased from 33 lakh bales (of 180 kg each) in 1950-51 to 108 lakh bales in 2013-14.

At present there are 83 composite jute mills in the country out of which 64 are in West Bengal, 7 in Andhra Pradesh, 3 each n Bihar and Uttar Pradesh, 2 each in Assam and Chhattisgarh and one each in Odisha and Tripura. As on January, 2012, total number of looms stood at 49,529 considing of 21,122 hessian looms, 26,663 sacking looms and 1,744 other looms.

Production and Distribution. Total production of jute goods in 2012-13 was 1,591.3 thousand metric tonnes which was 0.6 per cent higher than 1,582.4 thousand metric tonnes in 2011-12.

West Bengal has the largest concentration of jute industry. This state has 64 jute mills and 39,623 looms which respectively account for 81 per cent and 79 per cent of all India installation. Over 84 per cent of jute goods production of India comes from West Bengal. Andhra Pradesh is a distant second producing only 10 per cent of the Indian jute goods. Most of the mills are within a distance of 64 kilometres from Kolkata along the Hugli river. As a matter of fact, there is a narrow belt of jute mills which is 100 km long and 3 km wide along both the banks of Hugli river. Jute mills in the Hoogly region are much larger than mills in other parts of the country and give much higher production as compared to mills of other areas. Apart from Kolkata, the other important centres of jute textile industry are Titagarh (9 mills), Jagatdal (8 mills), Budge Budge (8 mills), Haora (8 mills), Bhadreswar (6 mills), Bally, Agarpara, Rishra, Serampara, Shibpur, Shyamnagar, Bansbaria, Kankinara, Uluberia, Naihati, Baidyahati and many others (**Fig. 25.2**).

Following few factors have been responsible for high concentration of jute mills in Hugli basin :

(*i*) The Ganga-Brahmaputra delta grows about over 73 per cent of India's jute and provides raw material to jute mills here.

(*ii*) Coal is obtained from Raniganj fields which are hardly 200 km away.

(*iii*) Cheap water transportation is available. The area is also served by a network of roads and railways (**Fig. 25.2**).

(*iv*) Abundant water is available for processing, washing and dyeing jute.

(*v*) Humid climate is very convenient for spinning and weaving.

(*vi*) Kolkata is a big port which helps in the import of machinery and spare parts and in the export of finished jute products.

(*vii*) High density of population in West Bengal and in the neighbouring parts of Jharkhand and Bihar provides abundant cheap labour. Some labour comes from Uttar Pradesh also.

(*viii*) Big capitalists are living in and around Kolkata which makes easy flow of capital in this industry.

(*ix*) Banking and insurance facilities are also available in and around Kolkata.

(*x*) The early arrival of British merchants under the aegis of East India Company in Kolkata helped in setting up this industry here. So Kolkata enjoys the advantage of an early start.

Andhra Pradesh has 7 mills located at Guntur, Vishakhapatnam, Nelimarla, Chillivelsa, Eluru, Ongole, and Chitvalshah.

Bihar has 3 mills at Katihar, Darbhanga and Samastipur.

Uttar Pradesh also has three mills which are located at Kanpur, Shahjawan (near Gorakhpur).

Assam has two mills. The main centre is at Gauripur.

Chhattisgarh also has two mills. The main centre is at Raigarh.

Odisha has only mill is at Cuttack. Tripura's sole mill is of new origin.

Problems of Indian Jute Industry

Indian jute industry is facing some very serious problems. Some of these are briefly described as under:

1. Most of the jute-producing areas went to Bangladesh (erstwhile East Pakistan) resulting in acute shortage of raw jute. Although successful efforts have been made to increase the supply of raw jute since Independence, it still falls short of our current requirements.

2. Most of our customers could not get our jute products during World War II as a result of which

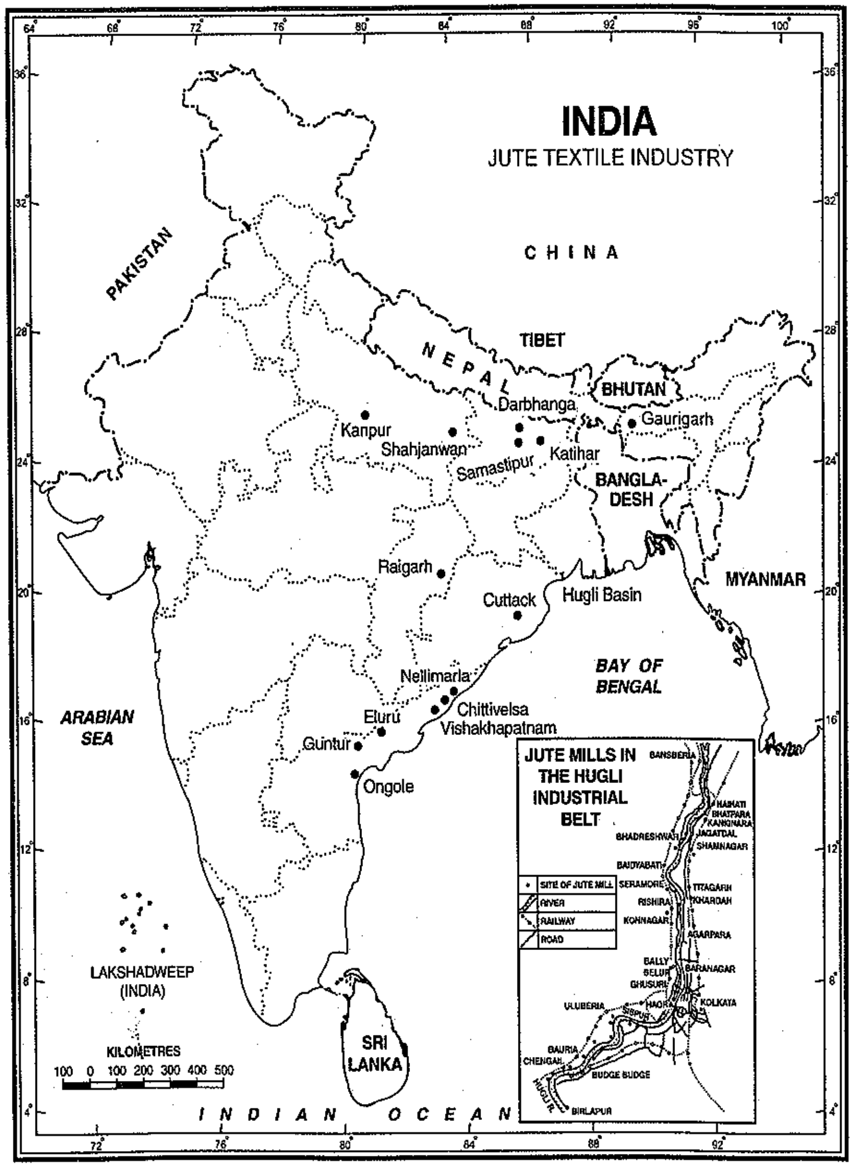


FIG. 25.2. India : Jute Textile Industry

TABLE 25.8. Exports of Jute Products

Year	1960-61	1970-71	1980-81	1990-91	2000-01	2010-11	2011-12	2012-13	2013-14
Quantity in thousand tonnes	790	560	660	220	—	—	—	—	—
Value in ₹ crore	135	190	330	298	932	2,092	2,226	2,124	2,296

Source : Economic Survey 2013-14, Statistical Appendix pp. 75-77.

several countries developed many substitutes to jute. Even today, our jute industry has to face a very tough competition from synthetic packing materials of the advanced countries of Europe and North America. As such the market for jute goods has shrunk considerably.

3. The newly established mills and improved machines in Bangladesh are able to produce better quality goods at cheaper rates and have an edge over the Indian jute products in the international markets.

4. The overall demand for jute products is gradually decreasing in the international market.

5. The input cost for jute products in India is quite high.

In order to solve the above-mentioned problems, we have to increase the production of raw jute in India for which new areas are to be brought under jute cultivation. There is also an urgent need for replacing the old and obsolete machinery in order to compete quality wise. The National Jute Manufacturing Corporation has undertaken the modernisation of its units. Attempts are being made to diversify the product range, to improve the quality of goods, to reduce the cost and to develop new products.

Exports

It is traditionally an export oriented industry and its survival largely depends upon its export performance. The rise and fall of the industry is closely linked with demand for jute goods in the international and national market. India lost much of her market as a result of World War-II and owing to sharp rise in synthetic substitutes as packing materials. **Table 25.8** shows that there has been sharp decline in the quantity of jute goods exported by India from 660 thousand tonnes in 1980-81 to 220 thousand tonnes in 1990-91. The earnings from export of jute goods also declined from ₹ 330 crore to ₹ 298 crore during the same period. However, situation improved afterwards and earnings from export of jute goods increased to ₹ 2,092 crore in 2010-11 and further to ₹ 2,296 crore in 2013-14.

Some of the advanced countries are becoming conscious about the environmental degradation with the increasing use of non-biodegradable materials such as plastic bags for packing and are trying to discourage such a practice. This has once again turned the tide in favour of jute bags in some advanced countries and India's jute industry is poised for a big boost in the years to come. The main buyers of Indian jute products are the USA, Canada, Russia, UAR, Australia, U.K., Czech Republic, Slovakia, etc.

The Government on June 2, 2006, approved the implementation of the Jute Technology Mission (JTM) at an estimated cost of ₹ 355.56 crores. The mission has the following four mini-missions :

(*i*) Mini-mission I, implemented on November 9, 2006 is concerned with strengthening of Research and Development (R&D).

(*ii*) Mini-mission II, implemented on December 21, 2006 is concerned with Transfer of Technology.

(*iii*) Mini-mission III implemented on February 6, 2007 aims at Development of Marketing Infrastructure.

(*iv*) Mini-mission IV also implemented on February 6, 2007 is devoted to Modernisation/Upgradation of Technology of Jute Sector and initiation of activities for promotion of Jute Diversified Products.

WOOLLEN TEXTILES

Growth and Development

Woollen textile is one of the oldest industries of India. There is evidence to prove that Aryans inhabiting the Indus Valley knew the use of wool as far back as 5000 B.C. Woollen textiles were quite popular as cottage industry in India during the historical times. However, the modern woollen textile industry started with the establishment of 'Lal Imli' at Kanpur in 1876. It was followed by setting of woollen textile mills at Dhariwal (Punjab) in 1881, Mumbai in 1882 and Bengaluru in 1886. The industry could not make much headway till the Second World War. Rapid progress has been observed during the planning era. At present there are 621 big and small mills, 1,100 hosiery units and 155 yarn spinning units.

Distribution

The main concentration of woollen textile industry is found in Punjab, Maharashtra and Uttar Pradesh. These states account for about three-fourths of the total spindleage capacity. Gujarat, Karnataka, West Bengal and Jammu and Kashmir are next in order of importance.

Punjab. Punjab leads all other states in manufacturing woollen goods. There are currently 257 big and small mills and the state possesses about half of the total spindleage installed capacity. Dhariwal is the largest centre. The other centres are Amritsar, Ludhiana and Kharar. The industry enjoys the benefit of hydroelectricity from Bhakhra Nangal Dam and wool from Kashmir and Kumaon regions.

Maharashtra. Maharashtra is the second largest producer of woollen textiles. The state has 31 mills, most of which are located at Mumbai. Better quality woollens are manufactured from the imported wool. Being an important port, Mumbai facilitates the import of wool which mainly comes from Australia, Italy and U.K. Shoddy and inferior goods are manufactured from the indigenous wool.

Uttar Pradesh. Kanpur in Uttar Pradesh is the birth place of modern woollen textile industry in India and is the largest centre in the state. The other centres are Shahjahanpur, Mirzapur, Varanasi, Agra, Modinagar and Tanakpur. As many as 37 mills are engaged in manufacturing different varieties of woollen goods in the state.

Gujarat. Gujarat has 10 mills located at Jamnagar, Ahmedabad, Kalol and Vodadara. Jamnagar specializes in worsteds, blankets and shoddy goods. Inferior wool is obtained from Rajasthan and Kathiawar while superior wool is imported from abroad.

Others. ***Haryana*** has 160 small mills located mainly at Panipat, Faridabad, Gurgaon and Bahadurgarh. ***Rajasthan's*** 72 mills are scattered over Bikaner, Alwar, Bhilwara, Sikar, Jaipur and Nagaur. Pushkar and Ajmer have handloom units producing mainly coarse blankets. Bengaluru and Bellary are important centres of ***Karnataka.*** The north-eastern parts of the state produce large quantities of coarse wool which helps in establishing handloom industry. Superior wool is imported. Most of the woollen textile centres of ***West Bengal*** are concentrated in the Hugli basin especially in Kolkata and Haora. The state has 6 mills in all. Kolkata is famous for shoddy goods, blankets, serges and flannels. ***Jammu and Kashmir*** is an important producer of handloom and powerloom woollen goods. Kashmiri woollen products are prepared from fine quality wool which is locally available. They are very attractive and find ready market throughout the country. Srinagar has 2 large mills in public sector. Kulu in ***Himachal Pradesh*** is famous for shawls. In ***Tamil Nadu,*** Chennai and Salem are important centres.

Woollen Carpets and Felts (Namdahs)

It is primarily a cottage industry and flourishes in areas where cheap skilled labour is readily available. There are about 240 units engaged in manufacturing woollen carpets and felts. The important carpet producing centres are Mirzapur, Gopiganj, Shahjahanpur, Agra, Bhadohi, Kanpur and Khamana in **Uttar Pradesh**; Jaipur, Jodhpur, Bikaner and Deogarh in **Rajasthan**, Srinagar in **Jammu and Kashmir**; Amritsar in Punjab; Panipat in **Haryana**; Eluru and Warangal in **Andhra Pradesh**; Obra and Danapur in Bihar; Bengaluru, Mysore and Bellary in **Karnataka**; Chennai and Wallanghpet in **Tamil Nadu** and Gwalior in **Madhya Pradesh.** About 90 per cent of the total production is exported mainly to the USA, Britain, Canada and Australia.

Hosiery Goods

There are about 1,100 hosiery units manufacturing a variety of products like jerseys, sweaters, pullovers, shawls, cardigans, caps, socks, gloves, mufflers, etc. Over 90 per cent units are located in Punjab and Haryana. The rest are scattered over Uttar Pradesh, West Bengal, Delhi and Maharasthra. Ludhiana in Punjab is the largest centre of hosiery manufacturing in India.

Pashmina Wool Development Scheme. India produces in finest quality of pashmina wool which comes mainly from the Ladakh region of Jammu and Kashmir. This region has about 2.45 lakh pashmina goats which produce 40 to 50 tonnes of raw pashmina every year. To solve the problem of the pashmina goat rearing tribal people and to popularize this high quality wool in other non-traditional regions, the Government has taken up a pashmina development package in the 12th Five Year Plan (2012-17).

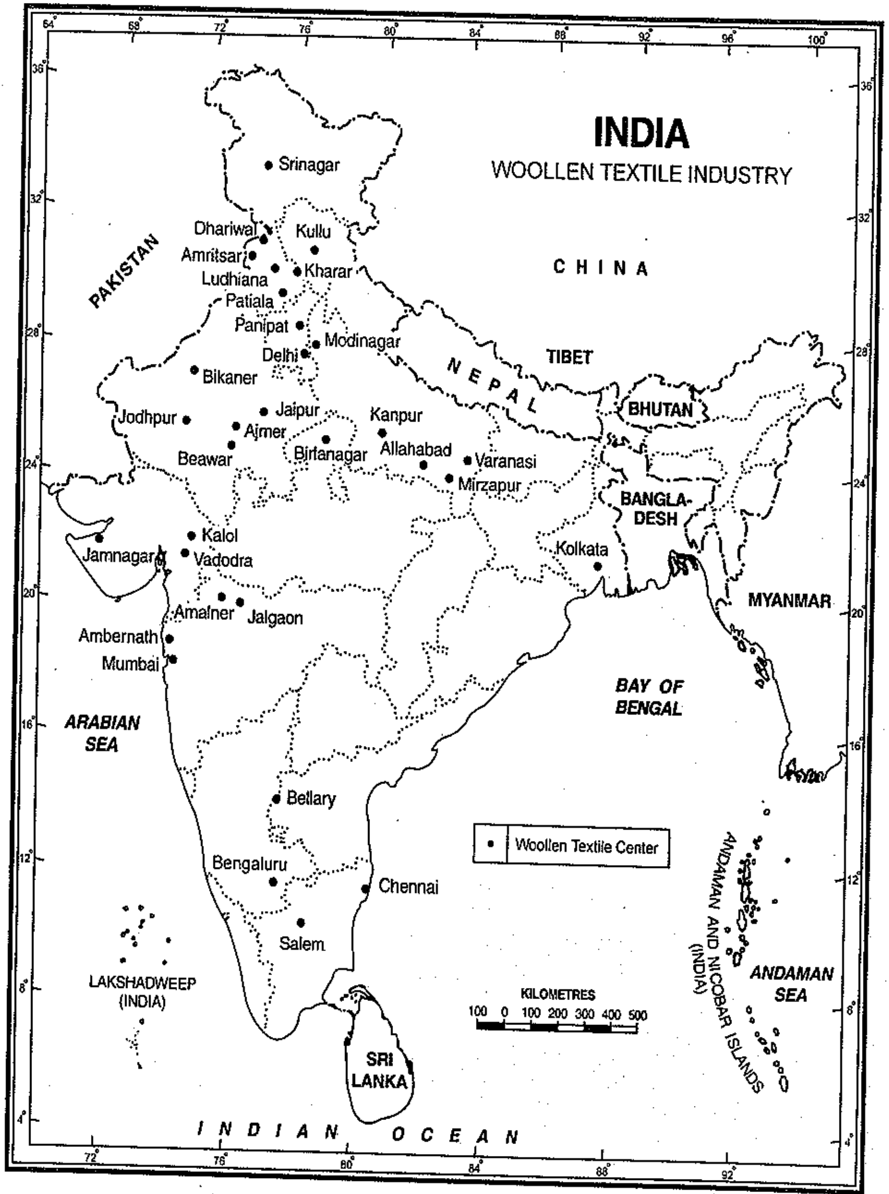


FIG. 25.3. India : Woollen Industry

Trade (Imports and Exports)

India does not produce quality raw wool in sufficient quantity and has to import large quantities of fine wool mainly from Australia. But India is an important exporter of woollen goods. The important items of export are woollen fabrics, hosiery and knitwear, druggets, carpets, shawls, blankets, *lohis*, *mandahs*, etc.

The USA., Russia, U.K., Canada, Australia, Germany, Denmark, Sweden, Chech Republic, Slovakia, France, Belgium, the Netherlands and some West Asian and African countries are the chief buyers of Indian woollen goods.

Problems of Woollen Textile Industry

1. Shortage of raw wool. As mentioned earlier, India does not produce sufficient quantity of fine quality raw wool. Also the productivity of Indian sheep is very low. On an average, an Indian sheep yields only 0.86 kg of wool per annum against 4.08 kg yielded by an Australian sheep. Large proportion of wool produced in India is of inferior quality and does not conform to international standards.

2. Lack of Market. Most parts of India have tropical and sub-tropical climate which restricts the demand for woollen clothes. The southern part of the country enjoys warm weather throughout the year and people do not require woollen clothes at all. Even in the northern parts of India, the winter season lasts only for four to five months in a year and it is only during this period that woollen clothes are required to some extent. The hot weather lasting for 7 to 8 months is the slack period during which production is carried out mainly for the Armed Forces and for export. For practical purposes, woollen textile industry is a seasonal phenomena in India.

3. Lack of Modern Equipment. Most of the equipment in woollen textile industry, like other textile industries, is obsolete and outdated as a result of which, its products are not able to cope with the everchanging designs and patterns, especially in the international market. There is an urgent need for mechanisation of the carpet industry keeping in view the rising demand to put a ban of the child labour. This will also help to increase the production and improve the quality.

4. Low Quality. Leaving aside a few exceptions, Indian woollen goods are considered to be of low quality in the international markets which results in lack of demand. Indian knitwear is often not shrink resistant, moth-proof and fast-coloured.

SILK INDUSTRY

India has been well-known for the production of silk since ancient times. Rulers of the medieval period encouraged this industry. India enjoys the distinction of being the only country producing all the five known commercial varieties of silk, *viz*., Mulberry, Tropical Tasar, Oak Tasar, Eri and Muga (of which golden yellow muga silk is unique to India). India's total silk production amounting to about 17 per cent of the world production, ranks India as the second largest producer of raw silk, next only to China. Sericulture is a labour intensive industry and provides employment to nearly 7.56 million persons mainly to weaker and marginalized sections of society. Indian silk industry has improved manifold since Independence from raw silk production level of 1,437 metric tonnes during the first Five Year Plan to 23,060 metric tonnes at the end of the 11th Five Year Plan. In the year 2012-13 India produced 18,755 metric tonnes of mulberry silk and 4,924 metric tonnes of non-mulberry silk which included 1,705 metric tonnes of tasar 3,100 metric tonnes of eri and 119 metric tonnes of muga silk. Thus it is clear that nearly 80 per cent of the country's total silk is mulberry silk which is produced mainly in the states of Karnataka, Andhra Pradesh, West Bengal, Tamil Nadu and Jammu and Kasmir. Tasar, eri and muga are collectively called ***vanya*** (wild) silk as these silks are mostly the products of the forests. These varieties are popular for their unique colour, lustre and are available in natural colours like golden brown, mauve, cream and beige. ***Tasar silk*** is largely produced in Jharkhand, Chhattisgrh, Madhya Pradesh, Bihar and parts of Odisha where it has great potential to enhance the livelihood of the tribal population. Idling women folk and unemployed youth are attracted towards tasar culture to a greater extent. The **oak tasar** culture is now practised in the sub-Himalayan states like Manipur, Himachal Pradesh, Uttar Pradesh, Assam, Meghalaya and Jammu and Kashmir. ***Eri silk*** ranks first among non-mulberry silk production and is produced mostly in hill tracks of the north-eastern states besides some parts of Bihar, West Bengal and Odisha.

Mugas silk, also known as golden silk is exclusively found in Assam and is widely distributed in the Brahmaputra valley.

Distribution

There are nearly 90 mills producing silk textiles. In addition, there are small and medium sized units also. It is also popular in the shape of handloom industry. About 98 per cent of the total production comes from Karnataka, West Bengal and Jammu and Kashmir.

Karnataka is the foremost silk producing state in India. It produces only mulberry silk and accounts for over 50 per cent of mulberry silk of the country. Mulberry trees grow over 8.5 thousand hectares. Mysore, Bengaluru, Kolar, Mandya, Tumkur, Belgaum and Kodagu districts are the main producers. About 50 per cent of India's silk cloth is also manufactured in this state. The main centres of silk cloth manufacturing are Bengaluru, Kolar, Mysore and Belgaum. ***West Bengal*** produces about 13 per cent of country's total silk, most of which is of mulberry variety. There are about five thousand handlooms mainly concentrated in Murshidabad, Bankura, 24 Parganas and Birbhum districts. ***Jammu and Kashmir*** has its main silk textile centres in Anantnag, Baramula, Jammu and Udhampur districts. Srinagar is a big centre for silk manufacturing where automatic machines are used for this purpose. ***Bihar*** is also an important producer. Patna, Gaya and Bhagalpur are the leading silk producing districts. In the neighbouring ***Jharkhand***, Ranchi, Palamu and Hazaribagh are important producers. ***Chhattisgarh*** produces about 2.6 per cent of India's silk, most of which comes from Bastar, Bilaspur and Surguja districts. The other areas of silk production are Mirzapur, Pratapgarh and Shahjahanpur in ***Uttar Pradesh***; Amritsar, Jalandhar, Ludhiana, Hoshiarpur and Gurdaspur in ***Punjab***; Goalpara, Kamrup and Nowgong in ***Assam***; Coimbatore, Tiruchirapalli, Dharmapur, Nilgiris, Salem, Thanjavur and Tirunelveli in ***Tamil Nadu***; Nagpur, Pune, Sangli, Chandrapur and Solapur in ***Maharashtra***; Ahmedabad, Surat, Bhavnagar, Porbandar in ***Gujarat***; Chittur, Kurnool, Vishakhapatnam and Anantpur in ***Andhra Pradesh***, Warangal, Adilabad and Karimnagar in ***Telangana*** and Balaghat in ***Madhya Pradesh***. ***Meghalaya, Manipur, Tripura and Himachal Pradesh*** also produce some quantity of silk.

Exports

The Indian silk is demanded in American, European as well as Asian markets. The USA, UK, Russia, Saudi Arabia, Kuwait and Singapore are the major importers of silk dress materials and scarves. The tough competition with Italy and Japan caused a setback to Indian silk industry. The synthetic fibres and the artificial silk being less expensive and easy to maintain, have been responsible for reducing the popularity of silk.

Man-Made Fibres

It is an important segment of textile industry. Man-made fibres have revolu-tionised the textile industry because they are in great demand due to their special qualities like strength, durability, dyeability and workability. Over and above, they are resistant to shrinkage.

Raw Materials. Man-made fibres are generally divided into two groups *viz*., cellulose (rayon and acetate) and non-cellulose (nylon, polyster, etc.) The basic raw material for producing viscose rayon yarn is the cellulose pulp derived from bamboo, eucalyptus and other soft wood trees. The chemicals used for making these fibres include caustic soda, sodium sulphate, sulphuric acid, carbon disulphide and soda sulphate. For acetate yarn and staple fibre, the primary raw materials are alcohol and cotton linters. The other materials are acetic acid, acetic acetone and ethyl acetate. For the production of synthetic fibres like nylon, polyester, acrylic, etc. we require caprolactum, naphtha, polyster chips, ethylene, glycole, etc.

Growth and Development

The man made fibre weaving units were started between 1925 and 1935 when the cost of pure silk fabrics became exorbitant. The powerlooms and handlooms had been using imported fibre till 1950 when a factory was established by Travancore Rayons Ltd. at Rayapuram in Kerala to manufacture synthetic fibre. This was followed by National Rayon Co. at Mumbai and the Sirsilk Ltd. at Hyderabad. By 1960, Century Rayon Ltd. at Kalyan (Maharashtra), the

Gwalior Rayon Silk Manufacturing Company at Nagda were also commissioned. Following units are making a significant contribution towards the manufacturing of synthetic fibres.

(*a*) Rayon Units. Kagaznagar (Telangana), Junagadh (Gujarat), Rayapuram (Kerala), Udhna (Gujarat), Birlagram (H.P.), Nagda (M.P.), Kalyan, Pimpri-Pune and Goregaon (Maharashtra), Kota (Rajasthan), Mettupalayam (Tamil Nadu), Kanpur (U.P.) and Tribeni (W. Bengal).

(*b*) Nylon Filament Yarn Units Kota, Pimpri, Pune, Bhonsari-Pune, Modinagar, Mumbai, Nagpur,

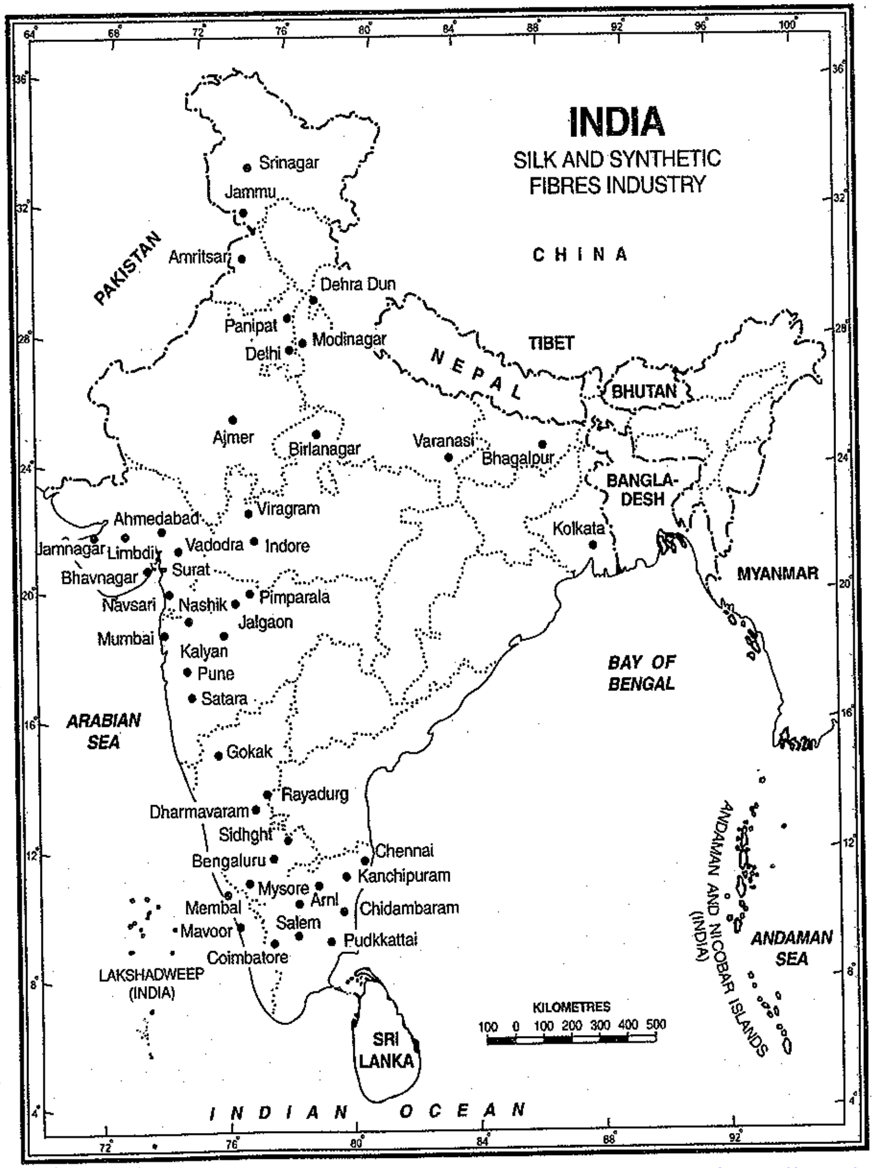


FIG. 25.4. India : Silk and Synthetic Fibres Industry

TABLE 25.9. Production of Man-made Fibre and Yarn (Thousand tonnes)

Year	Filament Yarn		Staple Fibre	
	Cellulose	Synthetic	Cellulose	Synthetic
1950-51	Neg.	N.A.	N.A.	N.A.
1960-61	21	N.A.	22	N.A.
1970-71	38	10	62	5
1980-81	43	32	83	32
1990-91	51	227	160	177
2000-01	55	865	236	666
2005-06	53	1,103	229	736
2006-07	54	1,303	247	889
2007-08	51	1,448	280	961
2008-09	42	1,360	233	830
2009-10	43	1,465	302	963
2010-11	41	1,496	305	976
2011-12	42	1,408	323	907

Neg. : Negligibly small, N.A. : Data Not Available.
Source : The Economic Survey 2012-13, p. A-33.

Vadodara, Bengaluru, Chennai, Hyderabad, Thiruvananthapuram, Barauni, Kanpur, Ujjain and Kolkata.

(*c*) **Nylon Staple Fibre Units.** Kota, Mumbai.

(*d*) **Nylon Tyre Cord Units.** Kota, Mumbai, Chennai, Kalyan, Kanpur, Goregaon, New Delhi, Udhna.

(*e*) **Polyster Staple Fibre Units.** Thane, Ahmedabad, Vadodara, Ghaziabad, Mandi, Kota.

(*f*) **Polyster Filament Yarn Units.** Mumbai, Kota, Pimpri-Pune, Modinagar, Ujjain, Udhna, Vadodara.

Man-made fibre industry has made manifold progress as is evident from **Table 25.9.**

India has to import large quantity of man-made fibres to meet the growing demand in the home market.

METALLURGICAL INDUSTRIES

Metallurgical industries are those industries which use metal as the basic raw material. It is a very wide term and includes several industries like iron and steel, aluminium, copper smelting, lead and zinc smelting, alloy, ferro-manganese, ferro-silicon, ferro-chrome, tungsten and a host of other industries. These industries form the *economic backbone* of a developing country. India has progressed a lot especially during the planning period and now occupies a place of pride with regard to the development and growth of metallurgical industries. Major metallurgical industries are briefly described in the following pages :

IRON AND STEEL INDUSTRY

We live essentially in an age of iron and steel. "Because of its hardness, strength and durability, because of the ease with which it can be cast and worked into any desired shape and because of its remarkable cheapness under modern methods of production, iron is the most important and widely used metal in the service of man". Iron and steel were the harbinger of industrial revolution in late 18th and early 19th century. Today this industry has proved to be the harbinger of globalisation. It is one of the very few industries that have assumed a global character with developments in one region affecting the industry almost everywhere else; and India is no exception. The proud machine civilization of modern age would not have existed without iron. The sturdy structure of modern industrial world is made of steel.

Iron and steel is the **basic or key industry** and lays the foundation of a vibrant industrial economy. Most of the subsidiary industries such as automobiles, locomotives, rail tracks, ship-building, machine building, bridges, dams and a host of other industrial and commercial activities depend upon iron and steel industry. No wonder, per capita consumption of iron and steel is one of the most significant measures of the level of industrialisation and economic growth of a country.

Although Indians are known for their technique of smelting iron since early time, the first iron and steel unit on modern lines was established in 1830 at Porto Nova in Tamil Nadu. However, it could not succeed and was closed down in 1866. The other efforts made during the second half of the 19th century also met with the same fate.

The real beginning of modern iron and steel industry was made in 1907 only when Tata Iron and Steel Company (TISCO) was set up at Jamshedpur (Sakchi at that time). The Indian Iron and Steel Company (IISCO) was set up in 1919 at Burnpur followed by the setting up of Mysore Steel Works at Bhadravati (now Visveswaraya Iron and Steel Works) in 1923. Iron and steel Industry witnessed rapid growth after Independence. India produced 16.9 lakh tonnes of pig iron in 1950-51. The development of iron and steel industry was envisaged during the first Five-Year Plan, but it was during the Second Five-Year Plan, that the three integrated steel projects were started at Bhilai, Rourkela and Durgapur. India is now the eighth largest producer of steel in the world. Recent developments have amply demonstrated the mettle of Indian steel industry to rise even further and become a major player in the world. However steel is known to be an industry witnessing periodic business cycles of upswings and downswings.

Steel Authority of India (SAIL) Established in 1973, SAIL is a government undertaking and is responsible for the management of steel plants at Bhilai, Durgapur, Rourkela, Bokaro and Burnpur and also the Alloy Steel Plant at Durgapur and Salem Steel Plant. The management of Indian Iron and Steel was taken over by Government on 14th July, 1976.

TABLE 25.10. Progress of Iron and Steel Industry in India

Year	Hot metal (including Pig iron) in Million tonnes	Crude Steel (Million tonnes)	Semi-finished steel (main plants) Million tonnes	Finished steel (including secondary producers) in Million tonnes	Steel castings (Thousand tonnes)
1950-51	1.7	1.5	1.2	1.0	N.A.
1960-61	4.3	3.5	1.0	2.4	35.0
1970-71	7.0	6.1	0.9	4.6	62.0
1980-81	9.6	10.3	2.0	6.8	71.0
1990-91	12.2	N.A.	4.3	13.5	262.0
2000-01	22.6	30.6	3.3	32.3	352.4
2005-06	36.5	46.5	3.2	46.6	449.5
2006-07	39.7	50.8	3.1	52.5	612.0
2207-08	42.1	53.9	2.8	56.1	567.0
2008-09	43.3	58.4	3.2	57.2	1,592.0
2009-10	47.4	65.8	4.1	60.6	1,486.0
2010-11	42.9	70.7	4.3	68.6	598.0
2011-12	42.5	73.8	4.5	73.3	770.0

N.A. : Data Not Available.
Source : Economic Survey 2012-13, p. A-31.

SAIL also took over Maharashtra Elektrosmelt Limited, a mini steel plant, in January 1986. Visweswaraya Iron and Steel Limited was also taken over by SAIL in August 1989.

With the introduction of new liberalised industrial policy in 1991, some changes were visualised in the functioning of SAIL which had great impact on the performance of steel industry in the country. Over a period of five years it brought down its manpower by around 40,000 and substantially improved its techno-economic parameters to contain its cost of operation in spite of a steady rise in input prices.

Locational Factors

Iron and steel industry uses large quantities of heavy and weight losing raw materials and its localisation is primarily controlled by the availability of raw materials. Coal and iron ore are the two basic raw materials used by iron and steel industry and on the basis of minimum transportation cost, most of the steel plants are located at three distinct places *viz*. (*i*) near coal fields, (*ii*) near iron ore mining centres and (*iii*) at places between areas of coal and iron ore production. Most of the iron and steel plants of India such as Jamshedpur, Burnpur, Durgapur, Rourkela, Bhilai and Bokaro are located in Jharkhand, West Bengal, Odisha and Chhattisgarh. These states are very rich in coal and iron ore deposits and are important producers of these materials. Visveswaraya Iron and Steel Works at Bhadravati is a major exception which is located far away from the main coal producing areas of the country. Earlier, this centre was depending upon charcoal which was available locally. Now it uses hydroelectricity from the Sharavati Power Project. The other raw materials used in this industry are manganese, limestone, dolomite, chromite, silica, etc. These raw materials are used in small quantities and can be transported without much difficulty. Hence, they do not materially affect the localisation of this industry.

Another important factor influencing the localisation of iron and steel industry is the availability of market. Steel products of an integrated steel plant are quite bulky and it has been estimated that the transport cost per tonne-kilometre of steel product is about three times more than that of coal or iron ore. Thus, following the theory of *minimum transprotation cost* many centres of iron and steel production tend to be attracted by market. Moreover, recent technological developments in transport, the use of scrap as raw material and the agglomeration economics have made market oriented location more advantageous than ever before. With the increasing popularity of open hearth process, scrap has become a very important raw material in this industry *About half of the metal now melted in world's iron and steel furnaces is scrap*. Industrialized areas, specially with steel consuming industries, are the major sources of scrap iron. Thus, the market has double attraction, as the consumer of steel and as a source of raw materials. However, the use of scrap as raw material on a large scale is yet to pick up in India.

From the above discussion, it is clear that in the present day localization of iron and steel industry, each of the three factors *viz*., coal, iron ore and market has almost equal significance. The geographical coincidence of any two of the three factors would easily determine the site of the steel plant.

In another situation, when some ingredients are to be imported or finished steel is to be exported, sea port locations are preferred. This is exemplified by the establishment of the Vishakhapatnam Steel Plant at a sea port. A few more plants in the offing such as Mangalore and Ratnagiri also favour seaboard location.

Centres of Production

At present there are 10 primary integrated plants and a large number of decentralised scondary units known as mini steel plants. Besides, there are several rolling and re-rolling mills and foundries which manufacture different items of steel using pig iron and ingot steel. There are about 10,000 foundries, 95 per cent of which are concentrated in the western states of Maharashtra and Gujarat and in the southern state of Tamil Nadu.

Large Integrated Iron and Steel Plants

1. Tata Iron and Steel Company (TISCO). This is the oldest iron and steel centre of India. It is a private sector enterprise. It was established in 1907 by Jamshedji Tata at Sakchi in Singhbhum district of

Jharkhand. Later on, it was renamed as Jamshedpur after Jamshedji. It started producing pig iron in 1911 and steel in 1912. The plant initially had capacity of producing 1.21 million tonnes of pig iron and 1.1 million tonnes of steel per annum. This capacity has been enhanced to 3.9 million tonnes of pig iron, 2 million tonnes of ingot steel and 3 million tonnes of saleable steel. Currently it produces about 3 million tonnes of saleable steel. Following facilities are available to this centre :

(*i*) High grade haematite iron ore is available from Noamundi mines of Singhbhum in Jharkhand and Gurumahisani mines of Mayurbhanj in Odisha. These mines are located at a distance of 75-100 km from Jamshedpur.

(*ii*) Coal is available from Jharia and Raniganj coal mines located 160 to 200 km from Jamshedpur.

(*iii*) Manganese comes from Joda mines of Kendujhar district in Odisha.

(*iv*) Dolomite, limestone and fire clay used as flux material are available from Sundargarh district of Odisha.

(*v*) Kolkata, located at a distance of 250 km, provides port facilities and its industrialised hinderland provides market for the products.

(*vi*) Sufficient water for cooling purposes is obtained from Subarnrekha river. In addition to this, the storage dam on Kharkai river also provides water.

(*vii*) Jamshedpur is well connected with Kolkata, Mumbai and Chennai by road and rail and enjoys good transport facilities.

(*viii*) Densely populated regions of Jharkhand, Bihar and Odisha provide cheap labour. Major part of labour is drawn from tribal areas of Chota Nagpur plateau.

Dubari Steelworks. The shortage of space in Jamshedpur and some other allied factors persuaded TISCO to locate a second steelworks at Gopalpur in Odisha, about 170 kms south-east of Bhubaneshwar. The favourable factors are coastal location, proximity to a rich iron ore belt, availability of sparcely settled land for the project, a nearby source of fresh water in the form of a rivulet, proximity to the trunk rail line and a national highway and the presence of a minor deep water port which could be expanded. Tata Steel acquired land near Gopalpur to set up a shore based steel plant in 1997 but shelved the project later due to slow pace of development of Gopalpur port and a resistance movement by local people. Consequently the Tata Steel decided to build a six million tonne plant at Dubari. The infrastructure included development of the Dhamra port and a railway line between Dhamra and Bhadrakh. This plant will use the latest technology and will be cost competitive with the most efficient steel plants in the world.

2. Indian Iron and Steel Company (IISCO). Three plants at Kulti, Hirapur and Burnpur in West Bengal were set up in 1864, 1908 and 1937 respectively. These plants have been merged together and are known as Indian Iron and Steel Company (IISCO). It was brought under government control and management in July 1972. The three plants are linked by Kolkata-Asansol railway line. Hirapur plant produces pig iron which is sent to Kulti for making steel. The rolling mills are located at Burnpur. IISCO enjoys the following advantages :

(*i*) Iron ore is available from Guna mines in Singhbhum district of Jharkhand located at a distance of 285 km. Some iron ore is also obtained from Mayurbhanj area of Odisha.

(*ii*) It used to receive coal from Jharia, located at a distance of 137 km but now the power from the Damodar Valley Corporation is extensively used.

(*iii*) Dolomite and limestone are obtained from Sundargarh district of Odisha which is 327 km away. Limestone is also available from Gangpur and Paraghat areas of Odisha.

(*iv*) Rail and road links connect it to Kolkata which is just 200 km away.

(*v*) Cheap labour is readily available from the neighbouring areas.

IISCO has annual capacity of producing 10 lakh tonnes of steel. Currently it produces over 4 lakh tonnes of pig iron, more than 3.5 lakh tonnes of crude steel and around 3.8 lakh tonnes of saleable steel.

3. The Visweswaraya Iron and Steel Ltd. It was established as Mysore Iron and Steel Company

(MISCO) in 1923 by the erstwhile state of Mysore. It is located at Bhadravati on the banks of river Bhadravati in Shimoga district of Karnataka. This plant was brought under Government control in 1962 and was renamed as Visveswaraya Iron and Steel Ltd. after the name of great engineer Dr. Visweswaraya. This plant has got a capacity of 1.38 lakh tonnes of steel. There are plans to raise its capacity to two lakh tonnes. This centre enjoys the following advantages.

(*i*) Bhadravati valley is 13 km wide as a result of which enough land is available.

(*ii*) High grade haematite iron ore is brought from Kemmangundi mines in Chikmaglur which is just 40 km away.

(*iii*) At the time of the setting up of the plant in 1923 the charcoal obtained from the forest-wood was used for smelting because coal was not available. Now it uses hydroelectric power obtained from Sharavati Power Project.

(*iv*) Limestone is available from Bhundiguda just 25 km away.

(*v*) Shimoga and Chitradurga supply manganese. These areas are just 50 km away.

(*vi*) Dolomite and chromite are also available within a radius of 45-50 km.

(*vii*) It lies on the main Biru-Shimoga railway line and makes use of railway facilities.

In order to increase the production of iron and steel, the Government of India established ***The Hindustan Steel Limited*** in public sector. Consequently, three plants under the public sector, *i.e.* Bhilai, Rourkela and Durgapur came into operation during the Second Five Year Plan. Capacity of each plant was fixed at 10 lakh tonnes of steel which was expanded during the Third Five Year Plan and a proposal of setting up a steel plant at Bokaro was also made.

4. Bhilai. Bhilai iron and steel centre was set up in Durg district of Chhattisgarh in 1957 with the technical and financial support of the then Soviet Union. It started production in 1959. Its initial capacity was 10 lakh tonnes which has been raised to 52 lakh tonnes. Durg happens to be a backward area and the purpose of setting this plant was to bring prosperity to this area. It enjoys following geographical advantages :

(*i*) It procures rich haematite iron ore from Dalli-Rajhara range which is 80 km south of Bhilai.

(*ii*) Coal is obtained from Korba and Kargali fields of Chhattisgarh located at 225 km away. Bokaro and Jharia (720 km) also supply coal.

(*iii*) Limestone comes from Nandini mines hardly 24 km away.

(*iv*) Bhandara of Maharashtra and Balaghat of Madhya Pradesh supply manganese.

(*v*) The Korba Thermal Power station is the main source of power.

(*vi*) It is connected with Kolkata-Nagpur railway line.

(*vii*) Dolomite comes from Bilaspur.

(*viii*) Cheap labour is available from the nearby areas.

5. Rourkela. Plant of Hindustan Steel Limited at Rourkela is situated in the Sundargarh district of Odisha. It was set up with the help of the then West German firm, Krupps and Demang, during the Second Five Year Plan (West Germany and East Germany have united to form one country now). It became operative in 1959. This plant has the following facilities for its successful operation :

(*i*) This plant uses iron ore obtained from Sundargarh and Keonjhar districts. These iron ore sources are located within a distance of 77 km from the site of the plant.

(*ii*) Coal is obtained from Jharia coalfields located at a distance of 225 km and Talcher, located at a distance of 169 km.

(*iii*) Hydro-electric power is obtained from Hirakud Power Project, located at a distance of 150 km.

(*iv*) The plant receives manganese from Barajmda, dolomite from Baradwar and limestone from Purnapani. These materials are located within a radius of 222 km in Odisha.

(*v*) It is located on the main Nagpur-Kolkata railway line and enjoys facilities of railway transport.

(*vi*) Kolkata provides the port facilities and its hinterland serves as market.

6. Durgapur. This plant of The Hindustan Steel Ltd. is located at Durgapur in Bardhaman district of West Bengal. It was set up in 1959 with the help of the United Kingdom. The production started in 1962. It has a total capacity of 35 lakh tonnes. It produced 12.45 lakh tonnes of crude steel, 10.93 lakh tonnes of saleable steel and 1.14 lakh tonnes of saleable pig iron in 2010-11. The Alloy Steel Plant at Durgapur has a capacity to produce 1.6 lakh tonnes of ingot steel which has been expanded to 2.6 lakh tonnes of crude steel. The following geographical factors favour its location and growth.

(*i*) Iron ore comes from Bolani mines. Mayurbhanj also supplies iron ore. These areas are located within a radius of 320 km.

(*ii*) Coal comes from Jharia and Raniganj.

(*iii*) Limestone is obtained from Birmitrapur in Sundargarh and manganese from Keonjhar district of Odisha.

(*iv*) Dolomite is supplied by Birmitrapur.

(*v*) Hydroelectricity is available from Damodar Valley Corporation.

(*vi*) Plenty of water is available from Durgapur Barrage built across Damodar river.

(*vii*) The Kolkata-Asansol railway line links it with other parts of the country.

(*viii*) Cheap labour is readily available from the surrounding areas.

7. Bokaro. A new public sector company, the Bokaro Steel Ltd. was formed in 1964 to erect a steel plant with the collaboration of the eartwhile Soviet Union at Bokaro near the confluence of the Bokaro and Damodar rivers in Hazaribagh district of Jharkhand. It is the second plant set up with the Soviet help. It started production in 1972. Its initial capacity was 10 lakh tonnes which was raised to 40 lakh tonnes. There are plans to raise its capacity to 100 lakh tonnes making it the largest iron and steel making centre in India. The achievement made by this plant has been made possible due to following few geographical factors :

(*i*) It receives iron ore from Kiriburu mine in Odisha.

(*ii*) Coal is obtained from Jharia coalfields located at a distance of 65 km.

(*iii*) Limestone comes from Palamu district of Jharkhand.

(*iv*) Hydroelectricity is obtained from Damodar Valley Corporation.

(*v*) Kolkata is just 300 km from here and provides port facilities.

Three more steel plants were planned during the Fourth Five-Year Plan in order to meet the growing requirement of steel. These plants are located at Salem in Tamil Nadu, Vishakhapatnam in Andhra Pradesh and Vijayanagar in Karnataka.

8. The Salem Steel Plant. The plant has been set up at Salem in the Salem district of Tamil Nadu. The plant has the advantage of rich iron ore and limestone, which is readily available in the adjoining areas. It also enjoys the facilities of cheap power, charcoal and vast market. The iron ore available here has low sulphur and phosphorus content and is suitable for producing special grade iron and steel.

The plant started commercial production in 1982. Its capacity was 32 thousand tonnes of stainless steel sheets in the beginning. This capacity was doubled in 1991 with the addition of another rolling mill. This capacity was further raised to 80 thousand tonnes of saleable steel in 1995-96. Today the Salem Steel Plant is a major producer of world class stainless steel and is in a position to export stainless steel to some of the advanced countries such as the USA, Mexico, Australia and some countries of South-East Asia. In order to cater to the growing demand for coinage of the Indian Government Mints, the management had also set up a blanking facility in 1993 with a capacity of 3,000 tonnes per annum. It also commissioned a hot rolling facility in November, 1995 which has state-of-the-art technology with high level of automation.

9. Vijayanagar Steel Plant. This plant has been set up at Tornagal near Hospet in Bellary district of Karnataka. It has the installed capacity of 30 lakh tonnes. The production of mild steel is its special feature. This plant enjoys the following facilities :

(*i*) Iron ore is obtained from Hospet region located in close proximity.

(*ii*) Coal comes from Kanhan valley in Chhattisgarh and Singareni coal fields in Andhra Pradesh.

(*iii*) Good quality limestone and dolomite is available at a distance of about 200 km.

(*iv*) Water and power requirements are met by the Tungabhadra hydel project located at a distance of about 36 km from the plant.

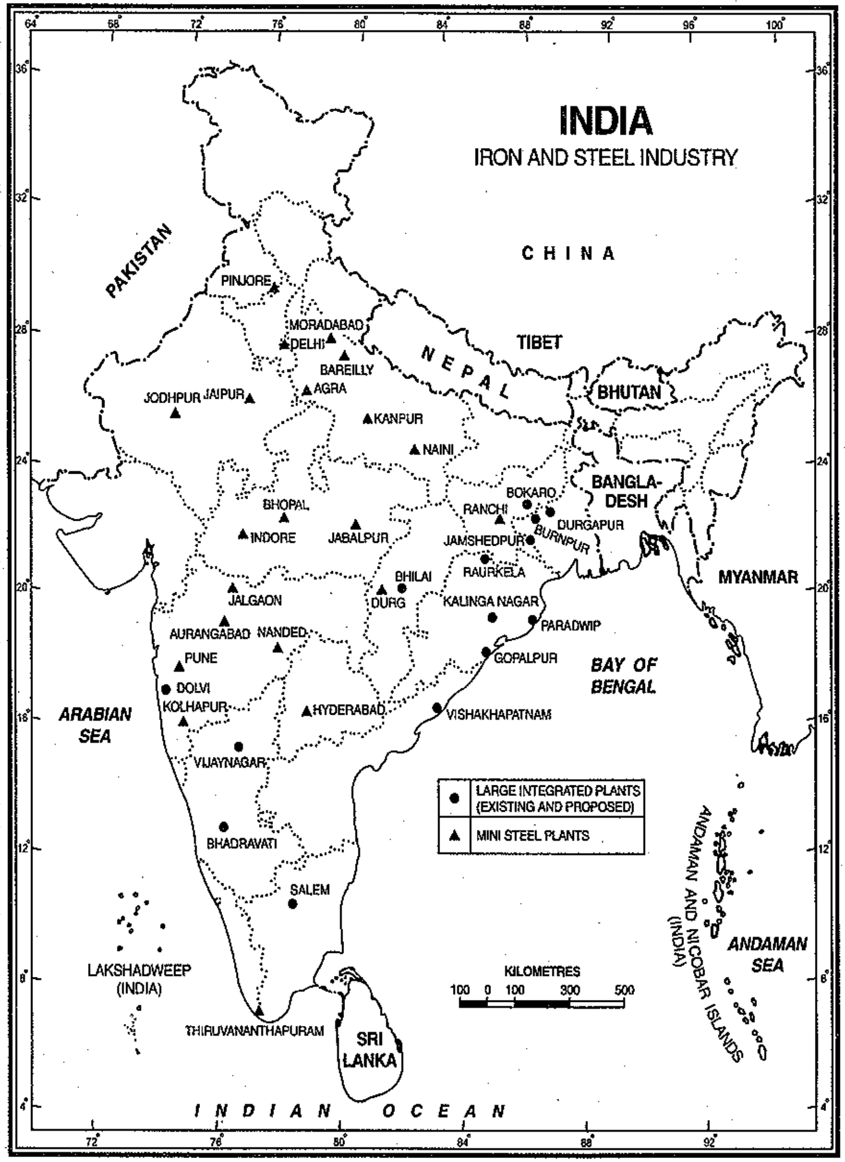


FIG. 25.5. India : Iron and Steel Industry

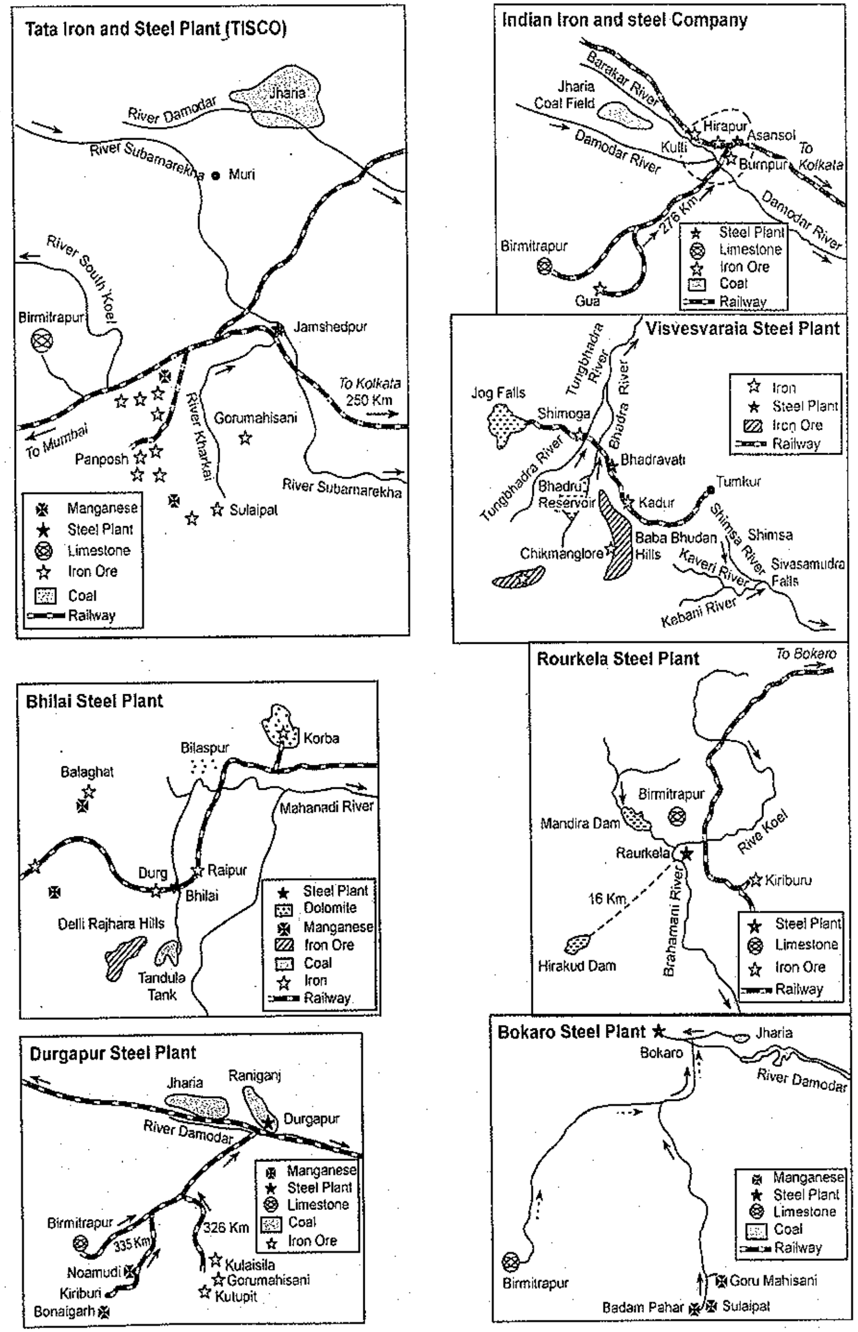


FIG. 25.6. Locational factors of major iron and steel plants in India.

Another steel plant at *Paradwip* is fast coming up.

10. Vishakhapatnam Steel Plant (VSP). This integrated steel plant has a unique location on the sea port. In fact, it is the first shore based steel plant in the country. Although the foundation stone of the plant was laid in 1972, the construction work could not start in the real sense till February 1982 when *Rashtriya Ispat Nigam Limited* was incorporated as a public sector company to implement the construction of the plant.

The project has been completed in two stages : the first stage was completed by March 1992 and the second and final stage by July 1992. This is the most sophisticated modern integrated steel plant in the country. Though the production commenced in 1991-92, 1993-94 was the first full year of integrated operation. It is a major export oriented steel plant and takes full advantage of its coastal location. Currently holding 67th rank among 80 largest steel makers on the globe, as certified by the Brussels-based International Iron and Steel Institute, VSP is smooth-sailing towards reaching its goal of turning into a 'world class company in steel industry'; as a result of the effective turn around strategy adopted by its management for the last couple of years. Buoyed by such a strong performance the VSP now intends to accelerate on the expansion trajectory. Presently it is the second largest producer of iron and steel in the country and the present annual capacity of ten million tonnes of liquid steel can be raised. The plant management intends to go in for massive upgradation of technology and skill of its personnel which will be required if the natural gas from the Krishna-Godavari basin is to be utilised to cut down cost. Import of metallurgical coal from Australia can be reduced considerably if proper arrangements for utilising natural gas from Krishna-Godavari basin are made. The natural gas requirement is placed at one billion cubic metres (BCM) a year and negotiations are in progress with the Reliance Group in this connection. The plant has the following advantages :

(*i*) The coastal location facilitates import of coal and export of iron and steel.

(*ii*) It is well connected to coal fields of Damodar valley in Jharkhand. Metallurgical coal is imported from Australia which meets about 70 per cent power requirements.

(*iii*) The plant has a bright future with respect to its energy requirements because there are plans to replace coal imported from Australia by natural gas from the Krishna-Godavari basin.

(*iv*) High quality rich iron ore deposits are available in the Bailadila area of Chhattisgarh.

(*v*) Most of the requirements of limestone, dolomite and manganese are met by supplies from Chhattisgarh; Madhya Pradesh and Odisha.

11. Daitari Steel Plant. A decision to set another steel plant at Daitari near Paradwip in Odisha has been taken. Initially, the plant was scheduled to be built by joint venture of British and South Korean companies but its responsibility has been given to the Tata group. The plant is expected to have capacity of producing 2.6 million tonnes of steel per annum.

12. Tata Steel Kalinganagar. Tata Steel will set up a six million plant at Kalinganagar in Odisha with an investment of ₹ 15,000 crore. Land for the project has been acquired and detailed project report has been prepared. The first phase of 3 million tonnes capacity will be completed in three and a half years. Along with this project, Tata Steel is going to build a port at Dharma in Odisha in a joint venture with Larsen & Toubro to handle 3,00,000 tonne ship. A ₹ 1,500 crore investment has been earmarked for the port to facilitate import of coal and export of finished goods.

13. Dolvi Steel Plant. A new steel plant is fast coming up at Dolvi in Ratnagiri district in Maharashtra. Being set up by the Ispat Industries Ltd., the plant will use new technology in steel making. The 3 million tonnes annual capacity hot rolled coil plant will be one of the most modern plants in the world. It will require less space, less energy, high labour productivity and will involve less cost of production. Producing thin strips will be a special quality of this plant.

Posco Steel, Paradwip. Pohang Steel Company (Posco) of Korea has entered into a Memorandum of Understand (MoU) with Odisha Government for setting up a steel plant in Jagatsingh disrtrict of Odisha with a total investment of ₹ 51,000 crore. The project with a capacity of 12 million tonnes per annum was scheduled to be completed by 2016. But

difficulties with respect to land acquisition is a big problem because the farmers are not willing to part with their land. Pasco needs 4,004 acres of land. It is billed as the biggest foreign direct investment (FDI) in Indian history. A huge quantity of 600 million tonnes of iron ore will be made available for manufacturing iron and steel.

Mini Steel Plants. In addition to the integrated steel plants, a large number of decentralised secondary units produce steel by using steel scrap/sponge iron as raw material and electric arc furnace and induction furnace for processing. With capacity varying from ten thousand to five lakh tonnes, these are known as mini steel plants. It is easy to construct such plants and their gestation period is short. While integrated steel plants mainly produce mild steel in bulk, the mini steel plants produce mild steel as well as alloy steel including stainless steel. Most of the mini steel plants are located in areas far away from the integrated steel plants so that they can meet the local demands there (*see* **Fig. 25.5**). Currently, about 200 units with an installed capacity of 12 million tonnes have been commissioned and have started commercial production. Other units are at various stages of implementation. This sector experienced rapid growth in 1970s but remained more or less stagnant in 1980s. The new Industrial Policy announced in July 1991 has removed iron and steel from the list of industries reserved for the public sector and also exempted it from the requirements of compulsory licensing. According to the provisions of this policy, no industrial licence is required for the establishment of iron and steel plants of any capacity in the private sector, except for locations within 25 km of the city with a population of 10 lakh as per the 1991 census. Entrepreneurs are, therefore, free to set up steel plants of any capacity, subject to locational restrictions.

International Trade. India is both an importer and an exporter of iron and steel as is clear from the following brief description. However, our imports are much higher than the exports.

Imports. Production of iron and steel in the country falls short of our demands and India has to spend crores of rupees to import various items.

A look at Table 25.11 reveals that imports of iron and steel by India have shown varying trends. The production picked up quickly in the second Five Year Plan. Due to spurt in production and slackness in demand, the industry faced problem of stockpiles for a short duration from 1974 to 1977 and even exported some steel. But this boom could not survive for long time and soon the surplus was replaced by shortages, resulting in heavy imports. The imports touched an all time high of 10,974.6 thousand tonnes in 2012-13 but cost of imports was highest as ₹ 74,063 crore in 2013-14. Although India is the fourth largest producer of steel in the world, her per capita consumption of 20 kg is much below the world average of 143 kg and way behind 420 kg in Russia, 422 kg in Britain, 620 kg in Japan, 700 kg in the USA and 734 kg in Sweden. A modest increase of upto 40 kg per capita in demand for steel would raise the total demand upto 40 million tonnes forcing the country to resort to huge imports of steel and its products.

Some quantity of steel is always needed to be imported, specially those grades and qualities which are required in small quantities and do not justify setting up of production capacities. Typical items of imports are rolled coils, cold rolled coils, semis and steel scrap.

Exports. Value addition in the Indian export basket has been a major trend with exports mainly consisting of hot rolled coils, cold rolled coils, colour coated sheets, galvanised plain (GP) sheets, galvanised corrugated (GC) sheets, and pig iron. Export of total finished steel (non-alloy and alloy) during 2012-13 (provisional) was 5.285 metric tonnes compared to 4.59 metric tonnes in 2011-12 registering a growth of 14.5 per cent.

TABLE 25.11. Imports of Iron and Steel

	1960-61	1970-71	1980-81	1990-91	2000-01	2010-11	2011-12	2012-13	2013-14
Quantity in thousand tonnes	1325.2	683.4	2,031.1	920.5	1,613.6	9,843.9	10,601.9	10,974.6	10,954
Value in ₹ crore	123	147	852	2,113	3,569	47,275	57,552	59,582	74,063

Source : The Economic Survey 2013-14, Statistical Appendix pp. 71-73.

Problems of Indian Iron and Steel Industry

1. Capital. Iron and steel industry requires huge capital investment which a developing country like India cannot afford. Many of the public sector integrated steel plants have been established with the help of foreign aid.

2. Lack of Technology. Throughout the 1960s and upto the oil crisis in mid-1970s, Indian steel industry was characterised by a high degree of technological efficiency. This technology was mainly from abroad. But during the following two decades after the oil crisis, steep hike in energy costs and escalation of costs of other inputs, reduced the margin of profit of the steel plants. This resulted in lower levels of investment in technological developments. Consequently, the industry lost its technology edge and is now way behind the advanced countries in this regard. Material value productivity in India is still very low. In Japan and Korea, less than 1.1 tonnes (and in several developed countries 1.05 tonnes) of crude steel is required to produce a tonne of saleable steel. In India, the average is still high at 1.2 tonnes. Only about ₹ 200 crore is invested in R & D activities which is hardly 0.15 to 0.25 per cent of the sales turnover. Improvement in the yield at each stage of production, particularly for value added products will be more important in the coming years.

3. Low Productivity. The per capita labour productivity in India is at 90-100 tonnes which is one of the lowest in the world. The labour productivity in Japan, Korea and some other major steel producing countries is about 600-700 tonnes per man per year. At Gallatin Steel a mini mill in the U.S. there are less than 300 employees to produce 1.2 million tonnes of hot rolled coils. A comparable facility in India employs 5,000 workers. Therefore, there is an urgent need to increase the productivity which requires retraining and redevelopment of the labour force.

4. Inefficiency of public sector units. Most of the public sector units are plagued by inefficiency caused by heavy investment on social overheads, poor labour relations, inefficient management, under-utilisation of capacity, etc. This hinders proper functioning of the steel plants and results in heavy losses.

5. Low potential utilisation. The potential utilisation in iron and steel is very low. Rarely the potential utilisation exceeds 80 per cent. For example, Durgapur steel plant utilises only 50 per cent of its potential. This is caused by several factors, like strikes, lockouts, scarcity of raw materials, energy crisis, inefficient administration, etc.

6. Heavy demand. Even at low per capita consumption rate, demand for iron and steel is increasing with each passing day and large quantities of iron and steel are to be imported for meeting the demands. Production has to be increased to save precious foreign exchange.

7. Shortage of metallurgical coal. Although India has huge deposits of high grade iron ore, her coal reserves, especially high grade coking coal for smelting iron are limited. Many steel plants are forced to import metallurgical coal. For example, steel plant at Vishakhapatnam has to import coal from Australia. Serious thought is now being given to replace imported coal by natural gas from Krishna-Godavari basin in this plant.

8. Inferior quality of products. Lack of modern technological and capital inputs and weak infrastructural facilities leads to a process of steel making which is more time consuming, expensive and yields inferior quality of goods. Such a situation forces us to import better quality steel from abroad. Thus there is urgent need to improve the situation and take the country out of desperate position.

ALUMINIUM SMELTING

Aluminium smelting is the second important metallurgical industry of India, next only to iron and steel industry. It plays a crucial role in the overall industrial development of the country. Its elasticity, flexibility, good conductivity of electricity and heat, and its capacity to be modulated into any desired shape has made aluminium a universally accepted metal. It is widely used in a large number of industries including generation and distribution of electricity, manufacturing of aeroplanes, railway coaches and bus bodies, building and architectural activities, defence and nuclear accessories, household utensils, packaging and for making coins. It is gaining popularity as a substitute to several other metals like steel, copper, zinc, lead, etc. in a large number of industries. The sectoral consumption of alluminium is given in Table 25.12. This table shows

that consumption in India differs widely from the world average consumption.

TABLE 25.12. Sectoral Consumption of Aluminium in 2003 (percentage share)

Sector	World	India
Electrical & Electronics	9	32
Transportation	31	18
Construction	18	16
Packaging	17	12
Consumer Durables	6	6
Industrial Machinery	9	4
Powders & Chemicals	—	6
Others	10	6
Total	**100**	**100**

Source : The Hindu Survey of Indian Industry, 2004, p. 197.

The per capita consumption of aluminium in India is barely 500 gram against 5.9 kilogram in the U.S. and 3.6 kilogram in Brazil.

Localisation

The production of one tonne of aluminium requires approximately 6 tonnes of bauxite, 0.26 tonnes of caustic soda, 0.09 tonnes of lime, small quantity of cryolite, aluminium flouride, calcium flouride, anthracite (calcined) and soda ash and 18,573 kWh of electricity. About 30-40 per cent of the production cost of aluminium is accounted for by electricity alone. This clearly indicates that the availability of bauxite and electricity are the two most significant factors which influence the localisation of this industry. Odisha and Gujarat are the major producers of bauxite in India.

Growth and Development

Manufacturing of aluminium metal commenced in 1886 and fabrication of utensils from imported metal started in 1929. Indian Aluminium Company started its production in 1938. Production of virgin aluminium from the indigenous bauxite ore made good progress during World War II. In fact, modern aluminium manufacturing is a war-born industry. The credit for this phenomenal growth goes to the Aluminium Corporation of India Ltd. It was formed in 1937 as a public limited company and its plant at Jaykaynagar in West Bengal started production of alumina in 1942 and that of aluminium in 1944. The Indian Aluminium Company Ltd. (INDAL) started fabrication of sheets from imported alumina in 1943 and production of alumina from indigenous bauxite in 1948. Its plant was set up at Alupuram in Kerala. These were the only two companies producing aluminium in the country till 1960. During the Second Five Year Plan, the demand for aluminium increased and two more plants at Hirakud in Odisha and Renukut in Uttar Pradesh were established by Indian Aluminium Company Ltd. (INDAL) and Hindustan Aluminium Corporation (HINDALCO) respectively.

Public sector has also contributed to the growth of aluminium industry. The Bharat Aluminium Company Ltd. (BALCO) came into being in 1965. Its first plant with a capacity of one lakh tonnes was set up at Korba in Chhattisgarh. It started production of alumina in 1973 and aluminium in 1975. The second plant by this company was established at Ratnagiri in Maharasthra. This plant has a capacity of 50,000 tonnes. Madras Aluminium Company Ltd. (MALCO) went into operation in 1965. Its plant is situated at Mettur. The National Aluminium Company Ltd. (NALCO) came into being in 1981. It has set up an integrated aluminium plant at Damanjodi near Jeypur in Koraput district of Odisha. This is the largest complex in India. The smelter with a capacity of about 2,18,000 tonnes a year has been set up at Angul in Dhenkanal district. Commercial production of aluminium started in 1988-89. As a result of expansion, the bauxite mining capacity of NALCO has doubled to 48 lakh tonnes a year and the alumina refinery at Damanjodi nearly doubled to 15.75 lakh tonnes. The new expansion plan has led to raising of the bauxite mining capacity to 63 lakh tonnes, alumina to 21 lakh tonnes, aluminium to 4.6 lakh tonnes and captive power generation to 1,200 MW. NALCO, the lowest cost producer of aluminium in the world, at present ranked among the top 10 global companies and is second to HINDALCO in India.

The Indian aluminium industry has taken giant strides following its decontrol in 1989 and launch of the economic liberalisation programme in 1991. Production has grown, cost efficiency is proven and the industry has abundant resources of bauxite, a sizable pool of experienced manpower and its proven competence in alumina and aluminium smelting to accelerate its growth.

TABLE 25.13. Production of Aluminium (Virgin Metal) in India

Year	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Production in thousand tonnes	4.0	18.5	168.8	199.0	451.1	620.4	831.7	1,061.2	1,042.7	934.5	1,045.1	790.4	963.2

Source **:** Economic Survey 2012-13, p. A-31.

The progress of aluminium industry was slow during the first three five-year plans but picked up later on till it reached first maxima of a record production of 1,061.2 thousand tonnes in 2006-07. After this, the production declined primarily due to power shortages and interruptions in the supply of bauxite.

Imports. Earlier, India was almost self-sufficient with respect to supplies of aluminium. But the demand for aluminium has increased considerably in the past few years due to rapid progress in different spheres of economic activity. As such, India has started importing aluminium in a big way.

COPPER SMELTING

Though copper has been used for various purposes since time immemorial, the development of copper smelting industry took place only recently. Earlier, efforts to smelt copper proved abortive. Indian Copper Corporation was set up in 1924 and a plant was set up at Ghatsila in Singhbhum district of Jharkhand. The Hindustan Copper Ltd. came into being in 1967. It took over Indian Copper Corporation in 1972. Since then the Hindustan Copper Ltd. is the sole producer of copper in the country.

At present, copper is produced at only two centres. One is located at Maubhandar near Ghatshila in Singhbhum district (Jharkhand) and the other at Khetri in Jhunjhunu district (Rajasthan). The smelter at Maubhandar (Ghatshila) receives copper ore from Mosabani, Rakha, Dhobani Rajdah, Tamapahar and Turamdih. All these areas are located in Singhbhum district. It was the only producer of copper till 1971 and it produced about 9.3 thousand tonnes of copper annually. The smelting unit has been replaced by blister copper unit with a capacity of about thirty thousand tonnes. HCL plans to double its capacity at a marginal cost.

The Khetri Copper Complex at Khetri has been erected by Hindustan Copper Ltd. It is an integrated copper mining-cum-metallurgical plant. The smelter was commissioned for large scale production of electrolytic copper in 1974. It receives copper ore from Khetri, Kolihan (5 km south of Khetri), Chandmari (8 km south of Khetri) and Dariba in Alwar district about 150 km away. The copper smelter at Khetri has an installed capacity of 31,000 tonnes of copper metal per year. HCL plans to expand its capacity from 31,000 tonnes per annum to one lakh tonnes per annum at an estimated cost of ₹ 560 crore. The plant also has a production capacity of 2 lakh tonnes of super phosphates and 1.82 lakh tonnes of sulphuric acid per annum. The Malanjkhand mines in Balaghat district of Madhya Pradesh supplement the supply of copper ore to Khetri. For treatment of Malanjkhand concentrates the capacity of smelter and refinery plants at Khetri have been increased to 45,000 tonnes per annum. Agnigundala Copper-Lead project in Guntur district of Andhra Pradesh has started production.

Sterile Industries is a private sector company which uses imported copper concentrates to produce cathodes. Its smelting plant was commissioned at Tuticorin (Tamil Nadu) in 1997-98. The initial capacity of this plant was 60,000 tonnes which was raised to about 1.5 lakh tonnes in 2000-01. During 1997-98, this plant produced 21,000 tonnes of anodes (unrefined copper).

Birla Copper Ltd. is a division of Indo-Gulf Fertilisers which has set-up a copper project at Dahej in Gujarat at an estimated cost of ₹ 1,850 crore. Its initial capacity was 1 lakh tonnes which was raised to 1.5 lakh tonnes later on. The smelter is based on imported copper concentrates.

Swil Copper Ltd. has set up a plant at Bharuch in Gujarat under the technical assistance from Boliden of Sweden. The plant has an annual capacity of 50,000 tonnes and is based on copper scrap. Most of the copper scrap is received from the USA, African countries and the Asia Pacific Region.

Production of copper in India increased substantially after 1970-71 when Khetri Copper

TABLE 25.14. Production of Blister Copper (Virgin Metal)

Year	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Production in thousand tonnes	764.1	797.5	889.6	853.8	705.4	670.6	684.6

Source **:** Economic Survey, 2012-13, p. A-31.

Complex in Rajasthan became operative. Production of copper and copper products researched an all time high of 853.8 thousand tonnes in 2008-09 after which declining trends in production have been observed which is primarily due to low rate of productivity of our copper smelting plants. The red metal's usage is regarded as a reliable indicator of economic growth in the industrial community as it has a variety of sophisticated applications. However, the consumption rate is likely to increase with the overall industrial growth in the country. The surge in demand has attracted investments from the private sector.

Imports. Presently, India produces only half of her requirements of copper and the remaining half is imported. The main suppliers of copper to India are Zambia, Zaire, Chile, the USA, Canada and some West European countries.

LEAD AND ZINC SMELTING

Lead

The first lead smelting plant was set up at Tundoo near Dhanbad (Jharkhand) in 1942-43 by a private company named as the Metal Corporation of India. The commercial production by this plant commenced in 1945. It was taken over by Hindustan Zinc Ltd. (HZL), a public sector enterprise in 1965. The supply of lead cocnentrates is obtained from the Zawar and Rajpur-Dariba areas of Rajasthan. The plant has an installed capacity of 8,740 tonnes per day. The HZL has set up another plant at Vishakhapatnam. It is primarily based upon the imported lead concentrates although some ore is obtained from Agnigundala also. Its installed capacity is 22,000 tonnes per annum. The lead-zinc complex at Chanderiya was constructed in 1991 under the British aid programme. It has an annual capacity of 35,000 tonnes of lead.

Indian Lead Ltd. (ILL) is a new plant with a rated capacity of 24,000 tonnes of lead per annum. The plant is based on lead scrap and concentrates.

The production of lead (virgin metal) was only 873 tonnes in 1951. It increased to 3,665 tonnes in 1961, and fell to 1,709 tonnes in 1971-72. It again jumped to 14,462 tonnes in 1981-82. Further it fell from 62,899 tonnes in 1999-2000 to 59,132 tonnes in 2012-13.

Imports. Production of lead always falls short of demand and large quantities of lead have to be imported every year to meet the growing demand.

Zinc

At present, there are four zinc smelters in the country, one each at Alwaye (Kerala), Debari and Chanderia (Rajasthan) and Vishakhapatnam (Andhra Pradesh). The Alwaye plant is wholly dependent upon imported supplies of zinc concentrates. It started production in 1967 and has an installed capacity of about fifty thousand tonnes per annum. It plans to raise its production from 20,000 to 30,000 tonnes. The Debari plant started production in 1968. It has installed capacity of smelting 18,000 tonnes of zinc annually which is being raised to 45,000 tonnes. Besides, it also produces 87,000 tonnes per annum of sulphuric acid, 190 tonnes of cadmium, 26,000 tonnes of phosphoric acid and 72,000 tonnes of high super phosphate annually. The ore is supplied by Balaria and Rajpur-Dariba mines. However, the supplies of ore from these mines are not sufficient and half of the zinc concentrates have to be imported. The Chanderia smelting plant was set up in 1991. It is based upon the supplies of ore from Bhilwara and Chittaurgarh. It is an HZL enterprise and has an annual capacity to produce 70,000 tonnes of zinc, 35,000 tonnes of lead and 74 tonnes of silver. Vishakhapatnam produces over 2.8 thousand tonnes of zinc. This plant has an installed capacity of 30,000 tonnes which is being increased to 40,000 tonnes per annum. The plant receives zinc ore from Agnigundala mines. These mines were earlier owned by the Hindustan Copper Ltd.

The production of zinc in India started after 1967. The total production was 20,800 tonnes in 1973 which increased to 45,500 tonnes in 1980-81 and 1,70,000 tonnes in 1996-97. At present the total production of zinc in India is over two lakh tonnes.

With the expansion of industries, the demand for zinc is rapidly increasing. Keeping the present trends in mind, it is estimated that the demand for zinc will increase to over six lakh tonnes in 2020 from the present level of about three lakh tonnes. India can meet about 90 per cent of her demands if proper care is taken to augment the smelting capacity and

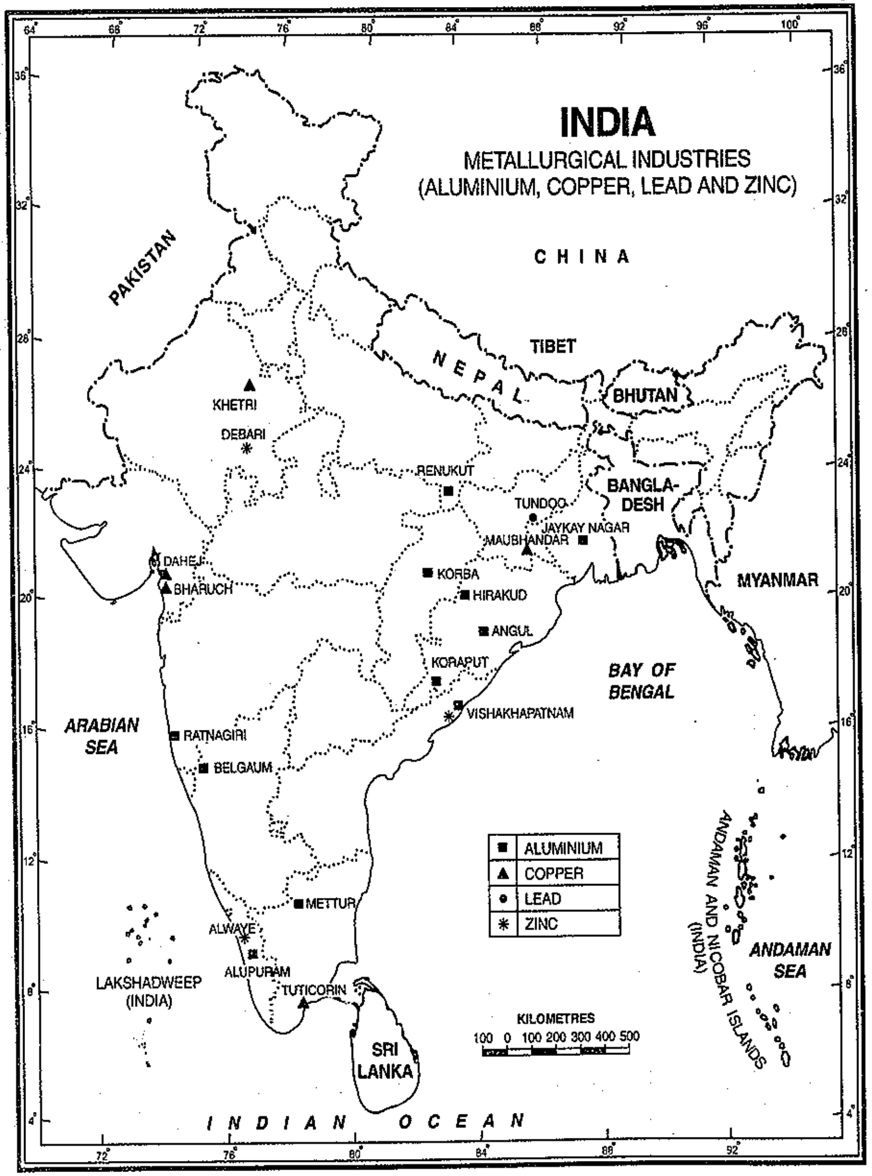


FIG. 25.7. India : Metallurgical Industries (Aluminium, Copper, Lead and Zinc)

increase production. However, India has resorted to imports of zinc to meet the growing demand for the commodity.

ENGINEERING INDUSTRIES

Engineering industries cover a wide range of industries and contribute substantially to the manufacturing of industrial machines, machine tools, transport, transmission and telecommunication equipments, building and construction, public health and sanitation and modern sophisticated goods. These industries need a large number of components which they do not produce themselves. Therefore, they have stimulated a large number of ancillary industries which depend upon the main engineering units. The products of the engineering industries cover a wide range varying from pins, screws, nuts and bolts through light and heavy machinery to ships, aircrafts, automobiles, rail coaches, air conditioners and computers, etc. Thus engineering industries are labour intensive and capital demanding and are located mainly in those areas where these major components are available. At present, engineering industries account for about one-third of the production capital in the organised sector, one-third of the value of output and nearly 30 per cent of the employment is in the public sector. Further, these industries contribute about 10 per cent of the total exports of the country.

Heavy Machinery

Manufacturing of heavy machinery made a beginning in 1958 when Heavy Engineering Corporation Ltd. was set up at Ranchi in Jharkhand. It has an installed capacity of 80,000 tonnes of heavy machinery and 25,000 tonnes of structures per annum. The plants produce castings, forgings and rolls to meet the requirements of heavy machine tools and heavy machine building plants. The Mining and Allied Machinery Corporation Ltd., Durgapur produces various items of mining equipment.

Structurals. Structurals include a wide range of items ranging from simple structures like ordinary warehouse building to sophisticated items such as railway bridges, steel plant buildings, etc. At present, there are over 130 factories engaged in fabrication of structural items with a total capacity of about 7 lakh tonnes. The Tungabhadra Steel Products Ltd. at Tungabhadra dam in Karnataka was set up in 1947. It manufactures structurals including gates and hoists, transmission towers and penstock pipes. The Triveni Structurals Ltd., a public sector enterprise, was set up in 1965 at Naini (Allahabad). It is a joint venture of Govt. of India and M/s. VOEST of Austria and manufactures complex steel structures such as building structures, crane construction, power transmission towers, pressure vessels, plate work, etc. The Bharat Heavy Plate and Vessels Ltd., established in 1966 at Vishakhapatnam, manufactures heavy plates and vessel equipment required by the fertilizer, petrochemical and other heavy chemical industries. Heavy plates are used in the construction of distillation column tanks and various types of vessels. It has a capacity of 23,000 tonnes per annum. A steel structural fabricating shop was set up at Ranchi (Jharkhand) in 1968. It has three units *viz.*, Heavy Machine Building Plant, Foundry Forge Plant and Heavy Machine Tools Plant. These plants produce castings, forgings and rolls to meet the requirements of heavy machine tools and heavy machine building plants. Another plant to manufacture high pressure boilers and boiler fittings has been set up at Tiruchchirappalli. Messrs Jessop and Co. Ltd. Kolkata, and Richardson & Cruddas Ltd., Mumbai produce machinery and heavy structurals. M/s. Larsen & Tubro Ltd., at Powai (Mumbai) produce machinery, heavy equipment for steel, under carriage parts, chemical, petro-chemical and cement industries. Drills for drilling holes in rocky areas are manufactured at Naroda near Ahmedabad.

Heavy machinery and structural industry has made much progress after Independence and the country is now in a position to export several items which were earlier imported from the western countries.

INDUSTRIAL MACHIENRY MANUFACTURING

India today produces a wide spectrum of industrial machinery including textile, cement, sugar, paper, chemical, mining, agricultural machinery, pharmaceuticals, fertilizer, dairy, metallurgical, leather and food processing industries. These industries got a good start during the Second World War but the real progress has been achieved during the plans period.

(*i*) **Textile Machinery.** India is an important producer of textile machinery. The country is in a position to export textile machinery after meeting the demand of the domestic market. Asian and African countries are the main buyers. Textile machinery manufacturing commenced with the Textile Machinery Corporation Ltd. (TEXMACO) at Mumbai in 1939. Later on, units were also started at Kolkata, Coimbatore, Ahmedabad, Ludhiana and Gwalior. The products include cording engines, ring frames, draw frames, fly frames, speed frames, sizing frames, open width bleaching plant, hot air stentors,

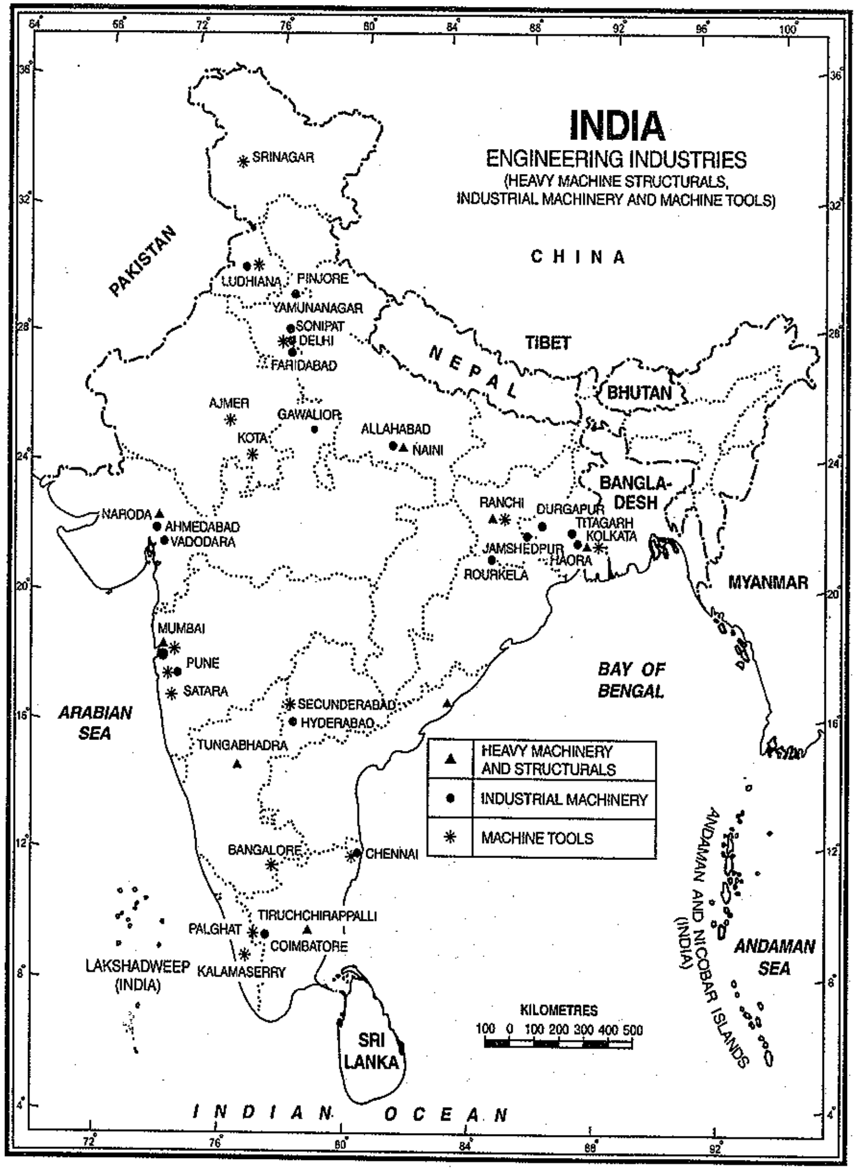


FIG. 25.8. India : Engineering Industries (Heavy machine, structurals, industrial machinery and machine tools)

mercerisers, polymerisers. The industry comprises over 1,446 machinery and components manufacturing with over 600 units producing complete machinery and other units mainly into the production of parts and accessories of textile machinery. In 2011-12, textile machinery worth ₹29,785 crores was produced. To encourage the textile industry, the industry is de-licenced and FDI upto 100 per cent under automatic route as well as technology collaboration is allowed freely.

(*ii*) **Jute Mill Machinery.** Currently 63 units are engaged in manufacturing jute mill machinery. Majority of them are concentrated in the Kolkata-Haora region.

(*iii*) **Sugar Mill Machinery.** The main centres of sugar mill machinery are at Kolkata, Chennai, Mumbai, Allahabad, Pimpri and Yamunanagar. About 12 units are engaged in manufacturing sugar mill machinery.

(*iv*) **Cement Mill Machinery.** There are 13 units engaged in manufacturing cement mill machinery. These units are largely located in Tamil Nadu, West Bengal, Odisha and Karnataka. The main centres are Mumbai, Chennai, Pune, Delhi, Shahibabad and Durgapur.

(*v*) **Paper Mill Machinery.** This machinery is manufactured by nearly 20 firms. These are spread over in West Bengal, Maharashtra, Jharkhand, Punjab and Odisha. The main centres are Titagarh, Jamshedpur and Rourkela.

(*vi*) **Chemical and Pharmaceutical Machinery.** There are about 70 projects engaged in the manufacture of chemical and pharmaceutical mill machinery manufacturing a wide range of machinery such as sulphuric acid plant, superphosphate plants, water treatment plant, solvent extraction plants, heat exchangers, pressure vessels, crystallizers, evaporators and a host of other machines.

(*vii*) **Agricultural Machinery.** Agricultural machinery covers a wide range of production including earth moving machinery, excavators, bulldozers, power tillers, steel discs, threshers, harvestors, cutters, tractors and many more implements and machines. Faridabad, Kolkata, Chennai, Vadodara, Hyderabad, Dehagaon and Sonepat are the main centres of producing agricultural machinery.

(*viii*) **Coal Mining and Washery Machinery.** The Coal Mining Machinery Project at Durgapur produces grinding mills, rotary fans, rotary kilns, power shovels, coal cutters, loaders, conveyors, haulages, electrical winders, booster fans, axial fans, automatic cape keeps, safety hooks, shutter cars and mine locomotives. Drilling rigs and other equipments for oil exploration are also produced here. Kolkata and Jamshedpur are the other important producers. Other machines, such as power driven pumps, diesel engines, building and construction machinery, weighing machinery, dairy machinery, oil mill machinery, rubber machinery, etc. are also produced in India.

MACHINE TOOLS

The machine tool industry is the core industry and forms the basis of developing engineering industry. The manufacturing of machine tools commenced in 1930s. Kirloskar Brothers Ltd. is the pioneer company in this regard. The industry got an impetus during the Second World War but rapid progress has been made during the plan period.

The Hindustan Machine Tools (H.M.T.) is the first large scale modern machine tool factory set up in public sector at Bangalore in 1953, with Swiss collaboration. It is a multi-unit, multi-product company which is the largest manufacturer of machine tools in the country. It is a leading player in the machine tool industry and produces a wide variety of machine tools, wrist watches, tractors, printing machinery, high precision lathes, radial drilling machines, grinding machines, gears, shapers, gear hobbing machines, die castings, lamp making machinery, lamp and lamp components, etc. Two units of the company are located at Bangalore and the others are at Pinjore (Haryana), Kalamassery (Kerala), Hyderabad, Srinagar and Ajmer. Its watch factories at Bangalore and Srinagar manufacture several varieties of ladies and gents watches and automatic date watches. The annual production is about four lakh watches.

Besides H.M.T., there are other public and private companies which produce different types of machine and hand tools. ***The Heavy Machine Tools Plant*** at Ranchi started production in 1966. It was set up with Czech assistance. With a capacity of 10,000 tonnes, it produces axle turning, radial drilling machines, burnishing lathes, wheel lathes, central lathes, double column planing machines, etc. It also produces special machine tools for the railways. ***The Praga Tools Ltd.***, another public sector enterprise at Secunderabad is mainly meant for defence equipment and stores. It also produces machine tools and accessories, precision tools, auto and diesel parts and railway components. ***The National Instruments Factory at Kolkata*** along with its Jadavpur unit produces precision instruments such as drawing instruments, office equipment, survey instruments, microscopes, binoculars, optical and vision sighting equipment and blood pressure equipment. ***The Instrumentation Ltd.*** has set up a precision plant at Kota and mechanical instruments plant at Palghat (Kerala). The Kota plant manufactures magnetic, electromagnetic and electronic instruments. The Palghat plant produces hydraulic and pneumatic instruments.

Currently there are around 200 machine tool manufacturers in the organized sector as also around 400 small scale units. They are dispersed all over the country with greater concentration at Mumbai, Kolkata, Delhi, Bangalore, Chennai, Thane, Pune, Coimbatore, Satara, Ludhiana and Amritsar. Today 65 per cent of machine tool requirement in India is met by indigenous manufacturers. The industry lacks in design and engineering capability to undertake high procision machines. Due to technology gap in the field of metal cutting machine tools, metal forming technology as well as research and development initiatives are encouraged to bridge the gaps. The industry is delicenced and FDI upto 100 per cent under automatic route as well as technology collaboration is allowed freely.

TRANSPORT EQUIPMENT INDUSTRY

This is vast and varied type of engineering industry which includes railway equipment (locomotives, coaches and wagons), auto-vehicles (trucks, buses, cars, three wheelers, two wheelers, shipbuilding, aircraft, and cycle manufacturing.)

RAILWAY EQUIPMENT

The manufacturing of railway equipment has made rapid strides since Independence. India today is not only self-sufficient with regard to production of railway equipment but is in a position to export substantial quantities of rails, locomotives, coaches, wagons, signalling equipment, etc. Rolling stock comprising the locomotives, coaches and wagons constitute the bulk of production.

LOCOMOTIVES

In the pre-Independence era, steam locomotives were assembled and partly manufactured at Ajmer in the B.B.&C.I. Railway workshop and at Kanchanpara in the workshops of Bengal-Assam Railway. Later on, three units started producing locomotives. They are : (*i*) Chittaranjan Locomotive Works, Chittaranjan (*ii*) The Diesel Locomotive Works at Varanasi and (*iii*) Tata Engineering and Locomotive Co., Jamshedpur.

The Chittaranjan Locomotive Works (CLW) at Chittaranjan has been set up in Burdwan district of West Bengal. It obtains iron from Asansol and Durgapur which are respectively 25 km and 67 km away from Chittaranjan. Raniganj Coalfields are also nearby. Hydroelectricity comes from DVC. Production started in 1950 and this locomotive works produced 2,351 steam locomotives till Dec., 1972. Since then, the production of steam locomotives has been discontinued and their place has been given to electric locomotives. In fact, the production of electric locomotives started in 1961 itself and since then their production has been increasing. There is no likelihood of resuming the production of steam locomotives because they use coal and emit huge quantity of smoke, thereby polluting the environment. Moreover, steam locomotives have less traction power and energy for a quick acceleration than that of electric or diesel locomotives.

The Diesel Locomotive Works at Varanasi started assembling locomotives from imported components in 1964. Its initial capacity was 150 broad gauge diesel locos per year. The first loco rolled out of the assembly lines in 1964 itself.

The Tata Engineering and Locomotive Works (TELCO) is a private sector unit and is located at Jamshedpur. It was set up in 1951 and it started production of steam locomotives in 1952. However, the production of steam locomotives was stopped in June, 1970 on the termination of company's commitment to the railways. It produced about 1200 steam locos during this period.

Bharat Heavy Electricals Limited (BHEL), **Bhopal** has developed capability to manufacture electric locomotives for the Indian railways. Diesel component works has been set up by the railways at **Patiala** for manufacturing and repairs of components of diesel locos and sub- assemblies.

A Wheel and Axle plant was set up at *Bengaluru* in 1984 to cut down imports in this field. The plant has performed exceedingly well and helped the railways to save valuable foreign exchange.

Other Railway Equipment. Rails and sleeper bars are manufactured in iron and steel works at Bhilai and Jamshedpur and wheels and axles at Durgapur, Jamshedpur and Rourkela. Coaches and wagons are manufactured both in public and private sectors.

COACHES

The Integral Coach Factory at Perambur near Chennai started production of railway coaches with Swiss collaboration in 1955. It now produces almost all types of coaches including air conditioned coaches, electric and diesel rail cars and electrical multiple units. It has an installed capacity of 1,150 coaches per annum.

The Bharat Earth Movers Limited (BEML) at Bengaluru manufactures coaches and electrical multiple units. It has an installed capacity of 400 broad gauge coaches per annum. A Rail Wheel Factory has also been set up at Bengaluru to cut down imports in this field.

Rail Coach Factory at Kapurthala in Punjab was set up in March, 1988. It has an installed capacity of 1000 coaches per annum. It is manufacturing AC 3-Tier coaches in addition to other coaches. Integral coach factory at **Rai Bareli** in Uttar Pradesh has also started functioning.

Some private companies are also manufacturing coaches and wagons. Jessop and Co. Ltd. at Kolkata has an installed capacity of 350 coaches and electrical multiple units. Textile Machinery Corporation (TEXMACO), Kolkata, Braithwaite Co. (India) Ltd., Kolkata, Burn and Co., Kolkata are some other companies which produce railway coaches.

WAGONS

Wagon manufacturing industry is fully geared to meet the growing demands of the railways. Most of the wagons are produced in private sector. There are 13 units with an installed capacity of 30,625 wagons (in terms of 4 wheelers) in private sector and three railway workshops with an annual capacity of about 4,000 units. About 60 per cent of wagons are produced in West Bengal and the rest come from Maharashtra, U.P., Punjab and Delhi.

AUTOMOBILE INDUSTRY

Automobile industry globally is one of the largest industries and is a key driver of economy. Owing to its deep linkages with several key segments of industry, automobile industry has a strong multiplier effect on the economy. A well developed Indian automobile industry ably fulfills the catalytic role by producing a wide variety of vehicles such as passenger cars, light, medium and heavy commercial vehicles, multi-utility vehicles, scooters, motor cycles, mopeds, three wheelers, etc.

Automobile industry did not exist in India in the real sense before Independence. Only assembly work was done from the imported parts. General Motors (India) Ltd. started assembling trucks and cars in 1928 in their factory at Mumbai. Ford Motor Co. (India) Ltd. started assembling of cars and trucks at Chennai in 1930 and at Mumbai in 1931. The real development of the industry began with the establishment of the Premier Automobiles Ltd. at Kurla (Mumbai) in 1947 and the Hindustan Motors Ltd. at Uttarpara (Kolkata) in 1948. Automobile industry in India has made considerable progress during the last three decades. Today, it is one of the most vibrant sectors of economy.

With gradual liberalisation of the automobile industry since 1991, more and more players have set up manufacturing facilities in India. At present there are 15 manufacturers of passenger cars and multi-utility vehicles, 9 manufacturers of commercial vehicles, 14 of two/three wheelers and 14 of tractors besides 5 manufacturers of engines. This industry currently employs 13.1 million people both directly and indirectly and contributes nearly 6 per cent to the national GDA. The industry is also making a hefty contribution of nearly 20 per cent to kitty of indirect taxes of the government.

Localisation

The automobile industry tends to be located near iron and steel producing centres because steel is the basic raw material used in this industry. The proximity of places producing tyres, tubes, storage batteries, paints and other ancillary industries is considered to be an added advantage. Port cities also find favour with this industry because of the import and export facilities offered by such places. Of late, automobile industry has become market oriented and prefers those locations which offer ready market for the manufactured vehicles. Under the Government plans for decentalization of industries, some locations in remote and industrially backward areas are given priority.

Production and Distribution

The Indian automobile sector is described as the *sun-rise* sector. During the last decade, the sector has been growing at approximately 12-15 per cent per annum. However, in 2008-09 the automobile sector was badly hit due to global economic slow down. But the industry soon recovered from this shock and bounced back on high growth track. Today, India is the seventh largest vehicle manufacturer of automobiles in the world, second largest manufacturer of two wheelers, largest manufacture of tractors and fifth largest manufacturer of commercial vehicles.

Mumbai, Chennai, Jamshedpur, Jabalpur and Kolkata are the chief centres producing automobiles. These centres produce almost all sorts of vehicles including trucks, buses, passenger cars, three wheelers and two wheelers. Motor cycles are also manufactured at Faridabad and Mysore. Scooters are also manufactured at Lucknow, Satara, Akurdi (Near Pune), Panki (near Kanpur) and Odhav (Ahmedabad dist.). Maruti Udyog Ltd. (MUL) at Gurgaon in Haryana started production of passenger cars in 1983. At present there are 38 units engaged in the production of automobiles producing four wheelers, three wheelers and two wheelers.

Commercial Vehicles. Commercial vehicles industry is divided into two broad segments, *viz.*, passenger and goods. The passenger segment is largely controlled by state owned transport undertakings (STUs) while goods vehicles are generally manufactured in private sector. The manufacture of commercial vehicles started in 1950s and the industry registered a rapid growth in the post-liberalisation period as a result of incentives given by the government. The production of commercial vehicles (including buses, trucks, tempos, 3 and 4 wheelers) increased from an insignificant of 8.6 thousand in 1950-51 and to 145.5 thousand in 1990-91 and 910.2 thousand in 2011-12 (**Table 25.15**).

Currently 7 companies are engaged in manufacturing buses and trucks. Tata Engineering and Locomotive Co. Ltd. (TELCO) is the leading producer of medium and heavy commercial vehicles and accounts for over 70 per cent of such vehicles produced in India. Four plants, each at Hyderabad, Pithampur (M.P.), Arson near Rupnagar (Punjab) and Surajpur in U.P. manufacture light commercial vehicles. Premier Automobiles and Mahendra and Mahendra are located in Mumbai, Ashoka Leyland Ltd. and Standard Motor Products of India Ltd. are located in Chennai, Hindustan Motors Ltd. is at Kolkata; and Bajaj Tempo Ltd. is located in Pune.

In addition to the above mentioned manufacturers, Shaktiman trucks are manufactured under the Ministry of Defence and Nissan Jeeps at Jabalpur in collaboration with the Nissan of Japan.

Passenger Cars. A number of companies are engaged in manufacturing passenger cars. Of these, Maruti Udyog Ltd. (MUL) is at the top. It is located at Gurgaon in Haryana. It started production in 1983 with the collaboration of Suzuki Motor Corporation of Japan. Currently this company produces about four-fifths of total cars produced in India. It produces a variety of models of which Zen, Wagon R, Esteem and Gypsy, Swift desire, etc. are very popular. The company has been facing a lot of problems with respect to labour unrest and is trying to shift its manufacturing activities to Gujarat, where congenial atmosphere for industrial investors prevails Hindustan Motors (Kolkata and Chennai), the Premier Automobiles (Mumbai), Standard Motor Products (Chennai), and the Sunrise Industries (Bengaluru) are other important producers. Several new companies have entered the car manufacturing industry of India after liberalization in 1991. These include Hyundai Motors India at Irrungattukottai in Kanchiura district (Tamil Nadu), Daewoo of Korea in 1995 at Surajpur (Uttar Pradesh), Telco at Pimpri (near Pune). Honda of Japan has set up a plant in Uttar Pradesh to

TABLE 25.15. Production of motor vehicles in India (Thousands)

Name	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Commercial vehicles*	8.6	28.2	41.2	71.7	145.5	152.0	391.1	520.0	545.1	416.5	565.6	752.6	910.2
Cars, jeeps and land savers (passenger cars)	7.9	26.6	46.7	49.4	220.8	632.2	1,047.5	1,238.7	1,422.0	1,516.8	1,910.5	2,452.8	2,513.2
Motor Cycles	NA	0.9	97.0	447.2	1,842.8	3,756.1	6,201.2	7,112.2	6,503.5	6,802.0	8,444.9	10,527.1	12,006.9
Tractors (Complete)	N.A.	N.A.	N.A.	71.0	142.2	284.4	236.4	3,060.5	295.0	293.6	373.7	465.4	648.7

*Includes buses, trucks and tempos, 3 and 4 wheelers.

Source : Economic Survey 2012-13, p. A-31.

manufacture 'City'. General Motors has launched Opel Astra. It has tie-up with Hindustan Motors. Ford in collaboration with Mahindra has introduced Ford. Hindustan Motors in collaboration with Mitsubishi of Japan has launched 'Lancer'. Mercedes Benz of Germany in collaboration with Telco is manufacturing E220 and 250D for upper strata of society. Premier Automobiles in collaboration with Fiat-India Auto Limited is manufacturing a number of models.

Table 25.15 shows that car manufacturing industry made rapid progress particularly after Maruti Udyog Limited (MUL) started production in the mid-1980s. The production of passenger cars increased from 220.8 thousands in 1990-91 to 2,513.2 thousands in 2011-12 thereby registering more than ten times increase in a short span of two decades.

Several factors have made it a buoyant industry in the recent past and the industry has a bright future. Reduction in excise duty on passenger cars has led to reduced car prices and created the potential for an increase in demand. This has helped in growth of the industry to a great extent. The government's Auto Policy also has the stated aim of making India an 'Asian hub' for the manufacture of small cars. The small car segment, which refers to the A and B segments, accounts for over 65 per cent of the market. Giving further push to this segment, therefore, adds impetus to a movement that is already underway. For India to become a large manufacturer of small cars, quality and price are the two basic deciding factors.

Introduction of NANO car by the Tata Motors was a big leap forward in popularizing small cars at affordable process to middle class buyers in India It became a big craze in the beginning but lost much of its sheen partly due to some technical problems and partly because of tough competition from other manufacturers of small cars.

The potential for growth is good considering that passenger car penetration in India is a mere 6 car per 1,000 population whereas it is much higher in other developing countries. Even in neighbouring countries like Pakistan and Sri Lanka the penetration is 12 vehicles per 1,000 population. The market is projected to grow at a rate of around 7 per cent annually.

Over the years car sales in A and B segments category as a whole have registered a steady growth because these cars are available in wide range of models and at affordable price. The mid-size category normally pertains to C segment cars. This segment accounts for 15-16 per cent of local car market. In addition to varied models and affordable price, various finance options have also grown with automobile industry. There were times when a car loan meant tedious trips to bank, reams of paper work and long waiting periods for requisite approvals from the sanctioning authority. Today the scenario is quite different, with customers having fast access to very flexible financing options that suit their different needs. Attractive automobile financing schemes have definitely boosted sales of passenger cars. Today, almost 70 per cent of new cars are financed through auto-loans.

Jeeps. Almost the entire production of jeeps comes from Mahindra, Mumbai. It has a capacity to produce about 13,000 jeeps per annum.

Two Wheelers. Two wheeler industry mainly comprises of motor cycles, scooters, mopeds and scooterettes. The Indian two-wheeler industry made a humble beginning in the early 1950s when Automobile Products of India (API) started manufacturing scooters in the country. Until 1958, API and Enfield were the sole producers. In 1960, Bajaj Auto set up a plant in collaboration with Pioggio of Italy. Two wheeler industry has also made rapid strides. It came a long way from an insignificant production of 0.9 thousand units in 1960-61 to 12,006.9 thousand units in 2011-12 (Table 25.15). The two-wheeler market was opened to foreign competition in the mid-1980s. Practically, all the global giants have been present in India for quite some time. First to come was Suzuki Motor Corporation with TVS in 1984. Honda followed within a year, in a joint venture with Hero Group. Then Kawasaki and Yamaha entered into licence agreement with Bajaj Auto and Escorts respectively. Piaggio has joined up with LML which is planning to expand its capacity to six lakh vehicles per annum. Bajaj Auto is expanding its capacity to two million vehicles per annum. Hero Honda is expanding its Dharuhera plant capacity to over 2,52,000 vehicles a year and has set up a plant at Gurgaon with an investment of ₹ 160 crore. TVS Suzuki plans to invest ₹ 200 crore to expand its production capacity to one million vehicles per annum. Yamaha-Escorts, a joint venture has also announced plans to introduce new range of products and expansion facilities in its Surajpur plant. Mumbai, Pune, New Delhi and Kanpur are main centres of scooter manufacturing. Public sector units are located at Hyderabad, Bengaluru, Satara, Lucknow and Alwar. Motorcycle producing units are located at New Delhi, Chennai, Mysore and Gurgaon.

The dynamics of two-wheeler industry in India makes a fascinating reading. From a semi luxury product for the urban middle class in 1980s and earlier, the two wheeler has now become not only the favourite form of personal transport but also the most coveted personal possession among various consumer classes except perhaps the most affluent. Leading this emergent boom has been the stylish, fuel-efficient and sturdy four stroke motorcycle that seems to be equally at home on highways and rural byways. In addition, economically active and ambitious consumer class, the relative youth of the population, the substantially lower cost of two-wheeler (as compared to cars) as well as its inherent attractiveness, especially to young male population have played crucial role.

Today with annual sales of over 12 million units, the Indian two-wheeler market is the second largest market in the world after that of China (annual sales of 25 million units). Technically, the two-wheeler industry is divided into five major classifications : mopeds, motorcycles, scooters, step thrus and ungeared scooters. Of all the two-wheelers, motorcycles have registered the maximum growth. In fact motor cycles are the fastest growth segment, with scooter and moped volumes seeing steady decline.

Like passenger car industry, the two wheeler industry has also gained a lot from the availability of easy finance. Financing was a rare of phenomenon till early 1990s but there has been phenomenal growth in this facility and loans are freely available now.

Two wheelers are the most effective safety valve which relieves pressure on urban personal transportation. More than 65 per cent of the two wheeler population is concentrated in urban and semi-urban areas. With public transport being scarce in most cities of India, the two wheelers offer a convenient alternative.

The demography of Indian population is skewed in favour of younger generation, which prefers two wheelers. Therefore, scope of further growth of the industry is great. The younger generation in the age group of 15-34 years comprises more than one-third of the total population and this is expected to increase in the near future. The office-going middle class (typically in the age group of 25 and 59 years) which prefers motorcycle on account of fuel economy, formed 23.5 per cent of the population in 2011, and this is expected to increase further in the near future. Consequently, this segment in expected to progress rapidly in the next ten years.

Although India is the second largest two-wheeler market in the world after China, the penetration levels are low at 38 per thousand people, compared to Indonesia (75), Thailand (150) and Malaysia (220). Thus there is ample scope for this industry to grow fast.

SHIP BUILDING INDUSTRY

India ranks second among the Asian countries next only to Japan in terms of shipping tonnage. However, her shipping fleet is much too small for her dimensions. Ship building is a large and complicated industry which requires huge capital investment. Harbours with large space are ideally suited for this industry.

At present, there are four main centres of ship building industry at Vishakhapatnam, Kolkata, Kochi and Mumbai, all in public sector.

Hindustan Shipyard Ltd., Vishakhapatnam. It was set up by M/s Scindia Steam Navigation Company in 1941 and the first ship was launched on 14th March, 1948. It was taken over by Government

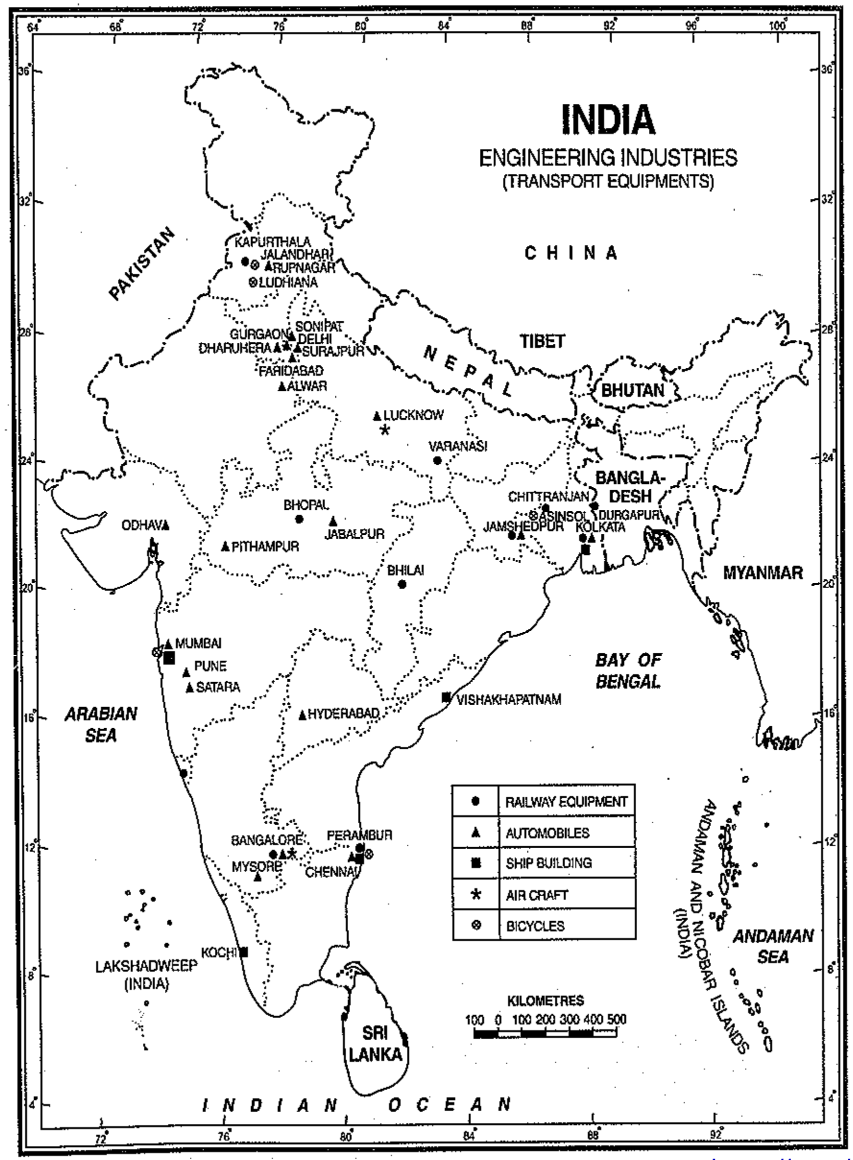


FIG. 25.9. India : Engineering Industry (Transport Equipments)

on 21st Jan., 1952 and was renamed as Hindustan Shipyard Ltd. In 1962, the shipyard became a central public sector enterprise. The shipbuilding capacity of the yard is 3.5 pioneer class vessels of 21,500 Dead Weight Tonnage (DWT) each. The maximum size of the vessel that could be built is 50,000 DWT. The yard has slipways, covered building dock, wet basin and outfit jetty. This is the first shipbuilding yard in the country which was awarded ISO : 9001 certification by Lloyds Register of Quality Assurance, London for international standard of quality assurance. So far as repair of ships is concerned, the yard has facilities of modern dry dock, wet basin repair shops, etc. and it can repair tankers, ships and submarines upto 70,000 DWT. It has so far constructed and delivered 123 vessels of various types.

Cochin Shipyard Limited, Kochi. This shipyard was incorporated on 29 March, 1972 as a company fully owned by the Government. It started commercial production in 1976. The yard is designed to construct ships of size upto 1,10,000 DWT and repair of ships upto 1,25,000 DWT. Till now the yard has constructed and delivered nine large ships (five Bulk Carriers and four Crude Oil Tankers). Recently the yard has delivered the Cargo Launch Vessel, the first export order to its owner National Petroleum Construction Company, Abu Dhabi. It has also constructed 36 vessels. At present, the yard has orders for more Tug Boats from M/s A.A. Tarki Corporation for Trading and Contracting, Saudi Arabia and six bulk carriers of 30,000 DWT each from M/s Clipper Group Management Ltd., Bahamas. Ships for Indian Navy are also built here. The yard has so far repaired 1,000 ships of various types.

Hooghly Dock and Port Engineers Limited Kolkata, became Central Public Sector Undertaking in 1984. The company has two working units in Haora district of West Bengal, one at Salkia and another at Nazirgunge. It has installed capacity of 1,100 tonnes shipbuilding and 125 ship repairs per annum. Apart from dry dock and jetty, it has six slipways. The yard is capable of constructing various types of ships (including passenger ships) and other vessels such as dredgers, tugs, floating dry docks, fishing trawlers, supply-cum-support vessels, barges mooring launches etc. and undertaking repairs of different types of vessels.

The Mazgaon Dock at Mumbai builds dredgers, dock cranes, cruisers, frigates, etc. for the Indian Navy. It can also build ocean-going vessels upto 27,000 DWT. It is capable of building cargo ships, passenger ships and dredgers. It has sub-units at Nhava and Mangalore. Recently it has started constructing submarines, missile boats, destroyers of the Navy and off-shore supply vessels etc for ONGC.

In addition to the above mentioned main centres, there are 33 smaller shipyards manufacturing vessels of small sizes meant for domestic purposes. *Goa Shipyard* Limited (GSL) at Vaso-da-Gama undertakes the manufacture of fibre glass boats, trawlers, dredgers and barges. It has undertaken construction/refit of variety of vessels for Indian Navy and Cost Guard as well for non-defence sector. Presently it is building advanced offshore petrol vessels of in-house design.

AIR CRAFT INDUSTRY

The first aircraft industry was set up at Bengaluru in 1940 under the name of Hindustan Aircraft Ltd. It was a private company and was taken over by the government in 1942. This factory was merged into Aeronautics India Ltd. in 1964 to form Hindustan Aeronautics Ltd. (HAL), Bengaluru. Different parts of aircrafts are manufactured at different places due to security reasons. The main divisions of the HAL are : (*i*) A three unit MIG complex comprising the Nashik Division where MIG airframe is manufactured. (*ii*) the Koraput division where the engine for MIG aircraft is manufactured and (*iii*) the Hyderated division where electronic equipment for the MIG is manufactured. Transport aircrafts are manufactured at Kanpur. Recently a factory was set up at Lucknow for producing equipment for aircraft. Among the other major products, mention may be made of Jaguars, Marut, Gnat Fighter Aircraft, Jet Trainer Aircraft, etc. and some helicopters. The first prototype of light combat aircraft (LCA) rolled out in November 1995.

BICYCLES

Bicycle is a poor man's drive and is much suited to the economic condition of Indian masses. It is the most convenient and popular mode of transportation among the lower and middle income groups.

Presently, over sixty million bicycles are being used in the country. The first bicycle manufacturing factory was set up at Mumbai in 1940. At present, there are about 13 units manufacturing complete cycles and over 40 units manufacturing cycle parts. The main centres of bicycle production are Mumbai, Asansol, Sonipat, Delhi, Chennai, Jalandhar and Ludhiana. Ludhiana has emerged as the major bicycle production hub in the country. This industry has made rapid strides during the last four decades. The production has increased from 99 thousand bicycles in 1950-51 to 13,046.14 thousand bicycles in 2012-13. This progress has made India the second largest producer after China. Hero, Atlas, TI and Avon account for 92 per cent of the production in the organised sector.

India has emerged as a major exporter of cycles to Pakistan, Afghanistan, Sri Lanka, Myanmar, Thailand, UAR, Turkey, Indonesia, Malayasia and Singapore. Indian exports of bicycles and components was around ₹ 281 crore in 2012-13. There has been a significant increase in exports to South America and African and European countries since 1991.

The bicycle industry is de-licenced under the current industrial policy and this sector is qualified for 100 per cent FDI under automatic approval.

LIGHT MECHANICAL ENGINEERING GOODS

India produces a wide range of light mechanical engineering goods. The important items are sewing machines, office equipment, etc. The main centres of sewing machine production are Mumbai, Delhi, Secunderabad and Jalandhar. The production of sewing machines is showing varying trend.

ELECTRIC MACHINERY AND EQUIPMENT MAKING INDUSTRY

Electricity is an integral part of modern life. The increase in generation, distribution and utilisation of electricity has resulted in increased demand for electrical machinery and equipment in the recent past. Consequently, this industry has made rapid strides during the last two-three decades. This industry is divided into two components *viz.* (*i*) heavy electrical equipment industry and (*ii*) light electrical goods industry.

Heavy Electrical Equipment Industry

Heavy electrical industry comprises equipment used for the generation, transmission, distribution and utilisation of power. It includes items such as generators, boilers, turbines, transformers, switchgears, etc. The indigenous industry is equipped to meet the entire domestic requirement. The entire industry has been delicensed under the New Industrial Policy of the Government of India. Also under the New Policy, these items qualify for automatic approval as regards to foreign collaborations. Heavy electrical equipment is mainly manufactured by the government owned factories which have been set up with foreign financial assistance and technical skill. This industry took its birth in 1956 when Heavy Electricals (India) Ltd. was set up at Bhopal with British help. It started production in 1960. Another company known as the Bharat Heavy Electricals was formed in 1964. The two organisations have since been merged to form Bharat Heavy Electricals Ltd. (BHEL). BHEL is an important milestone in the development of heavy electrical equipment industry. In last about five decades since its inception, BHEL has taken the country from a position of total dependence on imports to self-reliance in power plant design, manufacture, installation and servicing. The sets manufactured and supplied by BHEL now account for 65.3 per cent of the country's installed power generation capacity. With an annual production capacity of 4,000 MW, BHEL ranks among the most important power equipment manufacturers in the world. To meet the demand for rapid growth in power generation, BHEL has steadily introduced higher capacity boilers—right upto 500 MW unit sizes. BHEL boilers and auxiliaries have also been exported to Libya, Malayasia and Egypt and boiler assemblies to China and the U.S.A. It has six units located at Bhopal, Tiruchchirapalli, Ramchandrapuram (Hyderabad), Jammu, Bengaluru and Haridwar. The Bhopal unit produces heavy electrical equipment required for the generation, transmission and distribution of power. These include hydraulic and steam turbines, generators and motors and traction equipment. The plant at Tiruchchirapalli in Tamil Nadu produces high pressure boilers. The Ramchandrapuram unit (Hyderabad) in Telangana has heavy power equipment plant which has a capacity to manufacture 800 MW of steam turbines and turboalternatives per annum. It also produces air blast circuit breakers and minimum oil circuit breakers. The Haridwar Unit produces steam turbines. Some items of heavy electrical industry are produced at Jammu and Bengaluru.

Power Transformers. There are 33 units in the organised sector manufacturing power and distribution transformers. Transformers of 100 KVA capacity are mainly produced by small scale units. Most of the production comes from Mumbai, Chennai, Vishakhapatnam, Kolkata and Sonipat.

Electric Motors. India produces a wide range of electric motors to meet the requirements of industries, tube wells, pumping sets and electric traction. Heavy motors are manufactured by government factories while small motors are made by private factories. Mumbai, Chennai, Bangalore, Kolkata, Pune, Patiala, Delhi, Coimbatore, etc. are the main centres of motor manufacturing.

Electric Wires and Cables. Wires and cables whether they are made of fibre, optics, iron or non-ferrous (copper, aluminium, zinc), play a significant role in almost all areas of industrial and daily life. This is one of the earliest industries established in India in the field of electrical products. India produces a wide range of wires and cables which includes communication cables such as jelly fifted telephone cables, optic fibre cables, local area cables, switchboard cables, co-axial cables, electrical cables such as electrical wires, winding wires, automatic/battery cables, UPS cables, flexible wires, low voltage power cables, etc. The power cable industry is mainly divided into four segments *viz.* house wiring (upto 440 V), LT (1.1 to 3.3 KV), HT (11 to 66 KV), EHT (66 KV and above).

It is a fast developing industry as it has received a big boost from various government policies. In the year 2012-13, the non-small scale industry (SSI) sector reported production of insulated cable wire of all kinds at 53.70 lakh core rims. In 2011-12, India exported wires and cables worth ₹ 2800.09 crore. The industry is de-licenced and is eligible for automatic approval for FDI upto 100 per cent.

Transmission Towers. Transmission towers support high voltage transmission lines which carry electricity over long distances. Demand for transmission towers has increased considerably with the rapid pace of electricity distribution over long distances from the electricity generating stations to the consuming areas. The country has sufficient capacity to cater to the domestic demands. During the year 2012-13, India imported transmission towers worth ₹ 100.53 crore against a huge export of ₹ 1,515.27 crore.

Cranes. Cranes and hoists are an important category of material handling equipment required by almost all sectors of industry. India produces a wide range of cranes which include Electric Overhead Travelling (EOT) cranes, mobile cranes, ladle cranes, hydraulic decks, crab cranes, floating cranes, controller cranes, etc. There is good potential for growth of this industry in India. In the year 2012-13, India produced 17,417 tonnes of cranes. During the same year, India imported cranes worth ₹ 2,305.8 crore while the exports were worth ₹ 716.40 crore. The industry is de-licenced and is eligible for automatic approval for FDI upto 100 per cent.

Lifts and Escalators. During the recent past, Indian cities have tended to grow vertically due to fast growing urban population and also because of limited availability of land in urban areas. Consequently lifts and escalators have become the corner stone to support this development and lifeline for the buildings that constitute this development. Rapid urbanization and robust activity in the construction industry and corporalization of the real estate sector has led to a vary healthy growth of this industry. The use of lifts and escalators is increasing rapidly due to substantial investment in construction of multistoried housing complexes, large malls and supermarkets of international standards, modernization of airports and railway stations apart from industrial sectors. A wide range of lifts and escalators are manufactured in the country which include single speed, double speed, glearless, hydraulic, servo and Variable Voltage Variable Frequency (VVVF) elevators. In the year 2012-13, India produced lifts and escalators worth ₹ 1,053.34 crores. In the same year, the import was ₹ 2,261.45 crores against export of ₹ 296.25 crore. The industry is de-licenced and is eligible for automatic approval for FDI upto 100 per cent.

Light Electrical Goods Industry

This industry covers a wide range of products which include white goods (refrigerators, washing machines, air conditioners, etc.), household electric appliances, electric fans, storage batteries, dry cells, wiring accessories, fittings, electric lamps, etc.

Refrigerators. In India, refrigerators have the second highest aspirational value, next only to television. It is on account of this fact that this industry has witnessed extremely high growth rate during the last few years. This industry has become highly competitive as a number of brands, both national and international, have entered the market. In the year 2012-13, India produced 8,685.45 thousand units. During the same year, India exported refrigerators worth ₹ 1,225.57 crores. against the imports of ₹ 2,248.75 crores. The industry is delicensed and its eligible for automatic approval for FDI upto 100 per cent

Washing Machines. With growing number of working couples and higher aspirations as well as higher purchasing power of the urban middle class families, washing machines have become an integral part of domestic electrical appliances in most of the families. More efficient and energy saving washing machines are hitting the market every day as the technology advances. In the year 2012-13, India produced 32.24 lakh units. Even now India imports a variety of washing machines. In the year 2012-13, India imported washing machines worth ₹ 864.9 crores while the exports in the same year were worth ₹ 103.07 crore. The industry is de-licenced and eligible for automatic approval for FDI without any restriction.

Air Conditioners. Air conditioners are gradually being treated as a necessity in the changed socio-economic environment of the present day life in India. There are three types of ACs available in the market *viz.* window AC, split AC and central AC. Star rating of ACs has been introduced for energy efficiency. Market for ACs has grown considerably during the last few years. In 2012-13, India produced 18.97 lakh units. In the same year, exports of ACs account for ₹ 364.21 crore, against imports worth ₹ 5,073.69. The industry is de-licenced and eligible for automatic approval for FDI upto 100 per cent.

Electric Fans. India is one of the foremost producers of electric fans in the world. A complete range of electric fans such as ceiling fans, table fans, pedestal fans, exhaust fans, cooler fans, railway carriage fans, cabin fans and air circulators are being produced in different parts of the country. Mumbai, Kolkata, Secunderabad, Chennai, Delhi, etc. are the leading centres for production of electric fans.

Electric Lamps. This industry was established in 1932 and has made tremendous progress, especially after Independence. The range of electric lamps includes mercury vapour lamps, automobile lamps, photoflash lamps, miniature lamps for torches and flourescent tubes. There is an urgent need for energy conservation which has encouraged the need for manufacture of energy efficient electric lamps. Compact Fluorescent Lamps (CFL) which consume about 20% of electricity for the same light output and last upto 8 times longer than the GLS are getting more popular. The industry is receiving adequate encouragement from the Government. A number of foreign collaborations have already been approved for manufacture of energy efficient lamps. During 2012-13, the production of GLS lamps and fluorescent tubes was 784.44 million numbers and 182.21 million numbers respectively. In the same year the imports and exports of these items were worth ₹ 1,497.27 crore and ₹ 739.90 crore respectively.

Dry and Storage Batteries. Established in 1926, this industry flourished well after the Second World War. Almost all types of dry and storage batteries are produced in the country. Storage batteries are required for automobile industry, train lighting, posts and telegraphs apparatus, power houses and for traction. New units are coming up and the process of upgradation of technology in this industry is continuously benefitting the producer and customer alike.

Radio Receivers. This industry made a beginning in 1947 with a modest production of less than 4,000 sets. The production reached a peak of 1,734 thousand sets in 1980-81 and nose dived to a mere 0.7 thousand in 2003-04. The main reason for this drastic fall in the production of radio receivers is attributed to the growing popularity of television sets.

Electronics Industry

This industry covers a wide range of products including television sets, transistor sets, telephone exchanges, cellular telecom, paging, computers, and varied equipments for posts and telegraph, defence, railway and meteorological departments. It is practically a post-independence phenomenon and has revolutionised the life style of the Indian masses in the recent past. Bengaluru is the largest centre of electronics goods production and is rightly termed as the ***Electronic Capital of India***. The other major producing centres are Hyderabad, Delhi, Mumbai, Chennai, Kolkata, Kanpur, Pune, Lucknow, Jaipur, Coimbatore, etc.

Information Technology

Two main components of Information Technology (IT) are software and hardware.

The software has emerged as the major industry in the field of electronics. This industry made a modest beginning in the 1970s and by mid-1980s, the forecasters, analysts and policy planners started understanding the potential of computer software application. The industry achieved a major breakthrough in the 1990s and is now one of the important industries of India. The main cause of the rapid development of software industry is its vast reservoir of technically skilled manpower which has transformed India into a software super power. With a compound annual growth of about 52 per cent between 1991 and 1996, the Indian software sector has expanded almost twice as fast as the world's leading US software industry did, during the same period, although from a smaller base. There is now a critical mass of more than 500 software firms in the country and apart from these companies, there are an additional 1,000 start-up-companies. Today, India is one country that offers cost-effectiveness, great quality, high reliability, speedy deliveries and, above all, the use of state-of-the-art technologies in software industry. The year 1995-96 was a boom year for the Indian computer industry and the Information Technology (IT) industry of India really exploded in that year.

Despite the challenges such as the continued technology slowdown in the global market, strong fundamentals and core value position of the software and services industry led to outperforming all other sectors in the country. Today, India dominates the word scene with respect to software technology.

Hardware. The hardware segment of Information Technology (IT) industry is one of the fastest growing industry in terms of production, international trade and is characterised by innovation. According to a recent study, by 2020, the global electronics industry would cross $ 1.5 trillion mark and Indian electronic hardware industry may be well over $ 100 billion by then. This will offer employment opportunities to over 10 million persons.

After liberalisation in 1991, India is fast catching up with the world in terms of penetration of IT, telecommunications and consumer electronics products. This can lead to a huge demand for these products as well as provide base for global competition.

"The Personal Computer (PC), not TV, will be the key information appliance of 21st century," said Andy Grove, co-founder of Intel, the world's largest chip-maker over a decade ago. He was proved right in the U.S. before the turn of the 20th century when for the first time PCs outsold TVs. This has not happened in India, and may not happen for another decade. But PCs are gaining more popularity in India as compared to TVs as the time passes.

The phenomenal increase in PC sales can be attributed to home segment which posted a growth of 48 per cent. Significant consumption by telecom, banking, manufacturing as well as business process outsourcing (BPO) and IT enabled services (ITES) segment also contributed to rise in PC sales. India has emerged as the most preferred destination for BPO, a key driver of growth of software industry and the service sector. Smaller cities and towns fueled the IT consumption with class C cities accounting for over 50 per cent of total PC sales.

The Department of Information Technology has drafted a wholesome IT hardware policy which addresses the basic problems faced by this industry. This policy must be implemented to rid the industry of the ills it is currently facing.

The vision of IT policy is to use IT as a tool for raising the living standards of the common man and enriching their lives. Towards this end, the Department of Information Technology has taken up an ambitious programme of PC and Internet penetration to the rural and underserved urban areas. The Department has also announced a programme to establish State Wide Area Network (SWAN) up to the block level to provide connectivity for e-governance. The Department has also set up Community

Information Centres (CICs) in hilly, far-flung areas of the North-East and Jammu and Kashmir to facilitate the spread of benefit of information and communication technology. It is also proposed to set up CICs in other hilly, far-flung areas of the country like Uttarakhand, Andaman & Nicobar and Lakshadweep.

A mixture of software and hardware technology lies at the heart of burgeoning business of embedded system design and India is emerging as a key centre for products for both local and global players. IT infrastructural facilities (software as well as hardware) are available at a number of places in India (*see* **Fig. 25.10**).

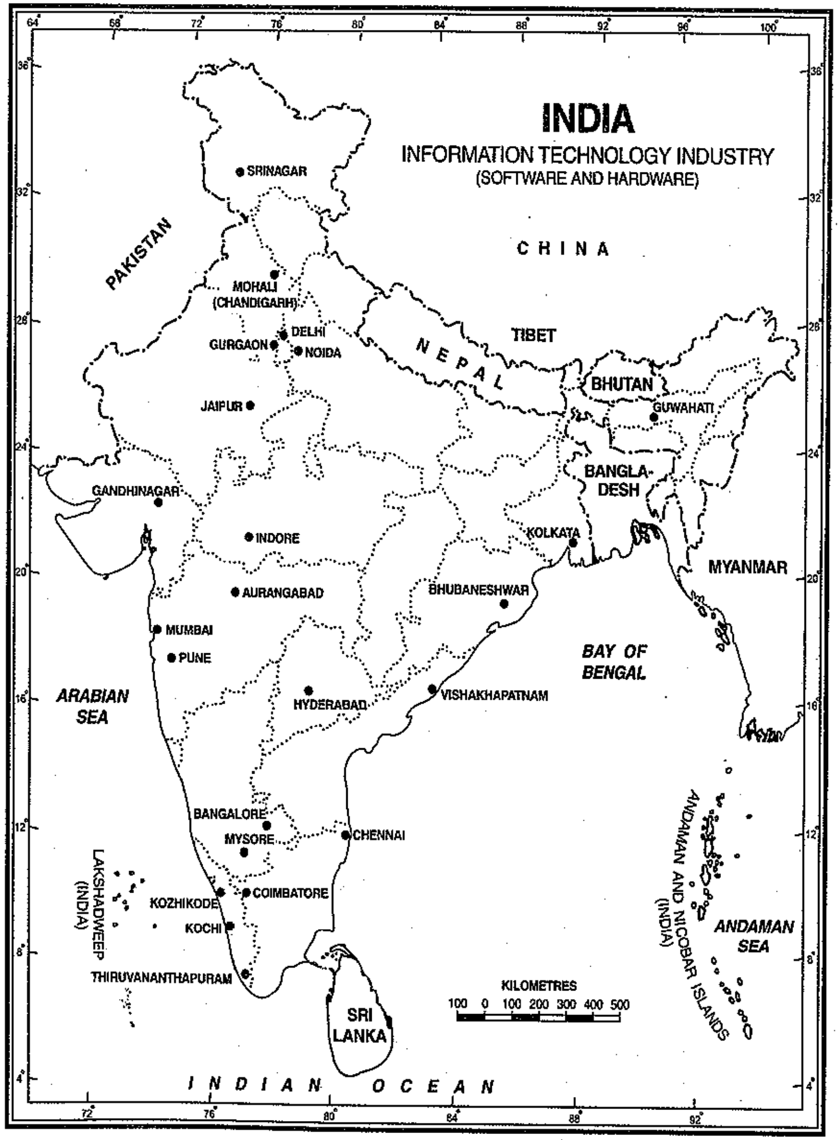


FIG. 25.10. India : Information Technology Industry (Software and Hardware)

The television industry had also grown tremendously in the 1990s. The market size is about 2.5 million units with top four brands taking up over 80 per cent of the share. BPL and Videocon are on the top and accounted for 26 per cent each of the market shares. They are followed by Onida and Phillips. Among the international brands, Panasonic, Soni and Akai are famous. LG has also become quite popular It is now asserted that TV has entered the smallest of homes and the tiniest of villages and communities.

The production of ***audio systems*** has registered a phenomenal growth during the recent past. The audio industry can broadly be classified as mono players, stereo players, midi systems, CD based systems and car audios. The present size of the Indian audio market is estimated at ₹ 2,000 crore and this is growing at an annual rate of 15-16 per cent. The mono players and stereo players contribute more than 50 per cent of the total market. The top three players in the Indian audio systems industry are Philips, BPL and Videocon. These three makers account for 35 per cent, 20 per cent and 10 per cent respectively with the remaining 35 per cent share of the market going to smaller brands and the unorganised sector.

Indian electronics industry is also contributing a lot to space technology. India has launched several indigenously built satellites including APPLE, INSAT-I series. The remote sensing programme of the Indian Remote Sensing Organisation at Hyderabad has also gained a lot from this industry.

CHEMICAL AND ALLIED INDUSTRIES

Chemical and allied industries constitute one of the most vital and essential components of the country's economy. Although chemical industry made a late start and is still a nascent industry in India, it has undergone a metamorphosis during the last four decades. This change has become more perceptible after the liberalisation of industrial policy in 1991. At present, it is the fourth largest set of industries after textiles, iron and steel and engineering industries. This set of industries can claim to be one of the top sectors of the economy to have responded well and benefited significantly by taking advantage of the stimulii for growth injected in recent years. The large manufacturing capacities commissioned for several chemical industries and still larger capacities to go on stream within another five years, have pushed the status of the Indian chemical industry forward in the comity of chemical manufacturing nations. The rate of growth of the chemical sector has been higher than the average growth rate of the Indian industry. During the last decade the industry has been growing at the rate of 10 per cent per annum. The present annual turnover in the chemical sector in India is estimated to be well over ₹ 40,000 crore.

HEAVY INORGANIC CHEMICALS

Sulphuric Acid. Sulphuric acid is used as an important ingredient for manufacturing fertilizers, synthetic fibres, plastics, paints and dyestuffs. It is also used in metallurgy, leather tanning and oil refining. It is manufactured from sulphur which is not available in appreciable quantity in India. About 90 per cent of the sulphur has to be imported. There are over one hundred units engaged in the manufacture of sulphuric acid. About 80 per cent of the production comes from Kerala, Maharashtra, Gujarat, Tamil Nadu, Madhya Pradesh, Chhattisgarh and West Bengal. The rest is contributed by Jharkhand, Andhra Pradesh, Telangana, Uttar Pradesh, Delhi, Karnataka, Assam, Punjab, Rajasthan and Odisha. Important centres of production are Mumbai, Trombay, Chennai, Kalyan, Jamshedpur, Delhi, Kolkata, Burnpur, Udaipur, Alwaye, Debari and Khetri.

Nitric acid. The production and use of nitric acid is associated with fertilizer plants and explosives. Trombay unit of Fertilizer Corporation of India is the main producer.

Alkalies. Alkalies form an important segment of inorganic chemical industry and the demand for alkalies is growing very fast as a result of growth of industries using them as essential inputs. The manufacturing of alkalies requires heavy and weight loosing raw materials like common salt (sodium chloride), limestone and coal. The final product has much less weight in comparison to the weight of the raw materials. This industry also requires cheap electricity in abundance. Thus the plants manufacturing alkalies tend to be located near the source of raw materials, electricity and market. The alkali industry comprises soda ash, caustic soda, liquid chlorine, calcium carbide, etc.

Soda Ash. It is used in the manufacture of glass, paper, soaps and detergents. Two chief raw materials used in the manufacture of soda ash are sodium chloride and limestone which are abundantly found in Gujarat. Okha, Mithapur and Dhrangadhra are important centres of manufacturing soda ash. The other centres are Sutrapada, Varanasi, Nangal and Tuticorin. The production of soda ash consistently increased from a meagre 46 thousand tonnes in 1950-51 to 1,631 thousand tonnes in 2000-01 and 2,427 thousand tonnes in 2011-12.

Caustic Soda. The caustic soda industry has grown steadily since the first plant, with a capacity of five tonnes a day, was put up at Mettur in 1936. It meets the needs of end-user industries like textiles, soaps and detergents and alumina. Its by-product, chlorine is an important chemical used in water treatment, paper and pulp, soaps and detergents, textiles and a large variety of other industries. The industry is growing at a rate of six per cent per annum in India whereas, internationally, the growth rate is around two per cent.

The basic raw material used for manufacturing caustic soda is common salt which is available in plenty in India. It is a highly power intensive industry and the cost of power constitutes more than two-thirds of the total cost of production of caustic soda. The major producing centres are Porbandar, Thane, Kalyan, Mithapur and Titagarh.

HEAVY ORGANIC CHEMICALS

Petrochemicals. Petrochemicals are those chemicals and compounds which are derived from petroleum resources. The main sources of feedstock and fuel for petrochemicals are natural gas and naphtha. These chemicals are used for manufacturing a large variety of articles such as synthetic fibres, synthetic rubber, ferrous and non-ferrous metals, plastics, dye-stuffs, insecticides, drugs and pharmaceuticals. Today, petrochemicals products permeate the entire spectrum of items of daily use, ranging across clothing, housing construction, furniture, automobiles, household items, toys, agriculture, irrigation and packaging to medical appliances.

This is one of the fastest growing industries in the Indian economy. The demand for organic chemicals increased so rapidly that it became difficult to meet them by chemicals prepared from alcohol, calcium carbide, and coal. At the same time, petroleum refining industry expanded rapidly. Many things are derived from crude petroleum, which provide raw materials to several new industries; these are collectively known as petrochemical industries. This group of industries is divisible into four sub-groups : (*i*) polymers, (*ii*) synthetic fibres (*iii*) elastomers, and (*iv*) surfactant intermediate. Mumbai is the hub of petrochemical industries. Cracker units are also located in Auraiya (Uttar Pradesh), Jamnagar, Gandhar, Hazira (Gujarat) Nagothane, Ratnagiri (Maharashtra), Haldia (West Bengal) and Vishakhapatnam (Andhra Pradesh).

Three organisations are working in the petrochemical sector under the administrative control of the Department of Chemicals and Petrochemicals.

(*i*) Indian Petrochemical Corporation Limited (IPCL) is a public sector undertaking which is responsible for the manufacture and distribution of various petrochemicals like polymers, chemicals, fibres and fibre intermediates.

(*iii*) Petrofils Cooperative Limited (PCL) is a joint venture company of the Government of India and Weavers' cooperative societies. It produces polyester filament yarn and nylon filament yarn at its two plants located at Vadodara and Naldhari in Gujarat.

(*iii*) Central Institute of Plastics Engineering and Technology (CIPET) is involved in imparting training.

Synthetic Fibres

These are widely used for manufacturing a large variety of fabrics because of their special qualities like strength, durability, dyeability, workability, washability and resistant to wrinkles and shrinkage. These fabrics are very popular among the masses in India, both in urban and rural areas. Although nylon industry made a beginning immediately after the World War II, the real progress was made in 1960s. The main cause of rapid progress in this period was the availability of feedstock from petroleum refineries. Units manufacturing nylon filament and polyester filament yarns are at Kota, Pimpri, Mumbai, Modinagar, Pune, Ujjain, Nagpur and Udhna

TABLE 25.16. Production of Selected Petro Chemicals (thousand metric tonnes)

	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Synthetic Fibres	2,251	2,524	2,343	2,600	2,791	2,697
Polymers	5,183	5,303	5,061	4,792	5,292	6,211
Elastomers (Synthetic Rubber)	95	104	96	105	94	88
Synthetic detergent intermediates	556	585	551	618	639	623
Performance Plastics	132	156	140	172	192	183
Total Major Petrochemicals	8,517	8,672	8,190	8,267	9,008	9,802

Source **:** India 2014, A Reference Annual, p. 547.

Acrylic staple fibre is manufactured at Kota and Vadodara. Plants of polyester staple fibre are at Thane, Ghaziabad, Manali, Kota and Vadodara.

Polymers

Polymers are made from ethylene and propylene. These materials are obtained in the process of refining crude oil in the refineries. Polymers provide the basic raw material for plastic industry. Among polymers, polyethylene is a widely used thermoplastic. Plastic is first converted into sheets, powder, resin and pellets, and then used for manufacturing plastic products. Plastic is a very useful industrial product in the modern day life.

Attempts to manufacture plastic polymers in India were made in late 1950s and early 1960s using other organic chemicals. The National Organic Chemical Industries Limited (NOCIL), instituted by the Mafatlal Group in 1961 started first naphtha based chemical industry at Mumbai. Later several other companies were formed. Mumbai, Barauni, Mettur, Pimpri and Rishra are major producers of plastic materials. The production of polymers (polyethylenes, polypropylene, poly-vinyl chloride and polystyrene) increased.

Production of polymers increased from 5,183 thousand metric tonnes in 2006-07 to 6,211 thousand metric tonnes in 2011-12, registering a growth rate of 19.8 per cent during this period.

The Plastic Processing Industry is making available quality products at reasonable prices to a diverse range of consumer demand in the country. There are about 20,000 units engaged in manufacturing various plastic products. Nearly three-fourths of these units are in small-scale sector which account for 20-25 per cent of total polymer consumption. With a total investment of ₹ 15,000 crore, the industry gives the annual turnover of ₹ 25,000 crore. The present installed capacity of these units is of the order of 6-7 million tonnes. The industry has an average annual growth rate of 15 per cent and employs three million people directly. The industry processes about 3.6 million tonnes of prime or virgin polymers and 1.4 million tonnes (or 30 per cent of the total of reprocessed materials (recycled plastic).

Elastomers, Surfactants and Performance Plastics. The production of elastomers which mainly comprise of styrene butadiene rubber and poly butadiene rubber (SRB and PBR) increased from 95 thousand MT in 2006-07 to 105 thousand MT in 2009-10, back-fell to 88 thousand tonnes in 2011-12 **(Table 25.16)**. With one plant of SBR lying idle in the country the capacity utilisation of these elastomers was just 55 per cent to 60 per cent.

Surfactant Intermediates, which are generally used in the detergent industry, comprise of Linear Alkyl Benzene and Ethylene oxide. There has been a growth in production of these surfactants from 556 thousand tonnes in 2006-07 to 623 thousand tonnes in 2011-12.

FERTILIZERS

Indian soils are generally deficient in fertilizing elements namely nitrogen, phosphorus and potassium and do not give high yields. It is, therefore, essential to feed these soils with chemical fertilizers so that their productivity increases. The significant contribution made by the chemical fertilizers can be seen from the impact of the Green Revolution on

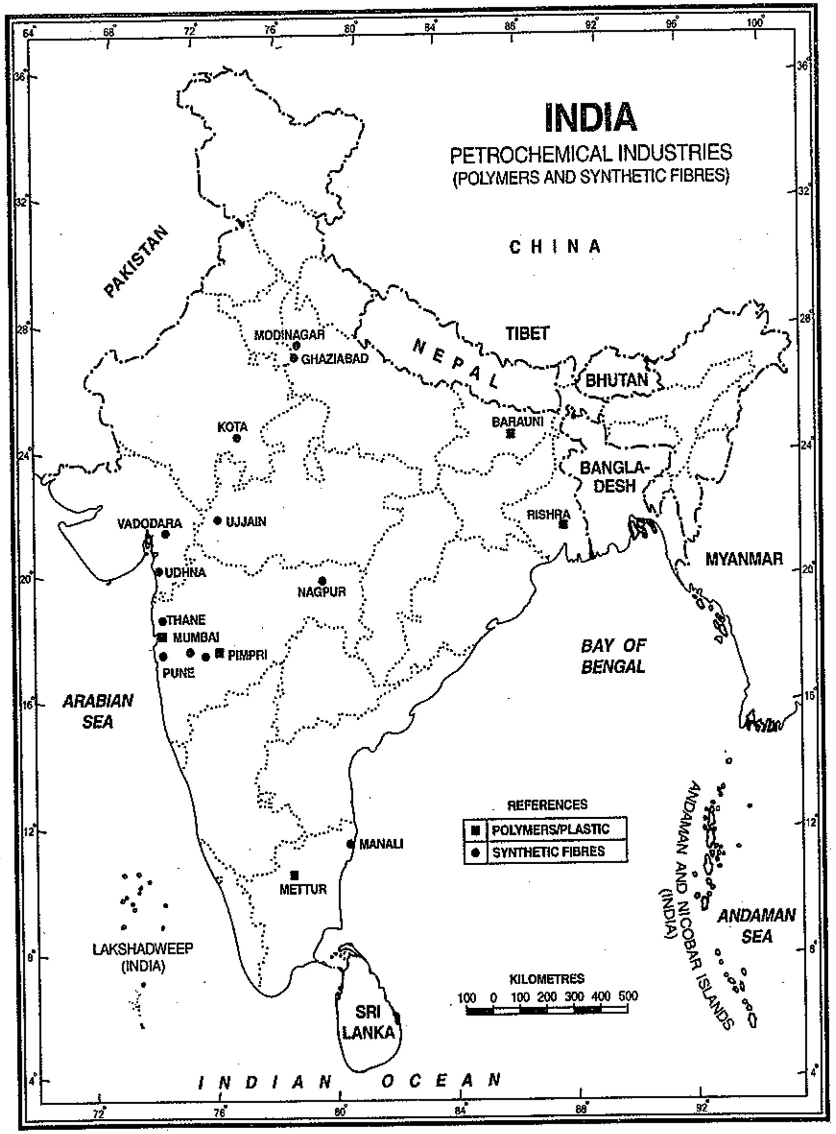


FIG. 25.11. India : Petrochemical Industries (Polymers and Synthetic Fibres)

Indian agriculture. The production of food grains increased from a miserably low of 50.82 million tonnes in 1950-51 to 255.36 million tonnes in 2012-13. The health and growth of the fertilizer industry is vital for increasing the growth of agricultural sector, to meet the foodgrain requirements of increasing population as well as increasing contribution to exports. We can ignore the significance of fertilizers for food production only at the cost of nation's welfare. The major role which fertilizers have played in raising the country's foodgrains production can be seen from the increase in fertilizer consumption from 0.55 kg per hectare in 1951-52 to 128.3 kg in 2011-12. This is much lower as compared to 368.7

kg/ha in Egypt, 209 kg/ha in Bangladesh, 269.7 kg/ha in Korea Republic, 265 kg/ha in Malaysia and 223.9 kg/ha in Vietnam.

Localisation

The localisation of fertilizer industry is closely related to petrochemicals. About 70 per cent of the plants producing nitrogenous fertilizer use naphtha as the basic raw material. That is why, most of the fertilizer plants are located near the oil refineries. However, some fertilizer plants draw their feed stock from steel slag as well as coke and lignite. Phosphatic fertilizer plants are primarily dependent upon mineral phosphate which is available in Uttar Pradesh, Madhya Pradesh and Rajasthan. Some plants are based on imported phosphate mineral. Sulphur is another important mineral used for manufacturing fertilizers. This is available in Tamil Nadu. During the recent years transportation of Neptha or Gas through rail or pipelines has facilitated the widespread distribution of fertilizer plants with priority to seaboard location. The HBJ Gas pipeline has given birth to six gas based fertilizer plants at Vijaypur, Jagdishpur, Aonla, Gadipan, Babrala and Shahajahanpur.

Growth and Distribution

A modest beginning with respect to manufacturing of chemcial fertilizers was made in 1906 when the first super-phosphate factory was set up at Ranipet in Tamil Nadu. The actual growth of fertilizer indsutry is mainly a post-Independence phenomena. The setting up of the Sindri plant by the Fertilizer Corporation of India Ltd. (FCI) in 1951 was a turning point and this industry did not look back after that.

It is now one of the fastest growing basic industries which has taken rapid strides in recent years. It produces a wide range of fertilizers to suit different soil and crop requirements in different parts of the country. India is now the third largest producer of nitrogenous fertilizers in the world only behind China and U.S.A. At present, there are 56 large size fertilizer units manufacturing a wide range of nitrogenous and complex fertilizers, including 29 units producing urea and 9 units producing ammonia sulphate as a by-product. Besides, there are about 72 medium and small scale units producing single superphosphate (SSP). The total installed capacity of fertilizer production which was 119.60 lakh metric tonnes in 2004, has marginally increased to 120.61 lakh metric tonnes in 2012-13.

Gujarat, Tamil Nadu, Uttar Pradesh, Maharashtra, Andhra Pradesh, Punjab and Kerala are the main fertilizer producing states and account for about half of the total fertilizers produced in India. Odisha, Rajasthan, Bihar, Assam, West Bengal, Goa, Delhi, Madhya Pradesh and Karnataka are the other producers.

1. Gujarat. Gujarat is the largest producer of fertilizers in India and accounts for more than one-fourth of the total production of nitrogenous as well as phosphatic fertilizers of the country. This state has more than 14% of the country's total installed capacity. Units at Vadodara and Kalol produce both nitrogenous and phosphatic fertilizers while units at Bharuch, Udhna, Kandla, Bhavnagar and Vadodara produce phosphates only. Two new plants have been set up at Hazira and Surat. Ahmedabad and Navsari are also important producers.

2. Tamil Nadu. This state accounts for about 11 per cent of the country's installed capacity. At present Tamil Nadu is the second largest producer of phosphatic fertilizers (about 16%) and the fourth largest producer of nitrogenous fertilizers accounting for nearly 9% of India. Nearly 65 per cent of the capacity is for nitrogenous fertilizers. Neyveli, Ranipet, Tuticorin, Ennore, Coimbatore, Mettur Dam, Cuddalore, Avadi and Manali are the main producing centres.

3. Uttar Pradesh. This state accounts for about 9 per cent of the country's total installed capacity. About 17 per cent of nitrogenous and 3.4 per cent of phosphate fertilizers of India are produced in Uttar Pradesh. Important centres of fertilizer production in Uttar Pradesh are Kanpur, Phulpur, Gorakhpur, Varanasi and Magarwara. New plants have been set up at Babrola, Aonla, Shahjahanpur and Jagdishpur.

4. Maharashtra. Maharashtra accounts for over 11 per cent of the nitrogenous and about 7 per cent of the phosphatic fertilizers of the country. The state has six plants in all. Mumbai with three plants is the largest producer. The remaining three plants are located at Trombay, Ambarnath and Loni Kalbhor.

5. Andhra Pradesh and Telangana These states together account for about 7 per cent of the total installed capacity and produces about 11 per cent of the phosphate and 3.5 per cent of nitrogenous fertilizers of India. The main centres of production are Vishakhapatnam, Ramagudam, Kakinada, Maula Ali (Hyderabad), Tadepalli, Tanukur and Nidadavole.

6. Odisha. Odisha has 6 per cent of the total installed capacity and produces 11.6 per cent of the phosphate and 3 per cent of nitrogenous fertilizers of India. The industry is located at Rourkela, Talcher, and Paradwip.

7. Kerala. Kerala also accounts for 6 per cent of the total installed capacity and produces about 6 per cent phosphatic and 3.5 per cent nitrogenous fertilizers of India. Its fertilizer units are located at Alwaye, Kochi and Karimnangalam.

8. Rajasthan. This state has 5 per cent of the country's total installed capacity and accounts for about 2.3 per cent of nitrogenous and 1.6 per cent of phosphatic fertilizers of India. More than half of the state's production comes from Kota. Debari, Khetri, Saladipur (Sikar district) and Chittaurgarh are the other important centres.

Others. *Bihar*—Sindri and Barauni, *Jharkhand*—Jamshedpur and Dhanbad, *Punjab*—Nangal and Bhatinda, *West Bengal*—Burnpur, Durgapur, Rishra, Kharda, Haldia, *Chhattisgarh*—Bhilai, Kumhari and Korba, *Assam*—Namrup and Chadrapur, *Karnataka*—Mangalore, Hubli, Mandya, Belagota and Munirchad, *Haryana*—Panipat, *Goa*—Sancoale (near Vasco) are other centres.

Public Sector Undertakings

The public sector undertakings are playing a dominant role in manufacturing chemical fertilizers. At present, there are 11 public sector undertakings under the administrative control of Department of Fertilizers.

1. The Fertilizer Corporation of India (FCI) was incorporated in January, 1961. It has four units one each at Sindri (Bihar), Gorakhpur (U.P.), Talcher (Odisha) and Ramagundam (Telangana). Its total installed capacity is 8.06 lakh tonnes of nitrogen.

2. The National Fertilizers Limited (NFL) was established on 23 August 1974. It has six units, *viz.*, the Calcium Ammonium Nitrate (CAN) plant at Nangal and the Urea plants at Nangal, Bhatinda, Panipat and Vijaipur (two units). It has a total installed capacity of 15.66 lakh tonnes of nitrogen and is the largest producer of nitrogenous fertilizers in the country.

3. The Fertilizers and Chemicals Travancore Limited (FACT) has three operating units out of which one is at Udyogamandal and two are at Kochi.

4. The Rashtriya Chemicals and Fertilizers Ltd. (RCF) is operating five fertilizer plants at Trombay set up during the period from October 1965 to July 1982 and a large gas-based fertilizer plant at Thal which started production in 1985. The installed capacity of RCF plants is 9.55 lakh metric tonnes of nitrogen and 1.20 lakh metric tonnes of phosphate.

5. The Hindustan Fertilizer Corporation Limited (HFCL) has total annual installed capacity of 6.54 lakh tonnes of nitrogen. Out of a total of five units under its control, three are at Namrup (Assam) and one each at Durgapur (W. Bengal) and Barauni (Bihar). HFCL and Fertilizer Corporation of India (FCI) were declared sick in November 1992. After considering the rehabilitation proposals of these two PSUs, the Government decided to close down HFCL and FCI on 5th September, 2002, excepting its Jodhpur Mining Organisation which has been hived off into a new company.

6. The Madras Fertilizers Limited (MFL) is a joint venture of the Government of India and the National Iranian Oil Company. Its plant at Manali (Chennai) has an annual installed capacity of 3.67 lakh tonnes of nitrogen and 1.43 lakh tonnes of phosphate.

7. Pyrites, Phosphates and Chemicals Limited (PPCL) was set up in March 1960. It is engaged in exploration of pyrites deposits as well as production of single super phosphate at Amjhore (Bihar), exploration-cum-production mining of pyrites deposits at Saladipura in Rajasthan and mining of rock phosphate ore from the Mussoorie phosphorite deposits. The company was declared as a sick company in April 2000 and was closed down on November 20, 2000.

8. Project and Development India Limited (PDIL) formerly known as Fertilizer Planning and Development India Limited, is engaged in design,

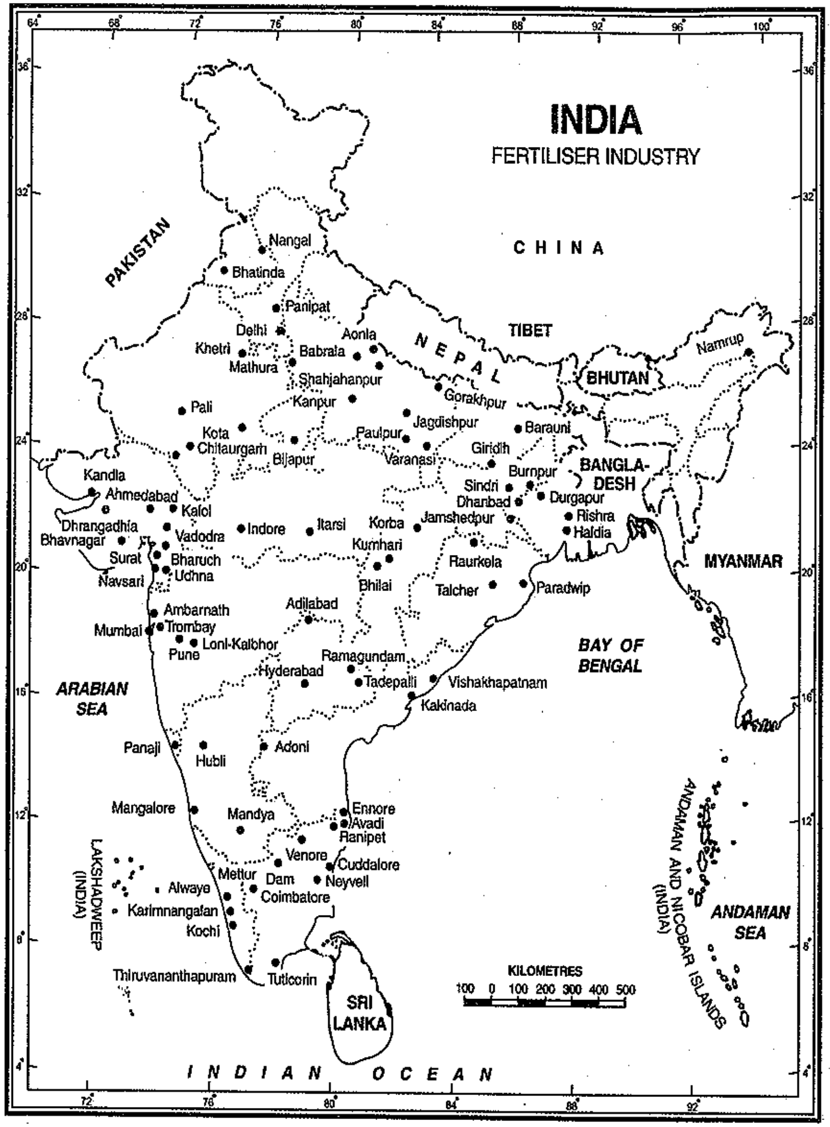


FIG. 25.12. India : Fertilizer Industry

engineering, procurement and supervision of construction/commissioning of fertilizer and allied chemical plants. The company was declared as a sick company in December, 1992 and was closed down in April 2003.

9. Paradwip Phosphates Limited (PPL) was established in Dec. 1981 for setting up phosphatic fertilizer complex at Paradeep in Odisha. Phase I and II of this project went into commercial production in 1986 and 1992 respectively.

10. Brahmaputra Valley Fertilizer Corporation Limited (BVFCL) has been constituted into a new company from April 1, 2002 after hiving off the Namrup units of HFC. Units I and III of

BVFCL have been commissioned in March 2002 after their revamp.

11. FCIL-Arawali Gypsum and Mineral India Limited (FAGMIl) has been incorporated on February 14, 2003 after hiving off Jodhpur Mining Organising from FCI. Apart from taking over the Jodhpur Mining Organisation which is engaged in mining of Gypsum in four districts of the Rajasthan, the new company is engaged in mining other minerals in Rajasthan.

Cooperative Sector

Two organisations are very active in the cooperative sector. Indian Farmers Fertilizer Cooperative Limited (IFFCO) is a federation of over 24,000 cooperative societies. It was incorporated in November 1967 and has five operating units, one each at Kalol and Kandla in Gujarat and Phulpur and Phulpur Extension, and Aonla Extension in Uttar Pradesh. At present, IFFCO's installed annual capacity in terms of nutrients is 20.16 lakh metric tonnes of nitrogen and 8.25 lakh metric tonnes of phosphate. Krishak Bharati Cooperative Limited (KRIBHCO) was incorporated in 1985. It has a gas based urea-ammonia plant at Hazira in Gujarat with a capacity to produce 7.95 lakh metric tonnes in terms of nitrogen per annum.

Private Sector

A number of private companies are also engaged in manufacturing fertilizers. Some of the important companies are IEL (Kanpur), SRC (Kota), GNFC (Bharuch), Coromandel, (Vishakhapatnam), ZACL (Goa), EID Pary (Ennore), GSFC (Vadodara), SPIC (Tuticorin) and MFC (Mangalore). Their combined installed capacity is about 20 lakh tonnes per annum.

Imports

Although India is the third largest fertilizer producing country, she is also the third largest consumer of fertilizers in the world. There has always been a big gap between production and consumption of fertilizers in the country and the gap is widening with the passage of time. Even with a higher level of indigenous production, the gap between consumption and availability from indigenous sources increased considerably. **Table 25.17** shows the trends of fertilizer imports in India.

The table 25.17 shows that imports of fertilizers and fertilizer manufactures has increased tremendously during in last few years. India meets about half of the requirements of fertilizers through imports. However, strenuous efforts are being made to reduced undue dependence on imports.

India imports fertilizers from a large number of countries. The major suppliers of fertilizers to India are the USA, Russia, Canada, Japan and some European countries. A marginal fall in imports, both in terms of quantity and expenditure has been observed between 2011-12 and 2013-14.

CEMENT INDUSTRY

Cement is indispensible for building and construction work and cement industry is considered to be an important infrastructure core industry. It is one of the most advanced industries of India. In a developing country like India, the cement industry can play a significant role in the overall economic growth. The per capita consumption of cement is taken as one of the important indicators of well being of the people. The average per capita consumption of cement in India is 110 kg against the world average of 260 kg. This is much lower than some of the advanced countries and there is vast scope for improving the situation. India is currently on a fast track of economic growth and if the present growth trends continue, the per capita consumption is expected to touch 150 kg in 2020 even in the face of fast growing population.

TABLE 25.17. Imports of Fertilizers and Fertilizer Manufactures in India

Year	1960-61	1970-71	1980-81	1990-91	2000-01	2010-11	2011-12	2012-13	2013-14
Quantity (Thousand tonnes)	307	2,392.7	5,560.2	7,560.3	7,423.4	20,658.9	27,840.1	24,117.3	22,154.2
Value (₹ crore)	13	86	818	1,766	3,034	31,533	53,311	47,722	38,231

Source : The Economic Survey 2012-13, pp. A-84-86 and 2013-14, Statisical Appendix, pp. 71-73.

Locational Factors

Manufacturing of cement requires heavy, low value and weight loosing materials and is primarily a raw material oriented indsutry. Limestone is the main raw material and comprises 60-65 per cent of the total product by weight. On an average 1.5 tonnes of limestone are required to produce one tonne of cement. Hence, the location of a cement plant is based on the limestone deposits. The other raw materials used are sea shells, slag from steel plants and fertilizer plants and these raw materials influence the localisation of cement industry in their own way. Silica (20-25%) and alumina (5-12%) are also important ingredients. Gypsum is necessary to regulate the setting time of cement. Power is used in raw material grinding, clinkerisation of limestone in the kiln operation and clinker grinding along with gypsum to form cement. The older plants required 120 to 130 units of electricity per tonne of cement produced. Modern energy efficient plants consume only 80 to 90 units of electricity per tonne. Coal is another major input along with electricity and forms 40 per cent of the total cost. Coal is used not only as fuel in the kiln but also to burn the limestone. The ash of the burnt coal combines with the limestone to form clinker. On an average 250 kg of coal is required to produce one tonne of cement. The quantum of other materials required to produce one tonne of cement are 4 kg of gypsum, 0.4 kg of bauxite and 0.2 kg of clay.

Cement and its raw materials are low value bulk materials and the transportation over long distance by rails and roads involves huge costs. Some of the transportation cost on transporting limestone is reduced by beneficiating this mineral at the quarry heads. The transportation cost is also reduced if the manufacturing plant is located near the market. In fact ready market is the pre-requisite for the proper growth of an industry producing heavy commodity with low specific value like cement.

It is obvious from the above discussion that availability of raw materials, bulk transport facilities at reasonably low cost and market are the three main localisational factors, in that order, which favour the growth of cement industry in India.

Growth of Cement Industry

The first attempt to manufacture cement in India was made in 1904 when a mill based on sea shells as a source of limestone was established at Chennai. But this attempt proved abortive and a really successful attempt was made in 1912-13 when the Indian Cement Co. Ltd. set up a plant at Porbandar. World War I gave impetus to cement industry in India. Consequently, Katni Cement and Industrial Co. Ltd. at Katni (M.P.) started production in 1915 and Killick Nixon's Bundi Portland Cement Co. at Lakheri (Rajasthan) commenced in 1916. A number of companies came into existence to make use of the post war boom. Six new factories at Dwarka (Gujarat), Japla (Bihar), Banmore, Mehgaon, Kymore (M.P.) and Shahabad (Karnataka) were erected by 1922-23. Cement Production virtually took off the ground only after tarrif protection was granted to this industry in 1924. A turning point came in 1934 when 10 out of 11 existing companies merged into the Associated Cement Co. Ltd. (ACC). The Dalmia Cement Group was also formed in 1937. This group set up factories at Dalmianagar (Bihar), Dalmiapuram (Tamil Nadu) and Dalmia (Charkhi) Dadri in Haryana. By 1947, there were 18 cement factories with a capacity of 21.15 lakh tonnes and production of 20.16 lakh tonnes. Rapid economic progress associated with massive building programmes during the plan period accelerated the demand for cement and provided stimulus to this industry. India achieved self-sufficiency in cement only in 1980s during the short five year period of partial decontrol. Prior to that Indian cement industry had seen days of total controls, partial decontrols and imports. This industry was totally decontrolled in March, 1989 and it grew by leeps and bounds in 1990s. Today, in terms of quality, productivity and efficiency, the industry is second to none in the world. Its technology is state-of-the-art, its cost of production is one of the lowest in the world and its productivity is easily one of the highest.

Currently, the Indian cement industry is the second largest in the world after that of China. With a turnover of around ₹ 30,000 crore, the industry is the second biggest contributor to the exchequer. The Central government gets about ₹ 4,000 crore from excise duty and various state governments another ₹ 4,000 crore from sales tax, yet another ₹ 2,000 crore comes from royalties, octroi and cesses. The industry provides direct employment to 1.5 lakh

persons and indirect employment to 1.2 million persons. The industry comprises 183 large cement plants with an installed capacity of 324.9 million tonnes and more than 350 mini plants with an estimated capacity of 11.10 million tonnes as on 31st March, 2013. These plants are scattered in almost all parts of the country. The mini plants play a supplementary role. The concept of mini plants was accepted by the Government in 1979 to exploit smaller deposits of limestone scattered in remote and inaccessible areas. This concept was supported by incentives like 50 per cent reduction in excise duty. The main advantage of mini cement plants is that they provide employment opportunities to rural and remote areas and make cement easily available there. Further, they help in dispersal of production capacity and reduce strain on transportation infrastructure. Over 60 companies are engaged in the production of cement. The industry has been going through a period of re-alignment or consolidated 1970s. The supply of cement in the open market was very scarce and building activity was badly hampered inflicting a severe blow to infrastructure development. The government took initiative to remove control on price and distribution of cement in 1989 and the industry was de-licensed in 1991 under the Industrial (Development and Regulation) Act, 1951. Since then, this industry has progressed at a fast rate both in capacity/production as well as in process technology. In due course of time, Indian cement industry has efficiently managed to keep pace with the global technological advancement. The induction of advanced technology has helped the industry immensely to improve its efficiency by conserving energy, fuel and addressing the environmental concerns.

There has been impressive growth in the installed capacity during the last few years and the momentum is likely to continue in the future also (**Table 25.18**).

The production of cement has increased considerably during the plan period. It increased from a low of 2.7 million tonnes in 1950-51 to 8.0 million tonnes in 1960-61, 1970-71, 48.8 million tonnes in 1999-91 and 223.5 million tonnes in 2011-12 (**Table 25.19**).

Given the enormous need for infrastructure and housing, which require large quantities of cement as a basic building material, the prospects of industry are bright. The Working Group on Cement Industry for the formulation of Tenth Five Year Plan and other studies on global competitiveness of the Indian cement industry highlight constraints such as high cost of power, high freight cost, inadequate infrastructure and poor quality of coal. In order to utilize the excess production capacity available with

TABLE 25.18. Installed capacity of Projection (in million tonnes)

Ending March	Base Line	Base line + Concrete Roads	Base Line + Roads + Housing	Base Line + Road + Housing + Fiscal support
2011	323.2	323.2	323.2	323.2
2012	336.1	336.1	336.1	336.1
2013	349.6	349.6	349.6	349.6
2014	363.1	369.8	373.2	374.9
2015	386.1	396.9	402.3	405.1
2016	413.3	428.7	436.6	440.6
2017	442.5	463.3	473.3	479.3

Source : India 2014, A Reference Annual, p. 491.

TABLE 25.19. Production of Cement in India (Million tonnes)

Year	1950-51	1960-61	1970-71	1981-81	1990-91	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Production	2.7	8.0	14.3	18.8	48.8	99.2	140.5	154.7	167.6	181.4	200.7	209.7	223.5

Source : Economic Survey 2012-130, p. A-32.

the cement industry, the Government has identified the following thrust areas for increasing demand :

- Further push to housing development programmes.
- Promotion of concrete highways.
- Use of ready-mix concrete in large infrastructure projects.
- Construction of concrete roads in rural areas under Prime Minister's Gram Sadak Yojana.

The Indian Cement industry today produces 11 varieties of cement including ordinary portland cement (71%), portland pozzolana cement (18%) and portland blast furnace slag cement (10%). The balance one per cent is of all special cements including white cement.

Distribution

A look at the distribution pattern of cement factories reveals that they are mainly concentrated along the Vindhayan ranges—running from eastern Rajasthan to Jharkhand—where abundant supply of good quality limestone is available. In fact limestone deposits have acted as big magnets for attracting cement factories and rarely a factory in this region is situated at a distance of over fifty kilometres from the limestone quarries. The vast northern plain, on the other hand, is devoid of limestone deposits and does not support cement factories to any appreicable extent. It is for this constraint of raw material that 86 per cent of the factories and 75 per cent of the production capacity is found in Madhya Pradesh, Chhattisgarh, Andhra Pradesh, Rajasthan, Madhya Pradesh, Chhattisgarh, Gujarat, Tamil Nadu, Karnataka and Bihar.

Andhra Pradesh and Telangana. With 15 per cent of the total installed capacity and about 18 per cent of the total production of India, Andhra Pradesh along with Telangana occupy first place among the cement producing states of India. Most of the 21 plants are concentrated in the Telangana belt. The location of plants along the trunk rail route skirting the plateau along its junction with the coastal plain offers the best advantages with respect to raw material, market and transport. Peddapalli is the biggest plant with an installed annual capacity of 7 lakh tonnes. The other important producers are Krishna, Karimnagar, Cementnagar, Vijaywada, Panyon, Macherla, Mancherial, Tandur, Vishakhapatnam, Vizianagram, Nadikundi, Erranguntla, Yerranguntala, Adilabad, etc. Several mini plants are also functioning.

Rajasthan has surpassed Tamil Nadu and is now the second largest cement producing state accounting for over 13 per cent of India. The major cement plants skirt the Aravali Range where plenty of limestone is available. The large scale conversion of metre gauge railway lines into broad gauge has given the much needed improved transport facilities and stimulate cement industry in this region. The state has 10 major plants and the main centres of production are Sawai Madhopur, Lakheri, Chittaurgarh, Udaipur, Nimbaheda and Sirohi. With an annual capacity of 8.5 lakh tonnes, the plant at Sawai Madhopur is the largest in Rajasthan.

Madhya Pradesh. Madhya Pradesh is the third largest producer of cement in India after Andhra Pradesh (including Telangana) and Rajasthan. Its major production units are in the limestone rich districts of Satna, Katni, Rewa and Neemuch. These are located at Kaimur, Katni, and Bammore (Katni), Satno, Maihar (Satna), Vikramnagar (Neemuch), Kharadia (Dhar), Itarsi (Hoshangabad) and Damoh. This state supplies large quantities of cement to the neighbouring Uttar Pradesh.

Tamil Nadu. With an installed capacity of about 11 per cent of all India capacity, this state has 13 plants in different areas. Larger units are located at Talaiyuthu (Tirunelveli), Alangulam, Tulukapatti (Ramnathpuram), Dalmiapuram, Poliyur, Alathiyur (Tiruchirapalli), Sankaridurg (Salem) and Madukkarai (Coimbatore).

Gujarat. With an installed capacity of 13.93 million tonnes, Gujarat is the fourth largest cement producing state in India. This state had the advantage of an early start and the earliest successful attempt to manufacture cement was made at Porbandar. The industry enjoys the benefit of large deposits of limestone in the state. Besides, sea shells can also be used. Large market of Western India is readily available. Ten plants of the state are located at Sika, Sevolia, Okha, Porbandar, Dwarka, Vadodara, Ranavav, Veraval and Bhavnagar.

Maharashtra. Maharashtra is perhaps the largest cement consuming state in India due to on going construction of a mega-structures like big malls, roads, bridges, etc. With an installed capacity of about 10.9 million tonnes, this state has its major cement factories at Chanderpur, Ratnagiri, Saweri, Mumbai, Battam and Kolhapur.

Karnataka. High quality cement grade limestone occurs in Bijapur, Gulburga, Chitradurga, Mysore, Simoga and Tumkur. The state has a total installed capacity of about 9.8 million tonnes. Bagalkot, Bhadravati, Shahabad, Ammasaudram, Wadi, Bengaluru and Krukunta are the main centres. The Shahabad unit is the largest and the only factory

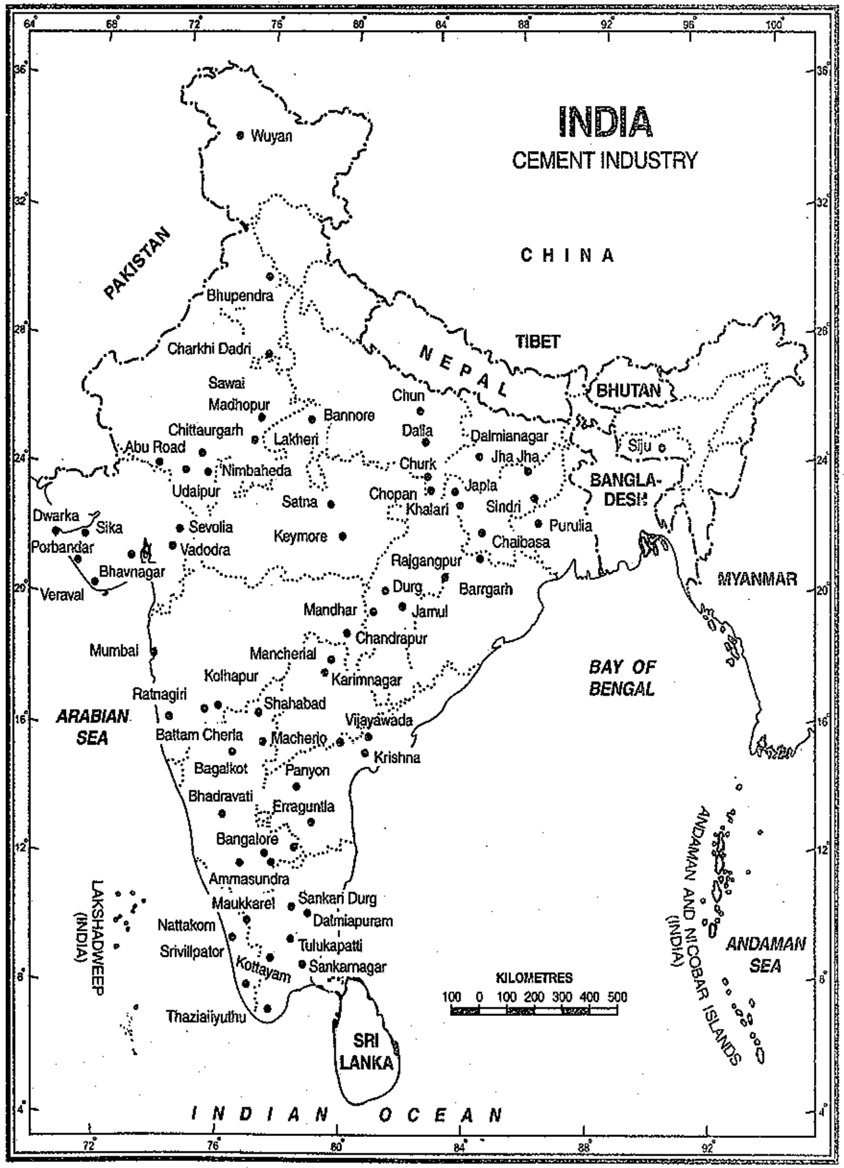


FIG. 25.13. India : Cement Industry

producing oil well cement in India currently. Two new units have come up at Hosdurga (Tumkur) and Tornagalu.

Chhattisgarh. This state has 6% of India's total limestone reserves and has an installed capacity of about 8.4 million tonnes. Chhattisgarh has 7 cement factories of which the larger ones are at Jamul (Durg), Mandhar and Modigram (Raipur), Lulli, Tilda and Akaltara (Bilaspur).

Jharkhand. Jharkhand has 5 cement plants with a total installed capacity of 5.9 million tonnes. Three plants are located at Sindri, Khalari (Ranchi), Bhavnathpur (Palam), Chhaibasa, Khodri and Jhikhani (West Singhbhum).

Uttar Pradesh. The main limestone deposits are found in the Upper Son Valley, where five cement manufacturing plants have been established. The major centres of production are Churk, Dalla, Chunar and Jhansi.

The other producers are **Himachal Pradesh** (Rajban in Sirmur district and Gagal in Bilaspur district), West Bengal (Durgapur, Purulia and Madhukunda), Odisha (Rajgangpur and Bargash), Haryana (Bhupendra), Bihar (Banjari, Japla and Chopan), Meghalaya (Cherrapunj and Garo), Nagaland (Waziho in Tunsang and Garampani), and Jammu and Kashmir (Basholi in Kathua district and Kharan in Baramula district).

Exports

From a net importer, India has emerged as a major exporter of cement in the international market. She entered the world cement scenario after 1989 when the production of cement increased considerably as a result of decontrolling the cement industry. The main buyers of Indian cement are Sri Lanka, Bangladesh, Myanmar, Indonesia, Malaysia, Nepal, Pakistan, Middle East countries and South-East Asian countries. The exports to these countries are likely to increase as they do not have appreciable deposits of limestone and cannot develop cement industry on their own.

Problems

Cement industry in India is facing a large number of problems. Some of the more serious problems are briefly described as under :

1. Inadequate Transport Facilities. The main raw materials (limestone, coal, gypsum, etc.) and the end product of cement industry are cheap and bulky and cannot afford high cost and inadequacy of transportation. It is estimated that transport of raw materials and furnished product accounts for 25-30 per cent of the total cost of cement manufacturing and supplies to the consuming areas. For example, cement plant at Sawai Modhopur in Rajasthan uses coal from Dhanbad mines in Jharkhand about 1,300 km away and supplies cement to consumers in Srinagar about 1,100 km away. Cement has short shelf life and should be dispatched to the consuming centres without any loss of time. All these factors require quick, cheap and efficient means of transportation for cement immediately after it comes out of the manufacturing plant. Earlier, railways used to be the main source of transporting cement but shortages of wagons, delays in transit and frequent increase in freight made this mode of transportation unattractive to the cement manufacturers. Consequently, a shift was noticed in favour of road transportation after 1989 and 60 per cent of the current needs of cement industry are met by the road transport.

2. Shortage of Coal. As mentioned at the outset, it requires about 250 kg of coal to produce one tonne of cement. Coal in India is always in short supply and most of the Indian coal varieties are of poor quality. Further, most of the coal reserves are concentrated in the north-eastern part of the peninsular plateau area and it becomes difficult to supply coal to areas located at large distances from the main coal producing region.

3. Shortage of Power. Currently, India is a power starved nation and the country is facing a serious power crisis. Although the consumption of power has come down from 120-130 units to 80-90 units per tonne of cement by using energy-efficient methods originating from the new technology, yet the industry is facing perpetual problem of power shortage. Load shedding and frequent declared and undeclared power cuts is a routine matter. This problem can be solved by increasing the power production.

4. Low Per Capita Consumption. Although there had been a spurt in the total consumption of cement in the country, the per capita consumption of cement in the country is still at a miserably low level.

TABLE 25.20. Production of tyres in India (in millions)

Year	1950-51	1960-61	1970-71	1981-81	1990-91	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Automobile tyres (truck/bus)*	NA	1.5	3.8	8.0	20.1	29.3	11.8	12.1	12.8	12.0	13.8	13.5	13.5
Cab/car tyres*	NA	NA	NA	NA	NA	NA	10.2	11.8	13.9	14.0	15.9	20.0	19.5

NA : Not Available. *New items/change in specifications, hence data prior to 2005-06 may not be comparable.
Source : Economic Survey, 2012-13, p. A-32.

Thus there is an overall shortage of demand for cement and the manufacturers do not get a ready market for their product. With new projects coming up very fast, it is hoped that there will be increase in consumption of cement and manufactures will not find it difficult to search for buyers of their product.

RUBBER GOODS INDUSTRY

Although nascent, rubber goods industry has emerged as an important industry in India. It covers a wide range of products such as tyres and tubes of all kinds, footwear, surgical gloves, prophylactics, conveyor and vee belts, hoses, instruments, sports goods, rubber coats and a host of other products.

The most important segment of rubber industry is constituted by tyres and tubes. At present, the industry has 32 tyre producing units spread over 13 states with about 220 medium scale units and over 5,500 units in the small scale sector, with an equal number in tiny sector having an annual turnover of over ₹ 12,000 crore. It directly employs about 3.5 lakh people. The number of automobile tyres (truck/bus) produced in 1960-61 was just 1.5 millions which rose to 13.5 millions in 2011-12. Similarly the number of car/cab tyres increased from 10.2 millions in 2005-06 to 19.5 millions in 2011-12 (**Table 25.20**)

India is one of the few countries which has attained self sufficiency in manufacturing a wide range of tyres for all applications. Currently, Indian tyre industry consists of 39 companies with 60 tyres manufacturing plants. Large tyre companies are namely MRF Ltd., Apollo Tyres, JK Tyres, Ceat, Goodyear and Modi Rubber etc. Three Indian companies namely MRF Ltd., Apollo Tyres and JK Tyres are in the list of top 25 global tyre companies. The annual turnover of the tyre industry was about ₹ 45,000 crore during 2012-13. Indian tyre market is growing rapidly and in order to meet the growing demand, major tyre companies have taken up the new expansion projects. New tyre projects to the tune of ₹ 7,929 crore have been completed upto 2012-13 and projects involving investment of about ₹ 1,340 crore are under implementation which are likely to be completed during the remaining period of XII Five Year Plan.

India has become a major tyre exporting country and has a track record of exporting to over 75 countries. During 2012-13, India exported tyres worth ₹ 9,191.5 crore. India also imports tyres mainly from China and Thailand. During 2012-13 tyres worth ₹ 2,559.18 crore were imported.

Rubber footwear is another important item of rubber goods industry. Among the hoses, radiator and vacuum hoses are the most important. Fan belt is another important item.

LEATHER AND LEATHER GOODS

India has the largest number of livestock in the world and has an old tradition of processing leather and manufacturing leather goods. This industry has been carried on in India at the village level since Vedic times. The two major sectors of this industry are tanning and goods manufacturing.

Tanning

Tanning of hides and skins is an old and a very important sector of leather industry. Raw leather has to be tanned before use so that it can be given proper colour, strength and shine. The first tannery was set up at Kanpur in 1867. At present, Kanpur, Chennai and Kolkata are three large tanning centres in the country. The other important tanning centres are Agra, Bengaluru, Belgaum, Bhopal, Mokameh (Bihar), Phulbani (Odisha), Sherbaug (Gujarat).

Kapurthala (Punjab), Pallavaram, Trichirapalli, Perambur, Eluru, etc. Besides, there are about 300 small tanneries.

Tanning industry has become the target of severe criticism from environmentalists and several agencies because waste discharge from the tanneries has led to large-scale environmental pollution. This has called for the development and implementation of new and improved technologies for enabling the leather industry to comply with pollution control standards. The role of alternatives in the tanning sector is widely recognised. State-of-the-art technologies for leather chemicals and cleaner production are being developed and new technology is being absorbed at a rapid pace. Tanning without wasteful discharge of chromium, fashion dyed leather without the support of mineral tanning, reduction of salt, sulphide and many other environmentally disconcerting chemicals in tanning waste are now possible. The need of the hour is to adopt these technologies without any reservations and without further loss of time. The Central Leather Research Institute (CLRI) at Chennai is the largest of its kind in the world. It has developed a number of techniques for the benefit of the Indian leather industry.

The first meaningful intervention by the government in leather sector came in 1992 in the shape of United Nations Development Programme (UNDP) sponsored "National Leather Development Programme (NLDP)." During the Ninth Plan period Tannery Modernisation Scheme (TMS) was implemented successfully on pilot basis. A total number of 109 tanneries in SSI and Non-SSI sector were taken up for upgradation and modernisation of technology.

Leather Goods

India produces a large variety of leather goods including footwear, suitcases, bags and portfolios, ladies handbags, belts and several industrial accessories. However, footwear is the most important of all the leather goods and far excels others.

Manufacturing of footwear has been tradition bound and India is now one of the top ten producers of footwear in the world. Vast raw material resources, skilled manpower, developed expertise, low labour costs and foreign collaboration have given fillip to Indian footwear industry. After 1991, this industry witnessed profound changes as a result of liberalisation policy and due to globalisation of economy. Consequently, the production increased tremendously, both of the Indian style and the western style footwear.

The Indian footwear industry can be divided into three segments—large organised units, small scale sector and tiny cottage industry. Under large units come Bata, Carona and Tata, small scale units include Liberty, Wasan, Aero, Bajaj, Tej and Lakhani. Large scale units contribute 7-8 per cent of the exports while the bulk is provided by the small scale units. The tiny cottage units contribute the bulk of production and offer their products to the domestic market. The main centres of producing leather shoes, shoe uppers and leather sandals are Chennai, Ranipet, Ambur, Vaniambadi, Mumbai, Kolkata, Kanpur, Agra, Kolhapur, Delhi, Jalandhar, Bengaluru, Hyderabad, Batanagar, Faridabad and Jaipur.

Exports

India has been a traditional exporter of raw hides and skins. But the scenario has undergone much change and now India is emerging as a strong contender of leather goods exports in the world market. In 2011-12, leather and leather manufactures including leather footwear, leather travel goods and leather garments worth ₹ 22,973 crore were exported. The industry has identified major export markets in the U.S.A, Germany, U.K., France, Japan, Australia and Russia. With the adoption of new technologies, Indian leather goods would be able to meet the international standards and exports are expected to increase substantially.

PLASTICS

This industry made a humble beginning in 1945 but has registered a fast growth since then. The growth accelerated in the 1960s and with the liberalisation of Indian economy in 1991, it has shown tremendous growth and diversification and is now the star performer along with other fast growing industries like electronics, computers and white goods. Whereas the developed world has reported 3-4 per cent growth, the Indian plastic industry has reported double digit growth each year. It is now estimated that the plastic

industry in India will grow at a rate of over 15 per cent per annum for several years to come.

The wonders of plastics cut across all sections of society. Due to its moulding capacity, its versatility, its non-corrosive and moisture resistant properties, its physical and chemical strength, its economic viability, its easy processability and also its attractiveness and durability in all weather conditions, it has become a material of choice and of universal use. The major uses of plastics are in the packaging industry, building industry and in the manufacturing of pipes, fittings, electrical accessories, consumer goods, houseware, toys, furniture and in host of other spheres of life. A time has come when plastics industry has the capacity to influence the progress of all other sectors. Plastic industry is regarded as '*sunrise*' industry due to its increasing versatility and burgeoning worldwide demand. *No wonder we are living in the plastic age.*

At present, the plastic industry produces goods from virgin and reprocessed polymer products. This sector provides employment to over 10 lakh skilled people directly and indirectly. That is why, the Governement has accorded it a *thrust industry status*. High growth in user segments such as retail packaging and building construction as well as in pipes, bulk packaging and agricultural use are expected to increase polymer demand tremendously making India the third largest polymer consumer after the USA and China. The low per capita polymer consumption is a pointer to the sector's immense growth potential. Mumbai, Delhi, Kolkata, Chennai, Bengaluru, Vadodara, Vapi, Kanpur, Amritsar, Coimbatore, Bongaigaon, Barauni, Mettur, Durgapur, Pimpri (Pune), Rishra, etc. are some of the outstanding centres which are well known for the production of either plastic raw materials or finished plastic goods. The Government has set up the Central Institute of Plastics Engineering and Technology (CIPET) at Chennai with the primary objective to develop skilled manpower and provide tehnical services to the plastic industry. To meet the growing demand of trained personnel, CIPET has set up nine extension centres at Ahmedabad, Amritsar, Bhopal, Bhubaneshwar, Hyderabad, Imphal, Lucknow and Mysore including the headquarter centre at Chennai. A service centre and a training centre of CIPET have also been opened at Goa and Patna respectively.

Exports

Though exports of plastics from India is a recent development, the country has made a big dent in the international market. Kuwait, Saudi Arabia, Egypt, Kenya, Nigeria, Iraq, Syria, U.K., Thailand, Sri Lanka, and a number of other countries are the regular buyers of Indian plastic goods.

Prospects and Problems

The plastic goods industry in India has bright prospects and serious problems stored for it in the time to come. As mentioned earlier, the plastic goods have universal acceptability and their production and use will grow unhindered. The per capita consumption of plastics in India at 3.6 kg is far below the global average of 21.5 kg. Thus there is great scope for expanding this industry. There are tremendous investment opportunities in downstream investments to the tune of $ 3.7 billion at a compound annual growth rate of 11 per cent. The fructification of new investments is estimated to raise plastic consumption from the present level of 3.6 million tonnes to 20 million tonnes in 2020. This will create millions of unskilled and semi-skilled jobs and change the export profile from raw materials to value added plastic products. But the unprecedented growth in the use of plastics as a packing material has created a serious problem of solid waste disposal. Plastic is a non-biodegradable substance and creates problems of environmental pollution. Many advanced countries are seriously thinking of reverting back to conventional packing materials, thereby dealing big blow to this industry. However, Indian plastic industry may thrive on the recycling of the used plastic material for which ragpickers can make valuable contribution. Recycling solves the problem of waste disposal, lessens the burden on raw materials, lightens the pressure on the biosphere and provides jobs to millions. It may be mentioned here that this process needs technological development and upgradation.

DRUGS AND PHARMACEUTICALS

The growth of drugs and pharmaceutical industry in India is primarily a post-Independence phenomenon. Before Independence, bulk of drugs were imported and only processing and formulations were done in the country. This industry has made tremendous progress during the last 50 years. The growth rate of this industry has been about ten per cent per annum, consistently for the last more than three decades. Today, India is in a position to meet 95 per cent of her requirements of bulk drugs and almost all the requirement of formulations. The present production covers a wide range of bulk drugs including antibiotics, vitamins, steroids and hormones, semi-synthetic penicillins, synthetic phytochemicals and biological products besides, practically the entire range of formulations required by the medical profession.

The industry is likely to grow rapidly in times to come.

Drug prices in India are some of the lowest in the world and India has one of the largest inventories of highly skilled pharmaceutical professionals. Modern drugs reach only 40 per cent of Indian population mainly in urban and semi-urban areas. Obviously the potential for growth in the domestic market is enormous.

There are about 250 units in the organised sector, five of these in the public sector (IDPL, HAL, SSPL, BCPL and BIL) and six in the joint sector. There are 21 MRTP companies and six FERA ones. About 5,000 units in the small scale sector are also engaged in the production of drugs. Of these, over 100 units are engaged in the production of bulk drugs.

Indian Drugs and Pharmaceuticals Limited (IDPL) a premier undertaking was incorporated on 5 April 1961. It has five plants located at Rishikesh for the manufacture of synthetic drugs, at Chennai for surgical instruments, at Gurgaon for formulations, Hyderabad (synthetic drugs plant) and at Muzaffarpur for drugs and chemical intermediates. Besides, IDPL has three subsidiary companies set up in association with the state governments. These are Rajasthan Drugs and Pharamaceuticals (RDPL), Jaipur, Uttar Pradesh Drugs and Pharmaceuticals Ltd. (UPDPL), Lucknow and Odisha Drugs and Chemicals Ltd. (ODCL), Bhubaneshwar.

Hindustan Antibiotics Limited (HAL) was incorporated on 1 March 1954. It is engaged in manufacturing Penicillin, Streptomycin, Amcillin, Hamycin, Gentamycin and Aureofungen, besides formulations. It has three subsidiary companies set up in collaboration with the state governments. They are (*i*) Maharashtra Antibiotics and Pharamceutical Limited (MAPL), Nagpur, (*ii*) Karnataka Antibiotics and Pharmaceuticals Limited (KAPL), Bengaluru and (*iii*) Manipur State Drugs and Pharmaceuticals Limited (MSDPL) Imphal.

The Government has also nationalised three sick units at Kolkata. These units have been converted into public sector companies. They are (*i*) Bengal Immunity Limited (BIL), (*ii*) Bengal Chemicals and Pharmaceuticals Limited (BCPL) and (*iii*) Smith Stanistreet Pharmaceuticals Ltd. (SSPL)

The leading companies in the private sector are Ciba, Sarabhai, Hoechst, Alembic, Glaxo, Unichem, Pfizer, Chemo Pharma and Warner Hindustan. These companies produce almost all types of drugs and formualtions.

Although small sector units are scattered all over the country, their heavier concentration is found at Mumbai, Chennai, Kolkata, Delhi, Vadodara, Kanpur and Hyderabad.

Pesticides. The importance of pesticides (which include insecticides, fungicides and rodenticides, etc.) in agriculture and public health, has led to a steady growth of pesticide industry in India. At present, more than 125 units are engaged in the manufacture of technical grade pesticides and over 500 units are making pesticides formulations. The Hindustan Insecticide Ltd. (HIL) is a public sector undertaking engaged in manufacturing of insecticides. It has three units, *viz*., Udyogmandal (Kerala), Rasayani (Maharashtra) and Delhi. Its subsidiary company, Southern Pesticide Corporation (SPC) has a factory at Kovur. The Hindustan Insecticide Ltd. produces BHC, DDT, Malathion and Endosulfan which are widely used in India.

India's installed capacity is 1.25 lakh tonnes while the total annual production is 85,800 tonnes. India used to import large quantities of pesticides but because of technical upgradation and increase in production, the imports have been drastically reduced. On the other hand, India is now in a position to export pesticides.

DYESTUFFS

The dyestuff industry represents the highest development of chemical technology and forms an

important link in the chain of other essential chemical industries. Although natural and vegetable colours have been used in India for centuries, the use of synthetic organic dyestuffs is largely a post World War II phenomenon. The need for indigenous dyestuffs was felt during World War II when the import of dyes practically ceased. The first organised dyestuff unit in India was Associated Research Laboratories (Now Arlab Ltd.) established in 1941 near Pune. Atul Products was set up in 1947 near Bulsar. The production commenced in 1952. This was followed by Amar Dyechem and Indian Dyestuff Industries in 1954. A number of companies with foreign collaboration also made their presence felt. Outstanding among them were Alic Industries in 1956 (ICI and Atul), Suhrid Geigy (Sarabhais and Geigy), Colurchem (Bayer, Hoechst and Ghais) and Sandoz (India) at Kolshet in 1961. Thus, by the 1960s, the stage was well set for rapid growth of the indsutry. Today, the industry produces a large variety of dyestuffs in sufficient quantity and is able to meet over 95 per cent of the demands for dyestuffs in the country. There are now 50 units in organised sector accounting for 65 per cent of the total production. The remaining 35 per cent is contributed by over 1,000 small scale units. The greatest concentration of this industry is in the two western states of Maharashtra and Gujarat and these two states together account for over 90 per cent of the dyestuff production in the country.

The dyestuff industry in India has some inherent strength, as a result of which it has shown rapid progress. The main users are the textile and the leather goods industries which are themselves growing very fast, thereby creating a large domestic market for dyestuffs. Increasing availabiity of basic feedstock, a matured chemical engineering industry, availability of skilled labour, trained supervisory and plant personnel, high degree of entrepreneurship and low overhead costs are added advantages enjoyed by this industry. Thus it can safely be predicted that this industry will grow at still faster rate in future. From a humble beginning, India is now in a position to export a large variety of dyestuffs.

SOAPS AND DETERGENTS

Soap industry started developing immediately after World War I and detergents followed it later on. The total current market of soaps and detergents is valued at ₹ 6,716 crore. The market can be classified into toilet soaps for personal wash and non-soap detergent (NSD) bars and powders and laundry soaps for washing cloth. The personal wash market is valued at ₹ 2,690 crore. The NSD bar and powder market is much bigger and is worth ₹ 3,037 crore. The laundry soap market is dominated by the small sector. This is estimated to be about ₹ 589 crore, whereas the personal wash market and fabric wash market is growing at the rate of 3-4 per cent per annum, laundry soap market is almost stagnant. It is worth mentioning that the rural market for soaps and detergents is more buoyant than the urban market.

Eighty eight units in the organised sector have a capacity of manufacturing 7,05,963 tonnes of soap per year. Thirty three units in the organised sector are busy in manufacturing synthetic detergents. They house a total installed capacity of 6,05,000 tonnes per year.

GLASS INDUSTRY

Indians are known to have acquired the knowledge of making glass since time immemorial. Glass industry came into being in India in 16th century when items like bangles, small bottles and flasks were made. By 17th century, enamalled glass was produced at a number of places in Karnataka and Uttar Pradesh. Although glass industry on modern lines was started in the 19th century, the real growth started only after 1932. The first successful organised glass factory was set up in 1941. The industry underwent large scale modernisation after Independence. At present, India is a major producer of glass and glass products. The production of bottle/bottle glassware was 12,48,075 tonnes during 2012-13.

Localisation

Glass industry requires a large number of raw materials. The most important raw material is silica sand which constitutes 75 per cent of the basic materials. This is a bulky material and cannot bear high transportation cost. Obviously the availability of silica sand influences the localisation of glass industry. The other raw materials used for manufacturing glass are soda ash, feldspar, limestone, dolomite, manganese dioxide, barium oxide, sulphur and copper. These raw materials affect the localisation of glass industry to some extent in their own way. All these raw materials except soda ash are abundantly available in the country. Sufficient supply of coal at cheap rates also influence this industry. But glass is a fragile commodity and easily breaks during transit. Therefore, this industry tends to be located near the market.

Distribution

Uttar Pradesh, West Bengal, Maharashtra and Tamil Nadu are the main glass producing states and contribute the bulk of production.

Uttar Pradesh. Firozabad in Agra district is the largest producer having as many as 100 small factories. The other major centres of glass production are Bahjoi, Naini, Hiranagau, Shikohabad, Hathras, Sasni, Allahabad and Jaunpur. Uttar Pradesh has the advantage of locally available raw materials and a ready market for glass and glass products. Skilled glass workers known as ***shisgars*** of Firozabad have been engaged in the process of glass making for several generations and provide cheap and skilled labour for this purpose. Only coal has to be transported from Jharkhand and West Bengal.

West Bengal. The state has 34 factories located at different places like Kolkata, Haora, Raniganj, Belgachiya, Belgharia, Belur, Sitarampur, Rishra, Durgapur and Asansol. Pure sand of high quality is available from the white Damudas sandstones at Mangalhat and Patharghata. Sand is also obtained from Bargarh and Lohagra near Allahabad. Good quality coal is obtained from the nearby coalfields at Jharia and Raniganj. Good market is readily available in the Hugli industrial region.

Maharashtra. The state has 22 factories. Main centres of galss industry are Mumbai, Talegaon (Pune), Satara, Nagpur and Kolhapur. The industry specializes in bottles, shells, flasks, lampware, beakers and sheet glass.

The other producers are *Gujarat* (Bharuch, Vadodara, Morvi and Panchmahal), *Tamil Nadu* (Salem, Chennai, Coimbatore), *Bihar* (Bhawaninagar, Patna), *Jharkhand* (Kandra, Jamshedpur, Kahalgaon), *Rajasthan* (Dhaulpur and Jaipur), *Haryana* (Ambala and Faridabad), *Telangana* (Warrangal and Hyderabad), *Delhi* (Shahdara), *Punjab* (Amritsar), *Kerala* (Alwaye), *Odisha* (Barang, Cuttack), *Madhya Pradesh* (Jabalpur, Gondia), *Assam* (Guwahati) and *Karnataka* (Bengaluru).

The export and import of glass and glassware during 2011-12 was worth ₹ 2,555.92 crores and ₹ 3,381.78 crores respectively.

CERAMICS INDUSTRY

It is a very old industry and dates back to about 5000 years B.C. The excavations of Harappa and Mohen-jo-Daro have revealed that a wide variety of pottery goods and ceramics of different designs and colours was used when the Indus Valley civilisation was at its peak. The beginning of modern ceramics industry is associated with the discovery of deposits of China clay in Rajmahal hills in Jharkhand. The first ceramic factory was established at Patharghatta in 1860. In the same year, Burn and Co. set up a factory at Raniganj in West Bengal and the production of glazed tiles commenced. Further discoveries of China clay in different parts of the country added new dimensions to ceramic industry and a number of factories came up in West Bengal, Bihar, Madhya Pradesh, Maharashtra, Gujarat, Karnataka and Kerala. World War II gave further impetus to this industry because metallic utensils could not be made due to ban on the import of metals. The industry has made rapid strides in the post-Independence era.

Today, ceramic industry produces a wide range of products, the outstanding being sanitary wares, porcelain wares, stoneware, enamel ware, tiles, crockery, insulators, etc. These products are used for a variety of purposes such as generation and transmission of power, construction of modern buildings, engineering, electronics, etc.

At present, there are above 150 units in the organised sector manufacturing different items. The important centres are Kolkata, Mumbai, Bengaluru, Delhi, Wankaner, Thanagarh, Ranipet, Rupnarainpur, Jabalpur, Nazarbagh, Gwalior, Jaipur, etc.

Indian ceramic products are some of the best so far as their quality, shape, design and colour are concerned and are easily accepted in the international market. The main buyers of Indian ceramic goods are Iran, Iraq, Saudi Arabia, Kuwait, Kenya, Uganda, Tanzania, Zambia, Sudan, Mauritius, Sri Lanka, Myanmar, etc. India also imports ceramic products from some Asian and European countries like China, Japan, U.K., Germany, the Netherlands, Czech Republic and Slovakia.

FOREST BASED INDUSTRIES

Forests provide us with different types of materials which are used as raw materials for certain industries. Those industries which use forest products as raw materials are called forest based industries. Paper, match, lac, sports goods, plywood, etc. are such industries.

PAPER INDUSTRY

Paper is one of the core industries and is linked to the basic human needs. Paper is the pre-requisite for education and literacy and its use is an index of advancement in these two fields as well as the overall well being of the society.

This is the most important of all the forest based industries. Some people treat it as a chemical industry due to its manufacturing process and because of certain chemicals used for its manufacturing. Still some other people include it in the group of agro-based industries because some of the agricultural products and residuals are used as raw materials. As large proportion of the basic raw materials is derived from the forests, it seems logical to treat it as a forest based industry.

Growth and Development

Paper manufacturing has been carried on in India since tenth century as a small cottage industry by the traditional craftsmen called ***kagzis***. They used gunny bags, rags, ropes, etc. for making paper. This industry could not survive the onslaught of the machine made paper and declined considerably. However, a part of it has managed to survive and even today, a large number of small units are producing handmade paper.

The beginning of modern paper industry goes back to 1816 when a factory was set up near Chennai. This venture proved abortive. Another papermill was set up in 1832 at Serampore on the bank of Hugli in West Bengal. This venture also failed and the first successful effort was made in 1870 with the setting up of the Royal Bengal Paper mills at Ballyganj near Kolkata. This is the principal seat of paper industry even today. Subsequent successful efforts were made at Lucknow in 1879, Titagarh in 1882, Pune in 1887, Raniganj in 1892, Kaukinra in 1892 and Naihati in 1918. The preferential treatment and tariff protection helped in solving the initial problems of this industry. World War II further infused life into this industry. But the progress was rather sluggish till Independence and it is only in the plan period that the industry has really made fast progress. The growing knowledge base coupled with synergistic contributions from flagship schemes of the government, namely Sarva Shiksha Abhiyan and Right is Education assured a robust demand for paper and paper board. The industry was de-licensed in July 1997. As per present policy FDI upto 100 per cent is allowed on automatic route for pulp and paper sector. In the year 1950-51 there were only 17 mills with a total installed capacity of 1.37 lakh tonnes. In 2012-13, the number of units manufacturing pulp, paper, paper board and newsprint was 759, out of which 652 were in operation. The total installed capacity was 12.7 million tonnes out of which nearly 1.37 million tonnes were lying idle due to closure of 107 units, mostly due to pollution problems. Thus the total operating capacity is around 11.33 million tonnes. The Indian paper industry is in a fragmented structure, consisting of small, medium and large paper mills having capacity ranging from 5 to 1,270 tonnes per day.

TABLE 25.21. Performance of Paper Industry in India (2012-13)

Type of mills	Scale of operation (Tonnes per day)	No. of mills	Percentage share in operating installed capacity
Large mills	100-1100	119	36
Medium mills	50-100	117	29
Small Mills	5-50	523	35
Total	—	759	100

Source : India 2014, A Reference Annual, p. 494.

The production of paper and paper board stood at 11.8 million tonnes in 2012-13. Trends in production of different types of paper are shown in table 25.22.

The industry in India is ranked among 15 top global paper industries. Its turnover is about ₹ 16,000 crore, employing nearly three lakh people directly and 10 lakh people indirectly. The per capita consumption of paper in India is still at 5.5 kg, which is far below the global average of nearly 50 kg.

TABLE 25.22. Production of paper in India

Year	Corrugated and other paper (₹ crore)	Craft Paper (Thousand tonnes)	Writing and printing paper (Thousand tonnes)
2005-06	270	899	1,974
2006-07	261	977	2,066
2007-08	214	1,014	2,144
2008-09	223	1,060	2,288
2009-10	226	1,184	2,387
2010-11	269	1,260	2,577
2011-12	259	1,263	2,867

Source : Economic Survey, 2012-13, p. A-32.

Raw Materials. Paper and paper board can be manufactured by using different types of raw materials. Raw materials account for 45-50 per cent of the total cost of production and form an important segment of manufacturing paper and paper board. Of the total installed capacity, 43 per cent is dependent on forest based raw materials, 28 per cent on agro based raw materials and the remaining 29 per cent on other materials including waste paper.

Bamboo. Generally speaking 2.3 to 2.4 tonnes of bamboo is required for producing one tonne of paper. The paper industry uses bamboo to the extent of 60-70 per cent of the total requirements of cellulosic raw materials. Bamboo has the advantage of the possessing long fibre, dense stands and quick regeneration. It reaches maturity in 2-3 years and provides continuous flow of renewable source of raw material. However, there is danger of this source of important raw material being depleted if the rate of exploitation exceeds the rate of regeneration. The total supply of bamboo at the current rate is estimated at 20-30 lakh tonnes per annum. Assam, Odisha, Andhra Pradesh, Telangana Madhya Pradesh, Tamil Nadu, Karnataka and Maharashtra are important producers of bamboo.

Sabai Grass. This is another important raw material for manufacturing paper. It was the sole raw material before introduction of bamboo as a significant raw material, but its use has decreased considerably since then. It now constitutes 7 to 9 per cent of the total cellulosic raw material in the country. Although sabai grass has long fibre and requires low chemical consumption, it grows in tufts intermixed with other vegetation and it is often difficult to separate impurities from it. Moreover, its supplies are much less than those of bamboo. The annual supply of sabai grass along with other allied grasses is about one million tonnes. It mainly grows in the sub-Himalayan tracts of Shiwaliks and Tarai area.

Bagasse. It is a fibrous residue of the sugarcane stalk, mainly from the sugar mills, obtained after sucrose is extracted by crushing the sugarcane. On an average 50-60 lakh tonnes of bagasse is produced in the country, half of which is used for manufacturing paper.

Other materials. Paper is also manufactured by using materials other than those mentioned above. These include waste paper, rags, straw from rice and wheat, jute sticks and soft wood obtained from eucalyptus, pine-wood, wattle and mulberry trees.

Chemicals. In addition to the above mentioned cellulosic raw materials, certain chemicals are also used in the manufacture of pulp, paper and paper board. The important chemicals are caustic soda, soda ash, sodium sulphate, chlorine, sulphuric acid, sulphur, lime, ferric alumina, ammonium sulphate, resin and clay. A variety of sizing and colouring agents are also used. Coal is also an important input in paper industry. Normally, 3.5 to 4.1 tonnes of coal is required for producing one tonne of paper. Large quantity of soft water is also needed.

Localisation of the Industry

Paper and paper board manufacturing uses coarse, cheap and weight losing raw materials and seeks raw material oriented locations. Chemicals used in this industry are needed in small quantity and are easily transported even over long distances from the place of production to the place of consumption. Therefore, there is a strong tendency among the paper mills to be located near the forest tracts along the Western Ghats, the Eastern Ghats, central India and the Tarai-Bhabar area at the foot hills of the Himalayas. There are vast stands of temperate forests in the Himalayan region which can provide large quantities of soft woods. These soft woods can provide excellent cellulosic material for the paper

industry. But because of the rugged terrain and poor means of transportation, these areas are inaccessible and the possibility of extraction of these soft woods and their supply to paper mills in the adjoining areas is remote. Moreover, the regeneration of wood pulp forests takes about 50-60 years, while bamboo forest is ready within 2-3 years. So far, no paper mill has been set up in the Himalayan region. Since the supply of cellulosic raw materials falls short of the demands of the paper industry, efforts are being made to bring more land under plantation of eucalyptus and other fast growing soft wood trees. However, plantations of eucalyptus has been discouraged during the last couple of decades in eastern parts of the country because this tree quickly exhausts the sub-soil water in large quantities. Some of the paper mills are located near the market where cheap labour is also available.

Distribution of Paper Industry

Maharashtra, Andhra Pradesh, Gujarat, Uttar Pradesh and West Bengal are the main producers and account for more than half of the paper and paper board production of India.

Maharashtra. Maharashtra has risen from fourth position in the mid-1980s to second position in 1993 and to first position in 1996 among the major paper producing states of India. The state has 63 mills, accounts for 16.52 per cent of the installed capacity and produces 18 per cent of the paper produced in India. Maharashtra is not very lucky with respect to the availability of raw material and coal. Most of the mills located in Maharashtra use rags, waste paper or pulp imported from Sweden and Canada as the principal cellulosic raw material. Hydroelectricity is used as a power resource in place of coal. Ballarpur has the largest paper mill. Sangli, Kalyan, Mumbai, Pune, Balarshah, Pimpri, Nagpur, Bhiwandi, Nandurbar, Tumur, Khopoli, Kamptee, Vikroli, Chinchwad, etc. are other major producers.

Andhra Pradesh. Although a late entrant in paper industry, Andhra Pradesh superceded West Bengal in early 1990s to become the top producer but conceded this position to Maharashtra in mid-1990s. At present, this state has 19 mills, accounts for 11.3 per cent of installed capacity and 13 per cent of India's total production of paper. Paper mills are mainly located at Rajahmundry, Tirupati, Kurnool, Srikakulum, Pallancheru, Nellore Bhadrachalam, Kakinada, Apidik, Bodhan, etc. Most of the mills use bamboo as the basic raw material. Bamboo grows widely in Andhra Pradesh and the recoverable reserves are estimated to be about 1.5 lakh tonnes per annum.

Telangana. In the neighbouring Telangana, Sirpur (Kagaznagar) is the most important centre of paper manufacturing. Sarapaka, Khammam are the other important centres of manufacturing paper.

Gujarat. Gujarat has improved its position considerably in paper manufacture. The share of Gujarat in the nation's total production of paper has gone up from a miserable 3 per cent in the mid-1980s to a respectable 10 per cent in the mid-1990s. The state has as many as 55 mills which largely depend upon bagasse and eucalyptus for supply of raw material. The main centres of production are Rajkot, Vadodara, Surat, Barjod, Bilmoria, Navsari, Songarh, Ahmedabad, Vapi, Bharuch, Dijandranagar, Limbdi, Gondal, Udvada and Bavla.

Uttar Pradesh. This state has the largest number of 68 mills, but the size of the mills being small, the installed capacity does not exceed 9 per cent. Saharanpur and Lalkuan have mills of large size. The other centres are at Meerut, Modinagar, Ghaziabad, Lucknow, Gorakhpur, Pipraich, Muzaffarnagar, Allahabad (Naini), Varanasi, Kalpi, Budaun and Mainpuri.

West Bengal. West Bengal was the pioneer state in the paper industry at the initial stage and led the country till mid-1980s. The state has since slided down the ladder to fifth place with 22 mills, 7 per cent of the installed capacity and about the same percentage of production. West Bengal has the advantage of early start of this industry. The paper industry in West Bengal is based on bamboo which is available locally or is obtained from Assam, Odisha and Jharkhand, and sabai grass which is obtained from Chhattisgarh and Madhya Pradesh. Coal is abundantly available from Jharia and Raniganj. Ganga and other rivers provide sufficient water for processing. High density of population provides cheap labour. The highest concentration of paper mills is found along the Hugli river. Titagarh, Kankinara, Raniganj, Bansberia, Sheoraphuli, Chandrabati, Triveni, Naihati, Kolkata and Baranagore are some of the important centres of paper manufacturing in West Bengal.

Madhya Pradesh. Madhya Pradesh has large tracts under cellulosic raw materials *viz.*, bamboo, sabai grass, eucalyptus, etc. and provides solid base to paper industry. The state has 18 mills which account for 6.62 per cent of the total installed capacity of India. The main centres of production are Bhopal, Amla, (Shahdol), Ratlam, Rajgarh, Vidisha, Abdullaganj, Rewa and Indore. Nepanagar is the birthplace of newsprint industry and is still an important centre of newsprint manufacturing in India.

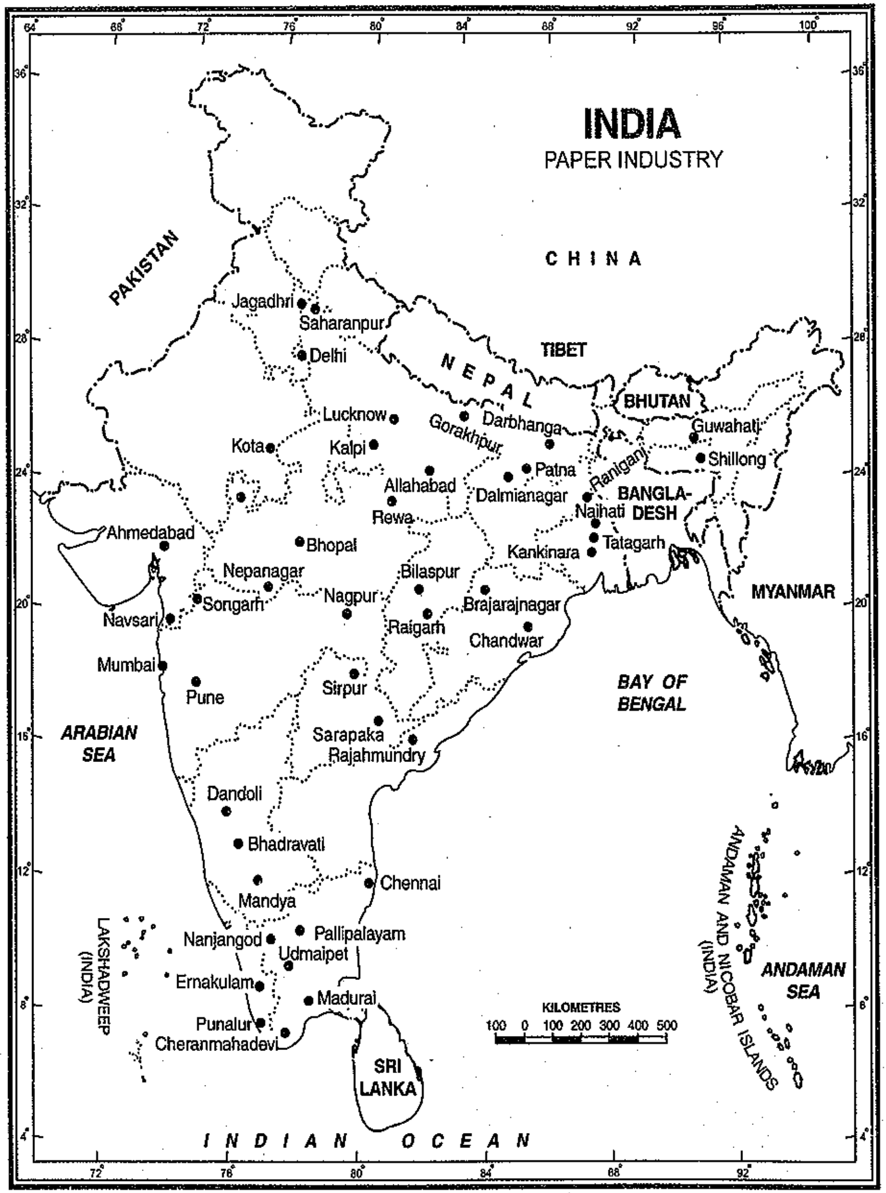


FIG. 25.14. India : Paper Industry

Odisha. The paper mills of Odisha make use of bamboo which covers large areas in the Eastern Ghats. The average annual production of bamboo is about five lakh tonnes. The state has only 8 mills but their size is sufficiently large enabling the state to account for over six per cent of the total capacity. However, with the dwindling supply of bamboo, the state's relative position has declined over the years. Brijrajnagar, Chandwar, Raygada are the main centres of production.

Tamil Nadu. Tamil Nadu has 24 small sized mills accounting for 5.74 per cent of the total installed capacity of the country. These mills use locally grown bamboo. Cheranmahadevi, Pallipalayam, Udmalpet, Chennai, Salem, Amravathinagar, Pahanasam, Madurai, etc. are the major producers.

Karnataka. Paper mills in Karanataka use locally grown bamboo and bagasse obtained from the sugar mills. Karnataka has 17 mills accounting for 5.48 per cent of the total capacity of India. The main cocentration is found at Bhadravati, Dandoli, Nandangaud, Belagola, Munirabad, Harihar, Mundyud, Bengaluru, Mandya, Ramnagaram and Krishnarajsagar.

Punjab. Punjab has 23 mills but their size is small as compared to those of Karnataka and their installed capacity is a little over five per cent of the total capacity of India. Most of the mills have capacities varying from 10 to 20 thousand tonnes. Hoshiarpur, Sangrur, Sailakhurd and Rajpura are the chief producing centres.

Assam. Assam has large areas under bamboo growth and supplies bamboo to neighbouring states, like West Bengal after meeting its own requirements. Nowgaon has one of the largest paper mills of India. The other producing centres are Guwahati, Cachar and Lumding.

Haryana. Haryana's 18 mills mainly depend upon imported pulp and eucalyptus wood as raw material. Yamunanagar has the largest mill. Small units are functioning at Faridabad, Dharuhera and Jagadhari.

Others. Bihar has 6 mills with a total installed capacity of 87.6 thousand tonnes. Dalmianagar, Patna, Darbhanga, Samastipur, Barauni are the chief producers. **Himachal Pradesh** also has 6 small units. Borokwala and Kala Amb are the main centres. **Kerala** (Punalur, Ernakulam, Mavoor, Rayanpuram and Kozhikode), **Rajasthan** (Kota), **Meghalaya** (Shillong), **Nagaland** (Mokekchong) also produce paper.

Newsprint. The production of newsprint in India commenced with the establishment of National Newsprint and Paper Mills known as NEPA in 1955 at Nepanagar in Hoshangabad district of M.P. Its initial capacity was 30 thousand tonnes which has now been raised to 75 thousand tonnes.This mill remained as the sole newsprint producer in the country till 1980. Mysore Paper mills, at Shimoga in Karnataka (capacity 75,000 tonnes) started production in 1981. The Hindustan Newsprint at Vellore near Kottayam in Kerala (capcity 80,000 tonnes) started producing in 1982. This was followed by commencement of production in 1985 by Tamil Nadu Newsprint and Paper Ltd. at Pugalur in Tiruchirapalli with a capacity of 50,000 tonnes. The newsprint sector in the country is governed by the Newsprint Control Order (NCO) 2004. The mills listed under the schedule of this order are exempt from excise duty, subject to actual user condition. At present there are 117 mills registered out of which only 73 are producing newsprint making in installed capacity of 1.3 million tonnes per annum.

Foreign Trade

Inspite of the phenomenal progress made by the paper industry in India, the production of paper, paper board and above all newsprint has always fallen short of the demand. This has forced the country to resort to heavy imports to meet the growing demand in the domestic market and put a check on the rising price of paper and paper products. The present rate of consumption of about 5.5 kg per capita per annum is extremely low as compared to the world average of 50 kg and over 300 kg of the highly advanced countries. A little increase in the capita consumption can lead to serious crisis of paper availability in the coming years.

Table 25.23 shows that the amount spent on the import of raw materials, like pulp and waste paper as well as that of finished paper, paper board and manufactures thereof has been rising at an alarming rate.

TABLE 25.23. Import of Paper, Paper Board and Raw Materials

Year	Paper, paper board and manufactures thereof		Pulp and waste paper	
	Quantity ('000 tonnes)	Value (₹ crore)	Quantity ('000 tonnes)	Value (₹ crore)
1960-61	55.6	12	80.3	7
1970-71	159.0	25	71.7	12
1980-81	371.4	187	36.9	18
1990-91	286.4	456	678.2	458
2000-01	585.6	2,005	1,050.9	1,290
2010-11	2,145.0	9,614	2,634.5	5,208
2011-12	2,586.0	12,305	3,215.9	6,524
2012-13	2,593.7	12,947	3,294.7	6,991
2013-14	2,761.3	15,067	36,484.8	8,378

Source : Economic Survey 2013-14, Statistical Appendix, pp. 71-73.

The position with regard to newsprint is still worse. The current per capita consumption of newsprint in India is too meagre 600 grams as compared to the Asian (excluding Japan and China) average of 1.9 kg and the world average of 6 kg. Consumption is forecast to grow to one kg by 2020 A.D.

Pulp and waste paper are imported from Norway, Sweden, Canada and Holland and the main sources of paper, paper board and newsprint are Sweden, Poland, Canada, Czech Republic and Slovakia.

Problems and Prospects

Paper industry in India faces many serious problems and prospects do not seem very bright. The biggest problem faced by this industry is the scarcity of raw materials. Most of the materials used for manufacturing paper are derived from the forests. With the increasing degradation of forest and fast depletion of forest based raw materials, like bamboo, the paper industry is facing a severe raw material crisis. With the exploitation of forests based raw materials reaching its saturation, any substantial capacity expansion in the near future is practically ruled out and the growth of industry has come to a standstill. In order to survive and expand, the industry will have to look for unconventional raw materials. This will require new advanced technology which a developing country like India may not be able to afford.

Another alternative is to increase the use of waste paper which will reduce dependence on the conventional raw materials. This will also reduce cost of energy used and other inputs. It may be mentioned here that only 15 per cent of the total output of paper and paper board is based on recycled material against the world average of 30-35 per cent. Thus there is a vast scope for using recycled material in paper industry.

Even now, large quantities of bagasse is just used as fuel in the sugar industry and is not made available to paper industry. If the sugar mills are encouraged to use coal fired boilers instead of those based on bagasse, this precious raw material can solve the problem of paper industry to great extent.

The growing consciousness for preservation of forests and maintenance of ecological balance and biodiversity during the last few years is further reducing the availability of raw materials to this industry. Environmentalists are also up in the arms against this industry due to effluents released by the paper mills into open drains, rivulets and rivers thereby polluting the environment. Unless technology to solve the effluent problem is evolved and implemented with only marginal additional investment, many of the paper mills run the risk of economic losses and even closure.

India is facing wide gap between supply and demand of paper even at the low rate of consumption.

Currently, India has about 17.5 per cent of the world's population but consumes a little over 1 per cent of the world's paper and paper board. With the spread of education and literacy, demand for paper is bound to increase and is expected to be double the present demand within ten years. This will constraint India either to increase the indigenous production considerably or resort to large scale imports.

The average size of paper mills is abnormally low at less than 10,000 tonnes against 50,000 tonnes in South-east Asia and 85,000 tonnes in Asia Pacific. The small size of the manufacturing units makes them uneconomic, prohibits the induction of new technology, needs larger capital inputs in proportion to the final production and increases the cost of operations. Several mini plants are using old technologies and worn out machinery and badly lack competitive strength. The spiralling cost of imported wood pulp and waste paper coupled with unremunerative selling price of the finished paper has rendered many paper mills economically unviable and forced them to close down. Recently, the Department of Industrial Policy and Promotion had commissioned a study on 'Global Competitiveness' of Indian Paper Industry by an agency of international repute to understand various issues concerning the paper and newsprint industry. The study had indicated inadequate availability of good quality of cellulosic raw material and obsolete technology, among others as the constraints for the paper industry. High cost of basic inputs and environmental issues are the other two major problems required to be addressed by the paper industry to become globally competitive.

However, one encouraging aspect is that Indian paper industry has trained manpower whose skill can be gainfully used to adopt modern technology for manufacturing paper and paper board of international standard at relatively lower manpower cost inputs. The country has vast reservoir of unemployed rural labour which can be deployed for development of raw materials. Thus, we can overcome some of the weaknesses which have plagued the paper industry for a long time.

MATCH INDUSTRY

The first match factory was set up at Ahmedabad in 1921. The Western India Match Company (WIMCO) came into existence in 1923 and it set up five factories at Bareilly (U.P.), Kolkata, Chennai, Ambarnath (Mumbai) and Dhubri (Assam). These five factories of WIMCO along with Assam Match Co. (AMCO.) produce about 65 per cent matches in India. The remaining 35 per cent match is produced by de-centralised small scale units and cottage industry. There are about one thousand small scale units manufacturing match. The production has shown varying trends.

Localisation

The chief raw materials used in this industry are soft timber and paper for making sticks and boxes. The main chemicals used are phosphorus, potassium chlorate, paraffin, potash, etc. Earlier, most of the timber requirements were met by imports. Now, locally available wood like *genwa*, *pipita*, *dhup*, *didu*, *bakoda*, *mango*, *semal* and *solai* is used and imports are drastically reduced. But most of the chemicals are still imported. Match factory requires cheap and skilled labour because one-third of the cost of manufacturing match is on labour.

Distribution

West Bengal, Tamil Nadu, Maharashtra and Gujarat are the main producers.

West Bengal has the highest concentration of match industry. Timber is obtained from Andaman and Nicobar Islands as well as from the Sunderbans. Some timber is imported from Sweden. Kolkata serves as a good port for importing chemicals. Coal is obtained from Jharia and Raniganj. The area is densely populated and there is no dearth of labour. 24 Parganas and Kolkata have the greatest concentration of match industry in this state. ***Tamil Nadu*** has nearly two-thirds of non-mechanised small scale units. The main centres are Ramnathpuram, Chingleput, Tirunelveli and Chennai. The other producers are ***Maharashtra*** (Pune, Thane, Chandrapur, Mumbai), ***Gujarat*** (Ahmedabad, Petlad, Ambarnath), ***Uttar Pradesh*** (Bareilly, Meerut, Allahabad, Varanasi), ***Karnataka*** (Shimoga), ***Kerala*** (Thiruvananthapuram), ***Telangana*** (Hyderabad, Warangal), ***Assam*** (Dhubri), ***Rajasthan*** (Kota), ***Madhya Pradesh*** (Bilaspur and Jabalpur).

LAC INDUSTRY

Lac is obtained from an insect named Cerria lacca which secretes a resin. This insect lives on trees which grow in areas at an elevation of 300 metres above sea level and having 12°C temp. and 150 cm annual rainfall. Resin is known as sticklac in its crude form and shellac or lac in the refined form. Lac is used for a variety of purposes including gramophone records, french polish, electrical insulating materials, shellac moulded articles, micanite, hats, grinding wheels, adhesives, cements, wood turning, metal enamelling, printing ink, paints and varnishes, photographic equipment, bangles, toys and many more.

The average annual production of lac in India is 20-25 thousand tonnes. Earlier, India was the largest producer of lac in the world and used to produce about 85 per cent of the world's total production of lac. But India's share in the world production of lac has fallen to 50-60 per cent due to increased production in Thailand, Myanmar and Indochina. Major part of the production comes from the Chota Nagpur plateau which accounts for about 50 per cent of the total production. The remaining 50 per cent is produced by adjoining areas in West Bengal, Chhattisgarh, Madhya Pradesh, Uttar Pradesh, Odisha, Maharashtra. ***Madhya Pradesh*** produces 25 per cent of India's lac. The main producing districts are Balaghat, Chhindwara, Jabalpur, Shahdol. About 15 per cent lac of India comes from ***Chhattisgarh*** where Bilaspur, Raipur, Surguja and Karia are the main producing districts.. In ***West Bengal***, Murshidabad, Malda and Bankura are the main lac producing districts. The other producers are ***Odisha*** (Mayurbhanj, Bolangir, Dhenkanal, Sambalpur and Keonjhar), ***Meghalaya*** (Garo, Khasi and Jaintia Hills), ***Assam*** (Nagaon, Kamrup and Sibsagar districts), ***Uttar Pradesh*** (Mirzapur), ***Gujarat*** (Panchmahals and Vadodara) and ***Maharashtra*** (Bhandara).

International Trade

India has been a traditional exporter of lac and is still the largest exporter in the world. About 85-90 per cent of the total product finds its way to foreign markets. The USA, UK, Germany and Russia are the main buyers and account for over 50 per cent of the country's total lac exports. The other buyers include Italy, France, Japan, Sweden, Australia, Brazil, Argentina, etc. India also imports raw lac from Thailand and re-exports it in the form of finished products.

SPORTS GOODS

Sports goods industry was first established at Sialkot (now in Pakistan) and Meerut in Uttar Pradesh. From a modest beginning the industry made rapid progress after Independence when several skilled workers shifted from Sialkot to various towns and cities of India including Meerut, Jalandhar, Delhi, Batala, Kolkata, etc. Later on this industry spread to Jammu, Srinagar, Patiala, Faridabad, Modinagar, Dehradun, Bulandshahr, Lucknow, Allahabad, Amritsar, Bhopal, Katni, Chennai, Mumbai, Pune and many more cities. Meerut and Jalandhar dominate the production of sports goods. Meerut has 270 units out of a total of 700 units in the whole of the country. Jalandhar has made rapid progress during the last couple of decades and manufactures quality sports goods.

Today, India is in a position to manufacture goods for almost all the sports. The factors contributing to India's progress in sports goods are the availability of raw materials and skilled, cheap and abundant labour. The principal raw materials used in this industry are wood, leather, rubber, metal, etc.

Indian sports goods are of good quality and are in great demand throughout the world. U.K., Germany, Australia, Malaysia and Singapore are the main buyers of Indian sports goods.

FOOD AND ALLIED INDUSTRIES

This group includes those industries which are connected with food. Sugar, edible oils and vanaspati, flour milling, rice milling, alcohol, etc. are some of the examples of food and allied industries.

SUGAR INDUSTRY

Sugar can be produced from sugarcane, sugar-beet or any other crop having sugar content. But in India, sugarcane is the main source of sugar. At present, this is the second largest agro-based industry of India after cotton textile industry. India is the world's second largest producer of sugarcane after Brazil and second

largest producer of sugar after Cuba. But India becomes the largest producer if *gur* and *khandsari* are also included. This industry provides employment to 2.86 lakh workers. In addition, 2.50 crore sugarcane growers also get benefit from this industry.

Growth and Development

India has a long tradition of manufacturing sugar. References of sugar making by the Indians are found even in the *Atharva Veda*. India is rightly called the *homeland of sugar*. But in ancient times, only *gur* and *khandsari* were made and modern sugar industry came on the Indian scene only in the middle of the 19th century, when it was introduced by the Dutch in North Bihar in about 1840. Unfortunately, this attempt could not succeed. The first successful attempt was made by the indigo planters at the initiative of Britishers in 1903 when Vacuum pan mills were started at Pursa, Pratabpur, Barachakia and Marhowrah and Rose in north-eastern U.P. and the adjoining Bihar. This happened when demand for indigo ceased to exist due to the introduction of synthetic blue in the market. In the early years of the 20th century, the industry grew rather sluggishly and there were only 18 mills in 1920-21 and 29 mills in 1930-31. The industry got a great fillip after the fiscal protection in 1931 and the number of mills rose to 137 in 1936-37. The production also shot up from 1.58 lakh tonnes to 9.19 lakh tonnes during the same period. The industry passed through an uncertain phase during and after the World War II and some stability was experienced only after 1950-51. There were 139 mills producing 11.34 lakh tonnes of sugar in 1950-51. After that, the plan period started and the industry made rapid strides. In the year 1994-95, there were 420 mills producing 148 lakh tonnes of sugar.

Table 25.24 shows that the year to year figures reveal great variations in production although there has been a steady increase in production on the long term basis.

Localisation of Sugar Industry

Sugar industry in India is based on sugarcane which is a heavy, low value, weight losing and perishable raw material. Sugarcane cannot be stored for long as the loss of sucrose content is inevitable. Besides, it cannot be transported over long distances because any increase in transportation cost would raise the cost of production and the sugarcane may dry up on the way. It is estimated that 50 per cent cost of production is accounted for by sugarcane alone. Normally, it requires about 100 tonnes of sugarcane to produce 10-12 tonnes of sugar. Even today most of sugarcane is transported with the help of bullock carts and cannot be carried beyond 20-25 km. The introduction of tractor-trollies, trucks and even railway wagon have increased the distance covered by sugarcane to 70-75 kms. beyond which the transportation cost would increase exorbitantly. Therefore, the sugar industry is established in areas of sugarcane cultivation.

Distribution

Figure 25.15 makes it amply clear that sugar industry has two major areas of concentration. One comprises Uttar Pradesh, Bihar, Haryana and Punjab in the north and the other that of Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh in the south.

Maharashtra. Maharashtra has progressed a lot and captured first position from U.P. to emerge as the largest producer of sugar in India. Large production of sugarcane, higher rate of recovery and longer crushing period are some of the factors which have helped the state to occupy this enviable position. The state has one-fourth of the total sugar mills and produces a little more than one-third of the total sugar of India. Sugar mills of Maharashtra are much larger as compared to the mills in other parts of the country. The major concentration of sugar mills is found in the river valleys in the western part of the Maharashtra

TABLE 25.24. Production of Sugar in India (thousand tonnes)

Year*	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Production	1,134	3,029	3,740	5,148	12,047	18,510	19,321	28,199	26,300	14,677	18,802	24,350	27,430

*Relates to October-September

Sources : Economic Survey, 2012-13, p. A-33.

FIG. 25.15. India : Distribution of Sugar Industry

Plateau. Ahmednagar is the largest centre. The other major centres are in the districts of Kolhapur, Solapur, Satara, Pune and Nashik.

Uttar Pradesh. Uttar Pradesh is the traditional producer of sugar and has been occupying the first rank among the major sugar producing states of India. However, its relative importance has been reduced during the last few years and the state has conceded the top position to Maharashtra and now occupies the second position. Uttar Pradesh has more mills than Maharashtra but they are of comapratively smaller size and yield less production. Presently, the state

accounts for about 24 per cent of the total production of sugar in India. There are two distinct regions of sugar production in this state. One region consists of Gorakhpur, Deoria, Basti and Gonda in eastern Uttar Pradesh and the other lies in the upper Ganga Plain consisting of Meerut, Saharanpur, Muzaffarnagar, Bijnore and Moradabad.

Tamil Nadu. Tamil Nadu has shown phenomenal progress with regard to sugar production during the last few years. High yield per hectare of sugarcane, higher sucrose content, high recovery rate and long crushing season have enabled Tamil Nadu to obtain highest yield of 9.53 tonnes of sugar per hectare in the whole of India. As a result of these advantages, the state has emerged as the third largest producer of sugar, contributing over nine per cent of the total sugar production of India. Most of the 32 mills of the state are located in Coimbatore, Tiruppur, Karur and Tiruchchirapalli.

Karnataka. Karnataka has 30 mills producing over 6 per cent of the total sugar of India. Belgaum and Mandya districts have the highest concentration of sugar mills. Bijapur, Bellary, Shimoga and Chittradurga are the other districts where sugar mills are scattered.

Andhra Pradesh. Andhra Pradesh has more mills (35) than the neighbouring Karnataka but produces only 5.8 per cent of India's sugar. This means that the mills are comparatively smaller. Majority of the sugar mills are concentrated in East Godawari West Godavari, Krishna, Vishakhapatnam, and Chittoor districts.

Gujarat. Gujarat's 16 mills are scattered in Surat, Bhavnagar, Amreli, Banaskantha, Junagarh, Rajkot and Jamnagar districts. The state produces about 5.56 per cent of the total sugar produced in India.

Telangana. Most of the sugar mills are concentrated in Nizamabad and Medak districts.

Haryana. Haryana has only 8 mills but their large size enables the state to contribute 1.91 per cent of the total sugar production. Sugar mills are located in Rohtak, Ambala, Panipat, Sonipat, Karnal, Palwal and Hisar districts.

Punjab. Punjab has a total of 13 mills which are located in Amritsar, Jalandhar, Gurdaspur, Sangrur, Patiala and Rupnagar districts.

Bihar. Bihar was the second largest sugar producing state next only to Uttar Pradesh till mid-1960s. Since then the state has been experiencing sluggish growth and consequently lost its prestigious position to the peninsular states like Maharashtra, Tamil Nadu, Karnataka and Andhra Pradesh. Its 28 mills make an insignificant contribution to the production of sugar. The belt of eastern Uttar Pradesh extends further east in Bihar and the districts of Darbhanga, Saran, Champaran and Muzaffarpur are included in this belt.

Others. Among the other producers are Madhya Pradesh (8 mills in Morena, Gwalior and Shivpuri districts), Rajasthan (5 mills in Ganganagar, Udaipur, Chittaurgarh and Bundi districts), Kerala, Odisha, West Bengal and Assam.

Difference between the Sugar Industry of Northern and Peninsular India

There are marked differences between the sugar industry of the northern and the peninsular India. As a result of better conditions prevailing in the peninsular India, the sugar industry is gradually shifting from north India to the peninsular India. This is evident from the fact that previously north India used to produce about 90 per cent of India's sugar which is reduced to 35-40 per cent now. A brief description of differences between the sugar industry of the northern and peninsular India is given below :

1. Peninsular India has tropical climate which gives higher yield per unit area as compared to north India.
2. The sucrose content is also higher in tropical variety of sugarcane in the south.
3. The crushing season is also much longer in the south than in the north. For example, crushing season is of nearly four months only in the north from November to February, whereas it is of nearly 7-8 months in the south where it starts in October and continues till May and June.
4. The co-operative sugar mills are better managed in the south than in the north.
5. Most of the mills in the south are new which are equipped with modern machinery.

Problems of Sugar Industry

Sugar industry in India is plagued with several serious and complicated problems which call for immediate attention and rational solutions. Some of the burning problems are briefly described as under :

1. Low Yield of Sugarcane. Although India has the largest area under sugarcane cultivation, the yield per hectare is extremely low as compared to some of the major sugarcane producing countries of the world. For example, India's yield is only 68,344 kg/hectare as compared to 72,910 kg/hectare in Mauritius, 74,231 kg/hectare in Thailand, 114983 kg/hectare in Egypt, 1,25,164 kg/hectare in Colombia and 1,27,812 kg/hectare in Peru. The world average is 68,854 kg/hectare (data for 2012). This leads to low overall production and results in short supply of sugarcane to sugar mills. Efforts are being made to solve this problem through the introduction of high yielding, early maturing, frost resistant and high sucrose content varieties of sugarcane as well as by controlling diseases and pests which are harmful for sugarcane.

2. Short crushing season. Manufacturing of sugar is a seasonal phenomena with a short crushing season varying normally from 4 to 7 months in a year. The mills and its workers remain idle during the remaining period of the year, thus creating financial problems for the industry as a whole. One possible method to increase the crushing season is to sow and harvest sugarcane at proper intervals in different areas adjoining the sugar mill. This will increase the duration of supply of sugarcane to sugar mills.

3. Fluctuating Production Trends. Sugarcane has to compete with several other food and cash crops like cotton, oil seeds, rice, etc. Consequently, the land available to sugarcane cultivation is not the same and the total production of sugarcane fluctuates. This affects the supply of sugarcane to the mills and the production of sugar also varies from year to year.

4. Low rate of recovery. The average rate of recovery in India is less than ten per cent which is quite low as compared to other major sugar producing countries. For example recovery rate is as high as 14-16 per cent in Java, Hawaii and Australia.

5. High cost of Production. High cost of sugarcane, inefficient technology, uneconomic process of production and heavy excise duty result in high cost of manufacturing. The production cost of sugar in India is one of the highest in the world. Intense research is required to increase the sugarcane production in the agricultural field and to introduce new technology of production efficiency in the sugar mills. Production cost can also be reduced through proper utilisation of by-products of the industry. For example, bagasse can be used for manufacturing paper pulp, insulating board, plastic, carbon, coltex, etc. Molasses comprise another important by-product which can be gainfully used for the manufacture of power alcohol. This, in its turn, is useful in manufacturing DDT, acetate rayon, polythene, synthetic rubber, plastics, toilet preparations, etc. It can also be utilised for conversion into edible molasses and cattle feed. Press-mud can be used for extracting wax.

6. Small and uneconomic size of mills. Most of the sugar mills in India are of small size with a capacity of 1,000 to 1,500 tonnes per day. This makes large scale production uneconomic. Many of the mills are economically not viable.

7. Old and obsolete machinery. Most of the machinery used in Indian sugar mills, particularly those of Uttar Pradesh and Bihar is old and obsolete, being 50-60 years old and needs rehabilitation. But low margin of profit prevents several mill owners from replacing the old machinery by the new one.

8. Competition with Khandsari and Gur. Khandsari and gur have been manufactured in rural India much before the advent of sugar industry in the organised sector. Since *khandsari* industry is free from excise duty, it can offer higher prices of cane to the cane growers. Further, cane growers themselves use cane for manufacturing *gur* and save on labour cost which is not possible in sugar industry. It is estimated that about 60 per cent of the cane grown in India is used for making *khandsari* and *gur* and the organised sugar industry is deprived of sufficient supply of this basic raw material.

9. Regional imbalances in distribution. Over half of sugar mills are located in Maharashtra and Uttar Pradesh and about 60 per cent of the production comes from these two states. On the other hand, there are several states in the north-east, Jammu and Kashmir and Odisha where there is no appreciable growth of this industry. This leads to regional imbalances which have their own implications.

10. Low per capita consumption. The per capita annual consumption of sugar in India is only 16.3 kg as against 48.8 kg in the USA., 53.6 kg in U.K., 57.1 kg in Australia and 78.2 kg in Cuba and the world average of about 21.1 kg. This results in low market demand and creates problems of sale of sugar.

TABLE 25.25. Production of Vanaspati

Year	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Production ('000 tonnes)	155	355	558	753	850	1,445	1,193	1,285	1,380	1,532	1,112	1,827	1,235

Source : Economic Survey 2012-13, p. A-33.

VEGETABLE OIL INDUSTRY

Vegetable oil is an important item of Indian food as it is the major source of fat. Vegetable oil industry of India can be divided into three broad groups depending upon the technology used.

(*i*) ***Ghani*** is the main technology for expelling oil in the villages. Different oil seeds are used in different areas. For example, groundnut is used in Gujarat, coconut in Kerala and mustard seed in Uttar Pradesh.

(*ii*) Factories using intermediate level of technology are located in towns. Oil seeds used are region specific.

(*iii*) Large scale sophisticated mills are located in big cities and are oriented towards bigger market. They also procure oil seeds from a much larger area.

Vanaspati is 'hydrogenated' oil. The first vanaspati factory was established in 1930 which produced a meagre of 298 tonnes. The World War II and the levy of import duty on vanaspati gave a fillip to this industry and in 1951, there were 48 factories with a capacity of 3.3 lakh tonnes and a production of 155 thousand tonnes. The production showed a significant progress and stood at 1,445 thousand tonnes in 2000-11 after which varying trends in production have been observed.

Although vegetable oil industry has developed throughout India, Maharashtra has the largest number of vanaspati producing units. Other important vanaspati producing states are Uttar Pradesh, Gujarat, Punjab, Andhra Pradesh, West Bengal, Karnataka, Rajasthan, Tamil Nadu and Madhya Pradesh. Chennai, Akola, Modinagar, Kanpur, Ghaziabad, Indore and Vadodara are the main centres of vegetable oil industry.

Production of vegetable oils falls short of the domestic demand and the country has to import oil seeds as well as vegetable oils from other countries.

Table 25.26 shows that imports of edible oils and their value in terms of foreign exchange spent in these imports keeps on changing depending upon the availability of edible oils in the country. However, there had been steep rise in the imports of edible oils since 1995-96. In 2013-14, India had to spend a huge amount of ₹ 56,489 crore to import 10,434.2 thousand tonnes of edible oils.

Cottage Industries

Industries which the artisans set-up in their houses and produce finished goods with the help of their family member by using locally available raw materials are known as cottage industries. In other words, cottage industry is a type of industry where creation of products and services is home based, rather than factory based. While the products and

TABLE 25.26. Import of Edible oils

Year	1960-61	1970-71	1980-81	1990-91	1995-96	2000-01	2010-11	2011-12	2012-13	2013-14
Quantity (Thousand tonnes)	31.1	84.7	1,663.3	525.8	1,062.0	4,267.9	6,677.6	8,445.0	11013.7	10434.2
Value (₹ crore)	4	23	677	326	2,260	6,093	29,860	46,255	61107	56489

Source : Economic Survey, 2013-14, Statistical Appendix, pp. 71-73.

services created by cottage industry are often unique and distinctive given the fact that they are usually not mass-produced, producers in this sector often face numerous disadvantages when trying to compete with much larger factory based companies.

The artisan may sell the product directly to the consumes or to an entrepreneur who pays money to the artisan according to the quality and quantity of the finished product. This type of industry has a long history in India and was perhaps the first industry developed in the country at the village level. It involves minimum investment and modern technical input and can be found in all parts of the country. It provides employment to a large number of people, many of them are unskilled or semi-skilled and belong to SC/ST and other backward classes including women. *Bidi* making, sports goods, lac industry, basket making, extracting oil from oilseeds, manufacture of crackers, toys, embroidery, handloom, khadi, utensil making, idol making, leather work etc. fall in the category of cottage industries. The main raw materials used by the artisans are wood, cane, leaves, leather, brass, stones of different varieties, etc. Some of the important industries have already been discussed in this chapter and some others are briefly described below.

Bidi Making. Bidi is made from *tandu* leaves or *Kachnal*. These two basic raw materials for bidi making are found in the forests of Chhattisgarh, Madhya Pradesh and West Bengal as well as on the slopes of the Eastern Ghats. An important ingredient of *bidi* making is inferior quality tobacco which is available in Andhra Pradesh, Telangana, Bihar, Chhattisgarh, Madhya Pradesh and Uttar Pradesh. The annual production of *bidi* is more than ten billion numbers. The main areas of *bidi* production are Bastar and Jagatpur in Chhattisgarh, Belgaun and Mangalore in Karnataka, Bhandura, Nagpur, Gondia, Kamptee, Pune and Nasik in Maharashtra, Jabalpur, Bhind and Murena in Madhya Pradesh, Kheda and Vadodra in Gujarat and Hyderabad in Telangana. As against cigarette, *bidi* is considered to be a cheap and light smoke and is relished by a large number of people belonging to lower strata of society in India. India is a net exporter of bidi to a large number of countries in Asia, Africa and Europe.

Basket Making. This is a typical cottage industry of hilly and mountain areas where baskets are prepared by using locally available raw materials from the forests. Bamboo, cane and willow are the chief raw materials used for basket making. The main areas of basket making are in the states of Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Meghalaya, Tripura, Jammu and Kashmir, Maharashtra, Madhya Pradesh, Uttar Pradesh, Odisha and West Bengal.

Others. Mirzapur district of Uttar Pradesh is famous for making *carpets* while Kashmir valley is well known for exclusive embroidery on shawls and other woolen garments. Lucknow's needle work on *kurtas* and other wearings is well known are over India. In Tamil Nadu, *Cracker* making is an important cottage industry. Almost each and every village in India has a cobbler who make shoes for the villagers and for sale in the adjoining markets. Similarly there are persons who make utensils, particularly from brass.

INDUSTRIAL REGIONS

Industries are unevenly distributed in India because the factors affecting industrial location are not the same everywhere. Industries tend to concentrate in a few pockets because of certain favourable factors. The pockets having high concentration of industries are known as *industrial regions*.

Goegraphers and specialists in other allied fields have made several attempts to delineat industrial regions of India making use of different criteria. One of the first attempts was made by Trewartha and Burnet in 1944 using employment figures. Karan and Jenkins tried to demarcate industrial regions of India on empirical basis. These attempts have become outdated and have lost much of their relevance because industrial landscape in India has undergone drastic changes during the planning era. **J.E. Spencer** and **W.L. Thomas** have also discussed this subject in their book entitled *Asia, East by South*. **R.L. Singh** recognised ten regions based on empirical observation. They are (*i*) Hugli, (*ii*) Mumbai, (*iii*) Ahmedabad (*iv*) The north-western extending from Ghaziabad to Amritsar (*v*) Lucknow-Kanpur (*vi*) Bangalore-Madras (*vii*) Quilon-Coimbatore (*viii*) Madurai (*ix*) Dalmiapuram and (*x*) Digboi-Dibrugarh.

The Centre for Monitoring Indian Economy (CMIE) recognised the industrial centres on the basis of industrial employment exceeding 10,000 in 1971.

Dr. B.N. Sinha (1972) has classified industrial regions into following three categories :

(*i*) **Major Industrial Region** is identified on the basis of a minimum daily factory working force of 1.5 lakh

(*ii*) **Minor Industrial Region** must have a minimum of 25,000 working labour force.

(*iii*) **Manufacturing District** has a working labour force of less than 25,000.

Another basis of indentification of industrial regions is the number of manufacturing units located close to one another or the quantum of industrial environment. Major industrial regions of India have developed in the immediate hinterlands of the ports of Kolkata, Mumbai and Chennai. The Britishers developed these clusters because the hinterlands of these ports provided enough raw materials, power and market. With the development of good transportation, some power resources like coal could also be brought easily.

Major Industrial Regions

Following are the major industrial regions of India (**Fig. 25.16**) :

1. Mumbai-Pune Industrial Region.
2. Hugli Industrial Region.
3. Bangalore-Tamil Nadu Industrial Region.
4. Gujarat Industrial Region.
5. Chotanagpur Industrial Region.
6. Vishakhapatnam-Guntur Industrial Region.
7. Gurgaon-Delhi-Meerut Industrial Region.
8. Kollam-Thiruvananthapuram Industrial Region.

1. Mumbai-Pune Industrial Region. This region extends from Thane to Pune and in adjoining districts of Nashik and Solapur. In addition, industries have grown at a rapid pace in Kolaba, Ahmednagar, Satara, Sangli and Jalgaon districts also. This region owes its origin to the British rule in India. The seeds of its growth were sown in 1774 when the island-site was obtained for construction of Mumbai port. The opening of the first railway track of 34 kms between Mumbai and Thane in 1853, opening of the Bhor and Thal Ghats respectively to Pune and Nashik and that of Suez canal in 1869 led to the development of Mumbai.

The growth of this industrial region is fully connected with the growth of cotton textile industry in India. As the coal was far removed, hydel power was developed in Western Ghats. Cotton was cultivated in the black cotton soil area of the Narmada and Tapi basins. Cheap labour-force came from the hinterland, the port facilities for export-import and communication links with the peninsular hinterland made Mumbai the *'Cottonopolis of India'*. With the development of cotton textile industry, the chemical industry developed too. Opening of the Mumbai High petroleum field and erection of nuclear energy plants added additional magnetic force to this region. Now the industrial centres have developed, from Mumbai to Kurla, Kolaba, Thane, Ghatkopar, Ville Parle, Jogeshwari, Andheri, Thane, Bhandup, Kalyan, Pimpri, Pune, Nashik, Manmad, Solapur, Ahmednagar, Satara and Sangli. In addition to cotton textile and chemical industries, engineering goods, leather, oil refineries; petrochemicals, synthetic and plastic goods, chemicals, drugs, fertilizers, electricals, electronics, software, ship-building, transport and food industries have also developed here.

The partition of the country in 1947 adversely affected this region because 81% of the total irrigated cotton area growing long staple cotton went to Pakistan. Mumbai, the nucleus of this industrial region, is facing the current limitation of space for the expansion of the industry. Dispersal of industries is essential to bring about decongestion.

2. The Hugli Industrial Region. Located in West Bengal, this region extends as a narrow belt running along the river Hugli for a distance of about 100 km from Bansbaria and Naihati in the north to Birlanagar in the south. Industries have also developed in Midnapur district in the west. The river Hugli offered the best site for the development of an inland river port as nucleus for the development of *Hugli industrial region*. The old trading centre of late 17th century has developed into the present industrial hub of Kolkata. Thus Kolkata-Haora form the nucleus of this region. It is very well-connected by the Ganga and its tributaries with the rich hinterland of Ganga-Brahmaputra plains. Besides navigable rivers, roads and the railways provided subsequent links to the great benefit of Kolkata port.

The discovery of coal and iron ore in Chotanagpur plateau, tea plantations in Assam and northern parts of West Bengal and the processing of deltaic Bengal's jute led to the industrial development in this region. Cheap labour could be found easily from the thickly populated states of Odisha, Bihar, Jharkhand and eastern part of U.P. Kolkata, having been designated capital city of the British India (1773-1912) attracted large scale British investment of capital. Establishment of first jute mill at Rishra in 1855 ushered in the era of modern industrial clustering in this region. A chain of jute mills and other factories could be established on either side of Hugli river with the help of Damodar valley coal. The port site was best-suited for export of raw materials to England and import of finished goods from that country. Kolkata's industries have established by drawing in the raw materials from adjoining regions and distributing the finished goods to consuming points. Thus, the role of transport and communication network has been as important as the favourable locational factors in the growth of this region. By 1921, Kolkata-Hugli region was responsible for two-thirds of factory employment in India.

Just after the partition of old Bengal province in 1947, the region faced, for some years, the problem of shortage of jute as most of the jute-growing areas went to East Pakistan (now Bangladesh). The problem was solved by gradually increasing home production of jute. Cotton textile industry also grew along with jute industry. Paper, engineering, textile machinery, electrical, chemical, pharmaceuticals, fertilizers and petrochemical industries have also developed in this region. Factory of the Hindustan Motors Limited at Konanagar and diesel engine factory at Chittaranjan are landmarks of this region. Location of petroleum refinery at Haldia has facilitated the development of a variety of industries. The major centres of this industrial region are Kolkata, Haora, Haldia, Serampur, Rishra, Shibpur, Naihati, Kakinara, Shamnagar, Titagarh, Sodepur, Budge Budge, Birlanagar, Bansbaria, Belgurriah, Triveni, Hugli, Belur, etc.

Alarming rate of silting of the Hugli river was a very serious problem. The depth of water in the channel from bay head to Kolkata docks must be kept at 9.2 metres for big ocean ships to come in. Dredging out of the silt rapidly filling up the water channel was very costly and not a permanent solution to save the life of Kolkata port. The construction of Farakka barrage about 300 kms upstream on Ganga and flushing of the channel are the only possible answers. The construction of Haldia port in the lower reaches of Hugli to the south of Kolkata is another landmark in relieving the great pressure of cargo ships on the port of Kolkata. However, the industrial growth of this region has slowed down as compared to the other regions. There are several reasons for this sluggish growth but decline in jute industry is said to be one of the main reasons.

3. Bangalore-Tamil Nadu Industrial Region. Spread in two states of Karnataka and Tamil Nadu, this region experienced the fastest industrial growth in the post-independence era. Till 1960, industries were confined to Bangalore district of Karnataka and Salem and Madurai districts of Tamil Nadu. But now they have spread over all the districts of Tamil Nadu except Viluppuram.

This region is a cotton-growing tract and is dominated by the cotton-textile industry. In fact cotton textile industry was the first to take roots in this region. But it has large number of silk-manufacturing units, sugar mills, leather industry, chemicals, rail wagons, diesel engines, radio, light engineering goods, rubber goods, medicines, aluminium, cement, glass, paper, cigarette, match box and machine tools, etc. This region is away from the main coal-producing areas of the country but cheap hydro-electric power is available from Mettur, Sivasamudram, Papanasam, Pykara and Sharavati dams. Cheap skilled labour and proximity to vast local market as well as good climate have also favoured the concentration of industries in this region. Coimbatore has grown rapidly mainly owing to its industrial growth based on Pykara power, local cotton, coffee mills, tanneries, oil presses and cement works. Coimbatore is known as *Manchester of Tamilnadu* because of its large-scale cotton textile industry. The establishment of public sector units at Banglore like Hindustan Aeronautics, Hindustan Machine Tools, Indian Telephone Industry and Bharat Electronics etc. has further pushed up the growth of industries in the region. Madurai is known for its cotton textiles. Visvesvarayya Iron and Steel

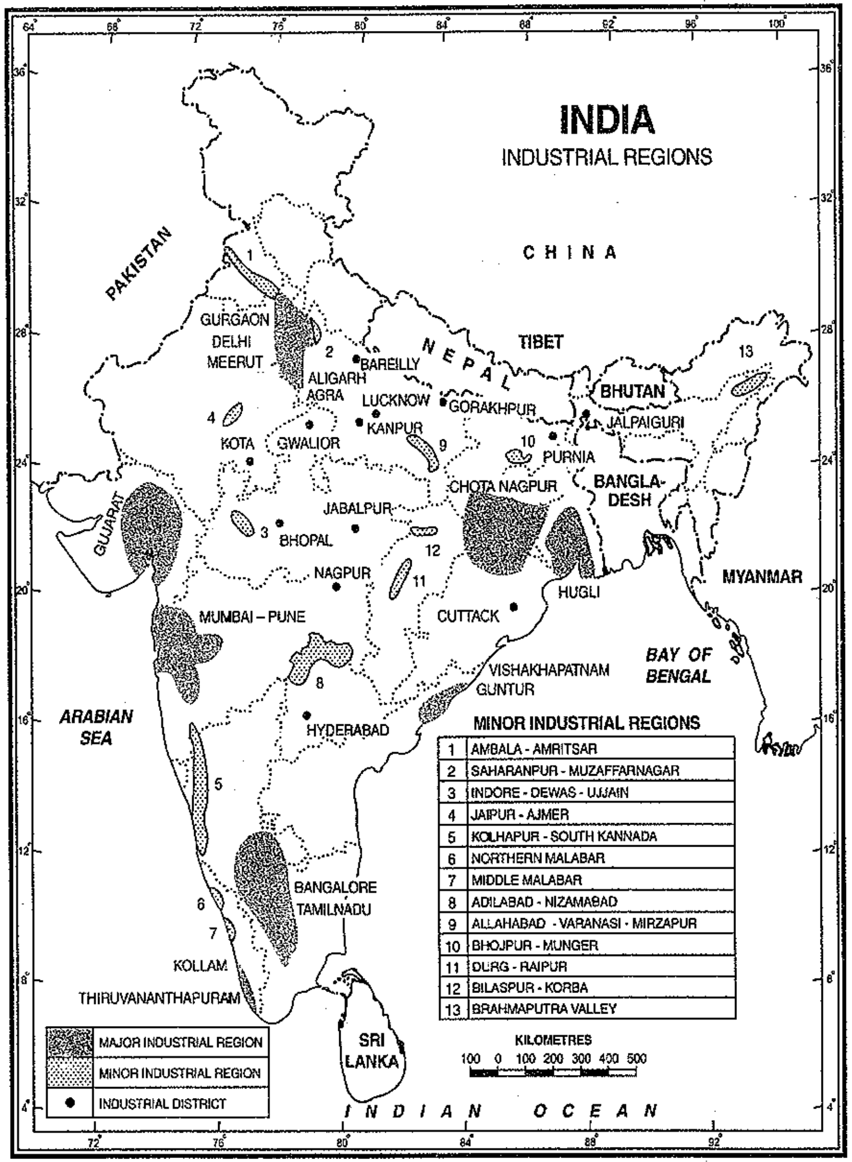


FIG. 25.16. India : Industrial Regions

Works is located at Bhadravati. The other important centres of this region are Sivakasi, Tiruchirapalli, Madukottai, Mettur, Mysore and Mandya. Petroleum refineries at Manali, Narimanam and Nagapattinam as well as iron and steal plant at Salem are recent developments.

4. Gujarat Industrial Region. The nucleus of this region lies between Ahmedabad and Vadodara as a result of which it is also known as **Ahmedabad-Vadodara** industrial region. However, this region extends upto Valsad and Surat in the south and Jamnagar in the west. The region corresponds to the cotton growing tracts of the Gujarat plains and the development of this region is associated with the location of textile industry since 1860s. This region became important textile region with the decline of cotton textile industry in Mumbai. Mumbai has the disadvantage of paying double freight charges for first bringing the raw cotton from the peninsular hinterland and then despatching the finished products to inland consuming points in India. But Ahmedabad is nearer the sources of raw material as well as the marketing centres of the Ganga and Satlui plains. Availability of cheap land, cheap skilled labour and other advantages helped the cotton textile industry to develop. This major industrial region of the country, mainly consisting of cotton textile industry, is expanding at a much faster rate in providing a greater factory employment.

The discovery and production of oil at a number of places in the Gulf of Khambhat area led to the establishment of petrochemical industries around Ankleshwar, Vadodara and Jamnagar. Petroleum refineries at Koyali and Jamnagar provide necessary raw materials for the proper growth of petrochemical industries. The Kandla port, which was developed immediately after independence, provides the basic infrastructure for imports and exports and helps in rapid growth of industries in this region. The region can now boast of diversified industries. Besides textiles (cotton, silk and synthetic fibres) and petrochemical industries, other industries are heavy and basic chemicals, dyes, pesticides, engineering, diesel engines, textile machinery, pharmaceuticals, dairy products and food processing. The main industrial centres of this region are Ahmedabad, Vadodara, Bharuch, Koyali, Anand, Khera, Surendranagar, Surat, Jamnagar, Rajkot and Valsad. The region may become more important in the years to come.

5. Chotanagpur Industrial Region. As its name indicates, this region is located on the Chotanagpur plateau and extends over Jharkhand, Northern Odisha and Western part of West Bengal. The birth and growth of this region is linked with the discovery of coal in Damodar Valley and iron ore in the Jharkhand-Odisha mineral belt. As both are found in close proximity, the region is known as the *'Ruhr of India'*. Besides raw materials, power is available from the dam sites in the Damodar Valley and the thermal power stations based on the local coal. This region is surrounded by highly populated states of Jharkhand, Bihar, Odisha and West Bengal which provide cheap labour. The Kolkata region provides a large market for the goods produced in the Chotanagpur region. It also provides the port facility to the region. It has the advantages for developing ferrous metal industries. The Tata Iron and Steel Company at Jamshedpur, Indian Iron Steel Co., at Burnpur-Kulti, Hindustan Steel Limited at Durgapur, Rourkela and Bokaro are the important steel plants located in this region. Heavy engineering, machine tools, fertilizers, cement, paper, locomotives and heavy electricals are some of the other important industries in this region. Important nodal centres of this region are Ranchi, Dhanbad, Chaibasa, Sindri, Hazaribagh, Jamshedpur, Daltonganj, Garwa and Japla.

6. Vishakhapatnam-Guntur Industrial Region. This industrial region extends from Vishakhapatnam district in the north-eastern part of Andhra Pradesh to Kurnool and Prakasham districts in the south-east and covers most of the coastal Andhra Pradesh. The industrial development of this region mainly depends upon Vishakhapatnam and Machilipatnam ports. Developed agriculture and rich mineral resources in the hinterlands of these ports provide solid base to the industrial growth in this region. Coal fields of the Godavari basin are the main source of energy. Hindustan Shipyard Ltd. set up at Vishakhapatnam, in 1941 is the main focus. Petroleum refinery at Vishakhapatnam facilitated the growth of several petrochemical industries. Vishakhapatnam has the most modern iron and steel plant which has the distinction of being the only plant in India having coastal location. It uses high quality iron ore from Bailadila in Chhattisgarh. One lead-zinc smelter is functioning in Guntur district. The other industries of this region include sugar, textiles, paper, fertilizers, cement, aluminium and light engineering. The important industrial centres of this region are Vishakhapatnam, Vijaywada, Vijaynagar, Rajahmundry, Kurnool, Elum and Guntur. Recent discovery of natural gas in Krishna-Godavari basin is likely to provide much needed energy and help in accelerated growth of this industrial region.

7. Gurgaon-Delhi-Meerut Industrial Region. This region was developed after independence, but is one of the fastest growing regions of India. It consists

of two industrial belts adjoining Delhi. One belt extends over Agra-Mathura-Meerut and Saharanpur in U.P. and the other between Faridabad-Gurgaon-Ambala in Haryana. The region is located far away from the mineral and power resources, and therefore, the industries are light and market oriented. The region owes its development and growth to hydro-electricity from Bhakra-Nangal complex and thermal power from Harduaganj, Faridabad and Panipat. Sugar, agricultural implements, vanaspati, textile, glass, chemicals, engineering, paper, electronics and cycle are some of the important industries of this region. Software industry is a recent addition. Agra and its environs have glass industry. Mathura has an oil refinery with its petro-chemical complex. One oil refinery has been set up at Panipat also. This will go a long way to boost the industrial growth of this region. Gurgaon has Maruti car factory as well as one unit of the IDPL. Faridabad has a number of engineering and electronic industries. Ghaziabad is a large centre of agro-industries. Saharanpur and Yamunanagar have paper mills. Modinagar, Sonipat, Panipat and Ballabhgarh are other important industrial nodes of this region.

8. Kollam-Thiruvananthapuram Industrial Region. This is comparatively small industrial region and spreads over Thiruvananthapuram, Kollam, Alwaye, Ernakulam and Allapuzha districts of south Kerala. The region is located far away from the mineral belt of the country as a result of which the industrial scene here is dominated by agricultural products processing and market oriented light industries. Plantation agriculture and hydroelectricity provide the industrial base to this region. The main industries are textiles, sugar, rubber, match box, glass, chemical fertilizers, food and fish processing, paper, coconut coir products, aluminium and cement. Oil refinery set up in 1966 at Kochi provides solid base to petrochemical industries. Important industrial centres are Kollam, Thiruvananthapuram, Alluva, Kochi, Alappuzha and Punalur.

Besides the above mentioned eight major industrial regions, India has 13 minor industrial regions and 15 industrial districts. Their names are mentioned below :

Minor Industrial Regions

1. Ambala-Amritsar in Haryana-Punjab.
2. Saharanpur-Muzaffarnagar-Bijnaur in Uttar Pradesh.
3. Indore-Dewas-Ujjain in Madhya Pradesh.
4. Jaipur-Ajmer in Rajasthan.
5. Kolhapur-South Kannada in Maharashtra-Karnataka.
6. Northern Malabar in Kerala.
7. Middle Malabar in Kerala.
8. Adilabad-Nizamabad in Andhra Pradesh.
9. Allahabad-Varanasi-Mirzapur in Uttar Pradesh.
10. Bhojpur-Munger in Bihar.
11. Durg-Raipur in Chhattisgarh.
12. Bilaspur-Korba in Chhattisgarh.
13. Brahmaputra Valley in Assam.

Industrial Districts

1. Kanpur, 2 Hyderabad, 3. Agra, 4. Nagpur, 5 Gwalior, 6. Bhopal, 7. Lucknow, 8. Jalpaiguri, 9. Cuttack, 10. Gorakhpur, 11. Aligarh, 12. Kota, 13. Purnia, 14. Jabalpur, 15. Bareilly.

INDUSTRIAL HOUSES IN INDIA

India has experienced rapid industrial growth, particularly after the new Industrial Policy of 1991 and India has emerged as one of the few industrial giants of the world. This is due to a variety of factors, important of which are vast and solid natural resource base, increasing interest of the common man in industries and incentives from the government. Above all these factors is the major contribution made by some big industrial houses towards industrial growth. Although most of the industrial houses have emerged on the industrial scene in India after Independence, some of the industrial houses were functioning even before Independence. These industrial houses have laid solid foundation and given a new direction to industrial growth of India. They have made a commendable contribution to make India an industrial force to reckon with at the international level. In the year 1965, the Monopolies Inquiry Commission found that 75 industrial houses have absolute control over 1,536 companies. Industrial Licencing Policy Inquiry Committee accepted the concept of industrial houses and Dutt Committee identified 20 big industrial houses in 1963-64, each with an investment of ₹ 35 crores. Larger scale changes were observed in the functioning of these industrial houses after Industrial Policy and Policy of Liberalization in 1991. A brief description of some of the major industrial houses is given as under :

1. The Tata. This is one of the oldest industrial houses active for the last over a century in India. The credit of laying solid foundation of India's industrial growth goes to this house as Jamshedji Tata established India's first large scale integral Iron and Steel manufacturing house at Sakchi in Singhbhum district of Jharkhand way back in 1907. Also known as Tatanagar, this place was later on renamed as Jamshadpur after Jamshadji. Since then, this house has never looked back and established a large number of industries. The main industries established by this house include automobiles, cement, publication, pharmaceuticals, power, energy, hospitality (hotels), refrigeration, air-conditioning, telecommunication, soft drinks, finance, insurance, consumer non-durables, etc. Tata Consultancy Services is an export oriented software development company which is one of the largest companies of India. It has left an indelible impact in the international market. It launched the low cost Nano car in the small car segment in 2009 which hit the headlines all over the world. However this car could not come upto high expectation of the buyers.

2. The Birla. Like the Tatas, the Birlas are also one of the oldest industrial houses in India. Their major contribution since inception has been in textile, paper, cement, aluminum, paraffin and automobile industries. In the recent past, the Birlas have diverted their attention towards diversification of industries and ventured into some other industries like telecommunications, pharmaceuticals, machine tools, consumer durables and non-durables, etc.

3. The Modi. Set-up by Gujarmal Modi, this is also one of the oldest industrials houses of India. The famous industrial town of Modinagar in Uttar Pradesh owes its origin and growth to this industrial house. The main industries set-up by this industrial house are textiles, ready-made garments, carpets, sugar, pharmaceuticals, tyres and tubes, hospitality, etc.

4. The Bajaj. This is also a very old industrial house of India which is known all over the world for its popular product, the Bajaj Scooter. They have started manufacturing motor-cycles also. The major industries of this house are electric and home appliances and entertainment. They are also venturing into small car segment.

5. The Ambanis. Dhiru Bhai Ambani spent his early life in acute poverty and deprivation but built a strong industrial empire by dint of his hard work and innovative ideas. His life story is the story of **rags-to-riches**. His vast industrial empire was divided between his two sons, namely Mukesh Ambani and Anil Ambani. The *Reliance Company* of Mukesh Ambani is credited with the discovery and production of natural gas in the Krishna-Godavari basin. It is a great achievement because it has solved India's energy problem to a great extent and charted the path to India's industrial progress. The traditional industries of this house are paraffin and synthetic yarn. Today this house runs more than a dozen industries which includes power, oil refining, textiles, garments, software, hospitality, telecommunication, pharmaceuticals, banking, insurance, etc. The oil refinery at Jamnagar in Gujarat with a capacity of 33 million metric tonnes per annum is the largest in India and perhaps the largest in the world.

6. The Sighania. This is also one of the oldest industrial houses of India. The main industries run by this house are textiles, pharmaceuticals, machine tools, tyres and tubes and entertainment.

7. The Sriram. Being credited as one of the oldest industrial houses of India, this house has a wide variety of industries which include textiles, ready-made garments, fertilizers, electricity, home appliances, generator sets, pharmaceuticals, hospitality, etc.

8. The Goenka. This is also one of the oldest industrial houses of the country. The main industries of this house are power generation and distribution, mechanic tools, pharmaceuticals, textiles, entertainment, etc.

9. The Escorts. This house also enjoys the privilege of being one of the oldest industrial houses in India. Its most important traditional industry has been tractor manufacturing. This was followed by manufacturing of motor-cycles. Of late, this house has made its mark in medical treatment. The heart-treatment hospitals run by this house provide world class heart-treatment at reasonably low cost.

10. The Oberois. This industrial house is well known for its mark in the hospitality industry. It has built high class hotels in different parts of India and in different countries in he world.

11. The Godrej. This is one of the top, oldest and famous industrial house which has been popular for manufacturing high class locks, furniture including almirahs, detergents, refrigerators, air-conditioners, etc. The Godrej produces are of high quality and meet international standards.

12. The Kirloskars. This is also one of the oldest and reputed industrial house of India and is famous for manufacturing high class heavy and light machine tolls. It has a place of pride in locomotion. The credit of producing India's first 'diesel pump set' goes to this industrial house. It has brought about a revolution in farm mechanization by manufacturing India's first tractor. Currently the company is producing a variety of farm implements. Its compressors are known for high quality performance. It is also producing cars in collaboration with Toyota.

13. The Jagjit Group. This industrial house is famous for textiles and sugar industries apart from distilleries.

14. The Sarabhais. The Sarabhais are mainly concerned with drugs and pharmaceutical industries for which they are renowned all over the world.

15. The Firodias. Being one of the oldest industrial houses the Firodias have attained speciali-zation in the field of manufacturing automobiles (four wheelers and two wheelers) generator sets, etc.

16. The UB Group. This is considered to be one of the oldest industrial houses in India with manufacturing of alcoholic drink as its traditional industry. During the last few years, this industrial house has entered in fields of civil aviation, hospitality and structurals. Of late it has shown its presence in the real estate also.

17. The Thapars. This house is famous for paper, sugar and some allied industries. It has also made a significant contribution in the field of education.

18. The Infosys. The main industries of this house are electronics and software for which it is a well reputed house. Besides this house is making a significant contribution in the fields of education and social work.

19. The Wipro. The doyen of the sunrise industries, this industrial house of India is primarily involved in the field of software development and export including the production of computer peripherals. The company has earned world-wide acclaim in the development of software. This is also a leading company in the field of business process outsourcing (BPO). Like Infosys, this house is also seriously committed to social work.

20. The Bharti. The Bharti is famous for its 'Airtel' mobile phone for which it has sought collaboration with 'Airtel' company of America. Recently, this company has taken several steps to diversify its activities in the areas of software, internet, agriculture, hospitality and a host of others.

21. The Becon. Its main field of activity is Biotechnology. Although a comparatively new comer in the industrial field, it has carved a niche for itself.

22. The Ranbaxy. Its main specialization is the manufacturing of drugs and pharmaceuticals in which it has earned great reputation all over the world. In addition to catering to the needs of the domestic market, it exports its products to a number of countries. Many other companies have been inspired by the Ranbaxy.

23. Hamdard. This industrial house is has done a pioneer work in the Unani tradition of medicines in India and has the high tradition of preserving, pursuing and propagating this stream of medicines. Its *Rooh Afza sharbat* is very useful to patients as well as to healthy people. This is very popular in a large number of countries and has a vast domestic and international market. Its child tonic called *Shinkara* is also very popular with the consumers.

24. The Dabur. Its primary activity is the manufacturing of Ayurvedic medicines for which it has earned a name for itself. Many of the medicines produced by the Dabur are used by allopathic doctors, some of which are useful even for the cancer patients. During the recent years, this industrial house has taken steps to diversify its products and is venturing in the areas of consumer non-durable like fruit-based drinks and toiletries.

25. The Baidhyanath. Like the Dabur, this house is also known to preserve and propagate the Ayurvedic medicines and is quite renowned in this field.

26. The Arya Vaidyashala. This is known as harbinger of the Ayurvedic tradition in India and also runs a hospital dealing with Ayurvedic treatment and naturopathy.

27. The Jaypee. This is one of the major real estate and construction companies of India which has earned the reputation of constructing major roads and bridges within the stipulated time.

28. Bombay Dying. This is one of the important companies engaged in textile industry and is well known for producing fine as well as cheap and durable bed-sheets and towels. Its products are well renowned in the international markets and are exported to a large number of European and American countries.

29. The Arvind Mills. This is one of the oldest textile mills in India which is engaged in producing and exporting some of the finest and cheapest cotton clothes and garments. This company is one of the largest producers of Jeans cloth and supplies this cloth to almost all the major brands in the world.

30. The Ansals. The Ansals are one of the largest and the oldest real estate developers and their activities can be seen in most of the cities of India.

31. The Pioneer. As the name goes, this company is doing a pioneer job in the development of high yielding varieties of seeds and is promoting hybrid seed-based farming in India. Thus it has played a significant role in the success of the Green Revolution of India. The company is also credited with producing different types of pesticides and herbicides.

32. The Pantnagar. This company is also producing better seeds and helps in the success of the Green Revolution. Apart form seeds, this company produces various pesticides and herbicides.

33. The ACC. This is the organisation of cement producing companies and is known as Associated Cement Company (ACC). It produces high quality cement which has great demand in the market. The company has contributed a lot in boosting the construction activity in the country.

Industrial Complexes

Industries in India are unevenly distributed because geographical, economic and a host of other factories affecting these industries are not evenly distributed. This trend has led to the development of concept of industrial complexes and their growth in different parts of the country. ***An industrial complex consists of a set of specific industries with prominence of production, marketing and other interrelationships among them, strengthened by their togetherness and innovations.*** In simple language, an industrial complex may refer to a factory or collection of buildings relating to industrial production. These complexes have specific geographical locations.

The concept and growth of industrial complexes gained popularity during the communist regime in the erstwhile U.S.S.R. when vigorous industrialization and planning were pursued after taking clues from the planned industrial development in France. This concept is associated with the concept of **'the growth pole'** of Francois Perroux (1955) and 'the growth centre' of J.R. Boudeville (1966). The concept industrial complexes started developing when the governments of various countries started planned economies and paid attention to industrial growth in certain favoured regions. The idea of an industrial complex, as developed by **W. Isard** is a method of analysing the *linkages* between industries in an industrial complex with the objective of identifying the type of industrial complex which would be most suitable for a given development plan or region—it is based on inter-industry relations of *input-output analysis* and *comparative cost analysis*.

In an industrial complex, the finished product of one industry becomes raw material for another industry. For example, automobile industry uses a large number of components which are manufactured by anxillary industries. Thus there is large scale sale and purchase of goods among different industries and their bond becomes stronger. In this way industries of various types play a complementary role in the development of one another. The quality of products is assured from the local industries and transport cost is also minimized. Thus the industries tend to cluster in a particular area and the industries as well as industrial complexes grow fast via the '*spillover effect*' and the '*multiplier effect*' ultimately benefitting the whole economy through the '*trickle down effect*'.

Industrial Complexes in India

There are thousands of industrial complexes which have grown in all the major and minor industrial regions of India. Such complexes may develop in the vicinity of iron and steel plants, and are known as iron and steel complexes. Some of the other complexes are petro-chemical complex, pharma complexes, hosiery complexes, garment complexes, electronic complexes, etc.

The major thrust for developing industrial complexes was given by the central and the state governments after the policy of liberalization and economic reforms was adopted as a result of the Industrial Policy of 1991. The Export Processing Zones (EPZs) and Export Oriented Units (EOUs) of the past and the Special Economic Zones (SEZs) of the present are some of the best examples of Industrial Complexes in India. Besides, Technology Parks, Hardware Parks, Biotechnology Parks etc. are also considered as industrial complexes. These complexes will remain relevant to the industrial growth, till planning is relevant to the economic growth in India.

Problems of Industrial Complexes

In spite of their above mentioned advantages, the industrial complexes have to face several problems, some of which are briefly described as under :

1. It often becomes difficult to select an industry which can attract auxiliary industries and the area may develop into an industrial complex.
2. India has a large number of such industries such as textile mills, paper mills, etc. This leads to break in the chain of *inter-linkage* which puts obstacles in the growth of industrial complexes.
3. Lack of infrastructural facilities, especially the power crisis has done untold damage to the growth of industrial complexes.
4. By and large, the market in India is underdeveloped and lopsided which is hampering the growth and development of the industrial complexes.
5. Indian industrial complexes have to face problems of proper support of external sector regarding imports-exports.
6. Lack of skill on the part of labour and entrepreneurship on the part of industrialists also act as big obstacles in the path of progress of industrial complexes.
7. Usually adequate finances are not available at the right time and industrial complexes have to suffer a great set-back.
8. Labour laws, generally prevailing in India are not conductive to the proper growth of industrial complexes.
9. Wrong selection of 'growth poles' and 'growth centres' often put hindrances in the growth of industrial complexes.

There is an urgent need to offer solutions to the above mentioned problems so that congenial atmosphere is provided for the proper growth of industrial complexes. Economic reforms were initiated in the policy of liberalization adopted in 1991 and some tangible results are visible in the industrial development. Experts are of the view that the industries will grow with the growth of economy and industrial complexes will also grow accordingly.

Public Sector Undertakings

A pubic sector undertaking is an organisation in which the finance, production, sale and management is governed by the Central or State Government. To put in simple words the Government owned corporations are termed as Public Sector Undertakings in India. In a Public Sector Undertaking, majority (51 per cent or more) of the paid-up share capital is held by the Central Government or a Statement Government or partly by the Central Government or partly by one or more State Governments. This is primarily a post-Independence phenomenon as there was virtually no Pubic Sector Undertaking before 1947. A few instances worth mentioning at that time were the Railways, the Post and Telegraphs, the Port Trusts, the Ordinance and Aircraft Factories and a few State managed undertakings like the government salt factories, quinine factories, etc. After Independence, the expansion of pubic sector was considered as an integral part of the 1956 Industrial Policy as this policy gave the public sector a strategic role in the Indian economy.

Immediately after Independence, the Indian economy was in a bad shape—basically an agrarian economy with a very weak industrial base, large scale unemployment, low level of savings and investment and near absence of infrastructural facilities. Under such circumstances, the Indian economy needed a big push which could come only from the Public Sector Undertakings because private sector was badly lacking in financial resources and managerial ability and was incapable of undertaking risks involved in large and long gestation period investments. At that time, the public sector was thought of as the engine for self-reliant economic growth to develop a sound agricultural and industrial base, diversify economy and overcome economic and social backwardness.

Central Government Enterprises

Table 25.27 shows that the Central Government has played a vital role with regard to public sector undertakings. In the year 1951, the number of enterprises operating was desperately small at 5 with negligibly small investment of ₹29 crores. The corresponding figures reached 22 and ₹6,66,848 in 2011. As on 31st March, 2011, the bulk of investment amounting to 27.83 per cent of the investment was in manufacturing. Even here, the bulk of investment was in basic industries such as iron and steel, coal, power, petroleum, fertilizers, etc. The basic purpose was to facilitate the process of industrialization by establishing heavy and basic industries.

TABLE 25.27. Growth of Investment in Central Government Enterprises

Year (as on March 31)	No. of Enterprises Operating	Total Investment (₹ crores)
1951	5	29
1961	47	950
1980	179	18,150
1990	233	99,330
2001	234	2,74,198
2007	216	4,21,089
2008	214	4,55,367
2009	213	5,13,532
2010	217	5,79,920
2011	220	6,66,848

Source : Government of India, Public Enterprises Survey (2010-11)

Objectives of Public Sector

Following objectives of setting up public sector enterprises have been concerned :

(*i*) to provide rapid economic development through creation and expansion of infrastructure

(*ii*) to generate financial resources for development

(*iii*) to promote redistribution of income and wealth

(*iv*) to create employment opportunities

(*v*) to promote balanced regional development

(*vi*) to encourage the development of small scale and ancillary industries, and

(*vii*) to promote exports on one side and import substitution on the other.

In addition to its major contribution to the industrial growth in the country, public sector has proved to be a great employment provider. Table 25.28 shows that public sector has offered employment to much larger number of people than the private sector. In the year 2001 public sector provided employment to 191 lakh persons in contrast to only 87 lakh persons offered by private sector.

TABLE 25.28. Public and Private Sector Employment in India (in lakhs)

Year	Public sector	Private sector	Total	Pubic sector employment as percentage of total employment
1971	111	67	178	62.4
1981	155	74	229	67.7
1991	190	77	267	71.2
2001	191	87	278	68.7
2005	180	84	264	68.2
2006	182	88	270	67.4
2007	180	93	273	65.9
2008	177	98	275	64.4
2009	178	103	281	63.3
2010	179	108	287	62.4

Source : Data computed from Economic Survey, 2011-12.

However, employment offered by public sector has been varying from 2001 to 2010 whereas employment offered by private sector has been consistently increasing. But employment offered by public sector has never fallen below 62 per cent of the total employment offered by both public and private sector.

Out of total employment of 179 lakh persons in 2010, 11.03 lakh was in mining and quarrying, 10.66 lakh in manufacturing and 8.35 lakh in electricity, gas and water.

Strong Industrial Base by Pubic Sector

It is a well known fact that the pubic sector undertakings laid a solid industrial base in India in the first three decades after Independence. This solid base led to fast industrial growth rate in the country. The Industrial Policy Resolution reserved certain industries such as atomic energy, ammunition and armaments, aircraft, etc. with the government in the interest of national security. The state also took the responsibility for developing key industries like coal, iron and steel, aircraft, ship-building, etc. Setting of integrated iron and steel plants at Durgapur, Rourkela, Bhiali and Bokaro. The Hindustan Machine Tools, locomotives at Chittaranjan and Varanasi are the outstanding examples of contribution by the public sector undertakings towards establishing a strong industrial base in India. Rest of the industries were left to the private sector. But the experience of the first three Five Year Plans made it very clear that private sector was not capable of laying a sound industrial base in the country due some of its inherent handicaps such as lack of capital infrastructure and administrative skill. Simultaneously, the Planning Commission realised that a much more diversified development in the field of industries was necessary if the Indian economy had to become self-generating. Naturally, the government had to undertake the development of basic and strategic industries, capital goods industries and even some consumer goods industries in a big way to boost the Indian economy. Even after the introduction of economic reforms, private sector investment has not increased according to expectations and even now it is being suggested that the pubic sector should take the responsibility of infrastructure development. Consequently, the public sector has entered into a wide spectrum of industries and products. Its operations extend from basic and capital goods like steel, coal, copper, zinc and other minerals, heavy machinery on one hand and drugs, chemicals, fertilizers, consumer goods like textiles, hotel services, watches, bread, etc. on the other hand. Most of these industries are of great strategic importance in the Indian economy because these are industries of high linkage.

In highly critical areas such as copper, coal, petroleum products, hydro and steam turbines the share of public sector is 100 per cent. In quiet a large number of products, it ranges between 50 to 95 per cent.

Removal of Regional Disparities

In addition to industrial growth, public sector undertakings have played a significant role in removing regional disparities in industrial development. With the beginning of the plan period after Independence, care was taken to identify industrially backward regions and pubic enterprises of the Central Government were set-up in those regions. Good example are setting up of three steel plants at Durgapur, Rurkela and Bhilai and Neyveli Project in Chennai. In certain cases, the State Governments could not raise sufficient resources for development of their regions. Under such circumstances, the only alternative available was the setting up of projects by the Central Government or to start enterprises which were financed by the centre. In the recent past, the Central Government had prepared an exhaustive plan to remove industrial backwardness of the north-eastern states and bring them in the main stream of the nation so far as industrial development is concerned.

Shortcomings of the Public Sector

Inspite of the fact that public sector undertakings have contributed a lot to the industrial development of India, there is lot of criticisms on account of the following shortcomings.

(*i*) **Mounting losses.** A review of the public sector enterprises reveals that most of them are running heavy recurrent accumulation of losses and very few are making little or no gain. This may be attributed to a large number of factors including subsidies.

(*ii*) **Political interference.** Often powerful politicians influence decisions regarding setting up of an industry in an area which is not suitable for that particular industry from the geographic and economic point of view. Such a situation results in high input, low output and considerable wastage of financial and human resources. A classic example of this type of political influence is the irrational approach in the decision of the Central Government to break up the MIG aircraft project into two parts to be located in two separate states. One of the project is at Nashik in Maharashtra and the other is at Karaput in Odisha. This was done to appease the political losses of these two states.

(*iii*) **Delays in Completion of Projects.** Since the government machinery has its own way of working which is slow and inefficient, there are often prolonged delays in completion of the projects. This results in colossal loss of resources and escalates the cost of construction due to high rate of inflation.

(*iv*) **Over-capitalisation.** Most of the public sector projects are plagued with over-capitalisation which means that input-output ratios is unfavourable. Some of the public sector undertakings facing this problem are Heavy Engineering Corporation, Hindustan Aeronautics, Fertilizer Corporation etc. According to a report of the Study Team on Public Sector Undertakings (1967), "The cause leading to over-capitalisation can be traced to inadequate planning, delays and avoidable expenditure during construction, surplus machine capacity, tied aid resulting in the compulsion to purchase imported equipment on a non-competitive basis, expensive turn key contracts, bad location of projects and the provision of housing and other amenities on liberal scale."

(*v*) **Price Policy.** Prices of most of the commodities produced by pubic sector undertakings are fixed by the Government and these price are fixed not based on the principle of profit maximisation, rather they are fixed keeping the pubic interest in mind. For example, fixing the prices of steel, oil, gas, coal, fertilizers and other essentials of everyday use will be suicidal for the overall growth of economy. Some times the prices of final products are fixed under public and political pressure.

(*vi*) **Excess of manpower.** In most of the public sector enterprises, recruitment of manpower is often in excess of actual requirement which is putting heavy strain on the input costs. On the other hand, low wages and lack of incentives are causing large scale flight of efficient and intelligent personnel from the public sector to the private sector. The Sixth Pay Commission has substantially raised emoluments of the executives and the Seventh Pay Commission is expected to further enhance their emoluments. This already has and is likely to check the shift from public to private sector.

In order to make pubic sector enterprises economically more effective, the Government has been shedding surplus workers in this sector. As a result of this policy, total number of employees in the Central Public Sector Enterprises declined from 19.92 lakh in 2001-02 to 16.14 lakhs in 2006-07.

(*vii*) **Under-Utilisation of Capacity.** There is a serious problem of under-utilisation of capacity in public sector enterprises. During 2005-06, out of 203 manufacturing/producing units, 103 units or 51% units had recorded capacity utilisation more than 75 per cent. On the other hand, 33 public sector enterprises operated in the capacity utilisation range of 50 to 75 per cent and 67 functioned below 50 per cent of the rated capacity. There is urgent need to investigate into the causes of such a situation and find remedial measures.

(*viii*) **Inefficient management.** There is a serious crisis of inefficient management in almost all the public sector enterprises. This is largely due to strict government rules, lack of elasticity and concentration of power in the hands of a few top executives. Each and every worker should know his responsibility. Unfortunately, there is a general failure to define responsibilities and duties in public sector enterprises in India.

INDUSTRIAL POLICY

'Industrial policy' is a comprehensive concept which coves all those procedures, principles, policies, rules, and regulations that control the industrial undertakings in the country and shape the patterns of industrialisation. It incorporates fiscal and monetary policies, the tariff policy, labour policy and the Governments attitude not only towards external assistance but the pubic and private sectors also.

Industrial Policy Resolution, 1948

The first industrial policy was announced by he Government of India on August 6, 1948. It contemplated a mixed economy in which both pubic and private sectors were involved for the purpose of industrial development. In accordance with this approach, industries were divided into following four broad categories :

(*i*) **Exclusive monopoly of the Central Government.** This included manufacture of arms and ammunition, the production and control of atomic energy and ownership and management of railway transport.

(*ii*) **State monopoly of New Units.** This category covered coal, iron and steel, aircraft manufacture, ship-building, manufacture of telephone, telegraph and wireless apparatus (excluding radio receiving sets) and mineral oil. New undertakings in this category could be undertaken only by the State.

(*iii*) **State Regulation.** This category included industries of such basic importance like machine tools, chemicals, fertilizers, non-ferrous metals, rubber manufactures, cement, paper, newsprint, automobiles, electric engineering, etc. which the Central Government would feel necessary to plan and regulate.

(*iv*) **Unregulated Private Enterprise.** This category of industries was left open to the private sector, individual as well as co-operative.

Industrial Policy Resolution, 1956

Significant development took place after the adoption of 1948 Industrial Resolution. The economic planning had proceeded on an organised basis and the First Five Year Plan had been completed. These important developments made it necessary to come out with fresh statements of industrial policy. Consequently a second Industrial Policy Resolution was adopted in April, 1956. Following were its important provisions.

(*i*) **New Classification of industries.** Industries were divided into following three categories :

(*a*) ***Schedule A.*** These were exclusive responsibility of the state and included seventeen industries *viz*., arms and ammunition, atomic energy, iron and steel, heavy castings and forgings of iron and steel, heavy machinery required for iron and steel production, for mining, for machine tool manufactures, etc., heavy electrical industries, coal, mineral oils, mining, iron ore and other important minerals like copper, lead, zinc; aircraft, air transport, railway transport, ship-building, telephone, telegraph and wireless equipment, generation and distribution of electricity.

(*b*) ***Schedule B.*** These were to be progressively state owned and in which the state would generally set-up new enterprises, but in which private enterprise would be expected only to supplement the efforts of the state. It included twelve industries *viz*. other mining industries, aluminium and non-ferrous metals not included in Schedule A, machine tools, ferro alloys and tool steels, the chemical industry, antibiotics and other essential drugs, fertilizers, synthetic rubber, carbonization of coal, chemical pulp, road transport and sea transport.

(*c*) ***Schedule C.*** It included all remaining industries and their future development, in general, would be left to the initiative and enterprise of the private sector.

(*ii*) **Fair and non-discriminatory treatment for the private sector.** The state was supposed to facilitate and encourage the development of industries in the private sector by ensuring the development of transport, power, and other services and by appropriate fiscal and other measures without any discrimination.

(*iii*) **Encouragement to village and small-scale enterprises.** The state would take appropriate steps to encourage village and small scale industries.

(*iv*) **Removing regional disparities.** Special emphasis was laid on developing industries in industrially backward areas so that those area as well the whole country is benefited.

(*v*) **Attitude towards foreign capital.** Keeping in view limited resources within the country, it was felt that there was need for securing the participation of foreign capital and enterprise particularly as regards to industrial technique and knowledge so as to foster the pace of industrialisation.

Industrial Policy Statement 1977

With the defeat of Congress Party in 1977, Janata Party came to power and announced its own New

Industrial Policy on December, 1977. Following were the main elements of this policy :

1. Development of Small Scale Sector. It was felt that the policies gave priority to large scale industries at the cost of small-scale industries. Thus the main thrust of this policy was on effective promotion of cottage and small-scale industries which are widely dispersed in rural areas and in small towns. Small-scale sector was classified into the following three categories :

(*a*) Cottage and household industries which provide self-employment on a wide scale.

(*b*) Tiny sector incorporating investment in industrial units, in machinery and equipment upto ₹ 1 lakh.

(*c*) Small-scale industries comprising industrial units with an investment upto ₹ 10 lakhs and in case of ancillaries with an investment in fixed capital upto ₹ 15 lakhs.

2. Areas for Large-Scale Sector. Large-scale industries were divided into the following sectors for their proper development :

(*a*) basic industries such as steel, non-ferrous metals, cement and oil refineries.

(*b*) capital goods industries for meeting the machinery requirements of basic industries and small scale industries.

(*c*) high technology industries which required large-scale production and which were related to agricultural and small-scale industries development such as fertilizers, pesticides and petrochemicals, etc.

(*d*) other industries.

The other elements of this industrial policy were :

3. Rational approach towards large business houses.

4. Expanding role of public sector which includes development of wide range of ancillary industries and decentralization of production.

5. Restricted role of foreign collaboration.

Industrial Policy of 1980

The Janata Party Government at the centre was dislodged by the Congress Party Government which announced its own industrial policy in July, 1980. This policy suggested the following measures :

(*i*) Effective operational management of the Public Sector.

(*ii*) Integrating industrial development in private sector by promoting the concept of economic federalism.

(*iii*) Redefining small scale units as per following divisions :

(*a*) to increase the limit of investment in the case of tiny units from ₹ 1 lakh to ₹ 2 lakhs.

(*b*) to increase the limit of investment in case of small-scale units from ₹ 10 lakhs to ₹ 20 lakhs; and

(*c*) to increase the limit of investment in the case of ancillaries from ₹ 15 lakhs to ₹ 25 lakhs.

(*iv*) Regularisation of unauthorised excess capacity installed in private sector.

(*v*) Automatic expansion of all industries specified in the First Schedule of 1951 Industrial Development Regulation Act.

(*vi*) Revival of those sick industrial units which showed the requisite potential.

Industrial Policy of 1991

A major shift in the industrial policy was made by the Congress Government led by Mr. P.V. Narasimha Rao on July 24, 1991. The main aim of this policy was :

(*a*) to unsackle the Indian industrial economy from the cobwebs of unnecessary bureaucratic control.

(*b*) to introduce liberalisation with a view to integrate the Indian economy with the world economy,

(*c*) to remove restrictions on direct foreign investment as also to free the domestic entrepreneur from the restrictions of MRTP (Monopolies and Restrictive Practices Act) and

(*d*) the policy aimed to shed the load of the public enterprises which have shown a very low rate of return or were incurring losses over the years.

Keeping in view the above mentioned aims, the following initiatives were taken :

1. Industrial Licensing Policy
2. Foreign Investment
3. Foreign Technology Policy
4. Public Sector Policy
5. MRTP (Monopolies and Restrictive Practices Act

1. Industrial Licensing Policy

The industrial licensing policy was framed with respect to the following :

(*a*) Industrial licensing to be abolished for all projects except for a short list of industries related to security and strategic concerns, social reasons, hazardous chemicals and overriding environmental reasons and items of elitists consumption. Industries reserved for the small-scale sector will continue to be so reserved.

(*b*) Areas where security and strategic concerns predominate, will continue to be reserved for public sector.

(*c*) In projects where imported capital goods are required, automatic clearance will be given in cases where foreign exchange availability is ensured through foreign equity. In other cases, imports of capital goods will require clearance from the Secretariat of Industrial Approvals (SIA) in accordance with the availability of foreign exchange resources.

(*d*) In locations other than cities of more than one million population, there would be no requirement for obtaining industrial approval from the central government except for industries subject to compulsory licensing. In respect of cities with population larger than one million, the industries other than non-polluting such as electronics, computer software, and printing will be located outside 25 km of the periphery, except in prior designated industrial areas.

2. Foreign Investment

For encouraging foreign investment in high priority industries, requiring large investments and advanced technology, it was decided to provide approval for direct foreign investment upto 51 per cent foreign equity in such industries.

3. Foreign Technology Policy

For improving the level of technology in Indian industry, the government proposed to provide automatic approval for technology agreements related to high priority industries within the specific parameters. No permission is required for hiring of foreign technicians, foreign testing of indigenously developed technologies.

4. Public Sector Policy

By and large public sector enterprises have given very small returns in proportion to the investment made in such enterprises largely due to their inefficient functioning and also due to take-over of sick private units. Thus they become a liability rather than an asset to the Government. The 1991 Industrial Policy adopted a new approach to public sector enterprises. The following areas were given priority for the future growth of public sector enterprises.

(*a*) Essential goods and services.

(*b*) Exploration and exploitation of oil and mineral resources.

(*c*) Technology development and building of manufacturing capabilities in areas which are crucial in the long-term development of the economy and where private sector investment is inadequate.

(*d*) Manufacture of products where strategic considerations predominate such as defence equipment.

5. MRTP (Monopolies and Restrictive Practices) Act

With the growing complexity of the Indian industrial structure and increasing need for achieving economies of the scale for ensuring higher productivity and competitive advantage in the international market, the interference of the Government through the MRTP Act was to be restricted. To meet this end :

(*a*) The pre-entry scruiting of investments or decisions by the so called MRTP companies will not be required. Instead, the emphasis will be on controlling and regulating monopolistic, restrictive and unfair trade practices rather than making it necessary for monopoly houses to obtained prior approval of the Central Government for expansion, establishment of new undertakings, merger, amalgamation and take over and appointment of certain directors.

(*b*) The thrust of the policy will be more on controlling unfair or restrictive business practices.

MULTINATIONAL COMPANIES (MNCs)

Induction and Definition

A multinational company/corporation is an organisation which has one its headquarters in one country but has business in more than one country. In other words it is an organisation or enterprise carrying business not only in the country where it is registered but also in several other countries. It may also be called as international corporation, global giant and transnational corporation. According to the most widely accepted definition, an international company is that organisation which produces at least 25 per cent of its global investment outside its original country.

According to the United Nations, a multinational corporation is "an enterprise which owns or controls production or service facilities outside the county in which it is based." In words of W.H. Morcland, "Multinational Companies/Corporations are those enterprises whose management, ownership and controls are spread in more than one foreign country."

Characteristics of MNCs

1. Large Size. MNCs are generally of large size with assets worth billions of dollars and their annual sales turn over is usually more than the gross national product of many small countries.

2. Worldwide Operations. As mentioned earlier a MNC has business in more than one country and often it spreads over a large number of countries. For example, Coca Cola has its branches in more than seventy countries.

3. International Management. MNCs have management at the international level. They operate on the basis of best possible alternative available anywhere in the world. Its local subsidiaries are generally managed by the people of the host country. For example, the management of Hindustan Lever lies with Indians whereas the parent company Unilever is in the U.S.A.

4. Mobility of Resources. Operations of MNCs involve the mobility of capital, technology, entrepreneurship and other factors of production across the territories.

5. Integrated Activities. A MNC is usually a complete organisation comprising manufacturing, marketing, research and development (R&D) and other facilities.

6. Several Forms. A MNC may operate in host of countries in several forms *i.e.* branches, subsidiaries, franchise, joint ventures, etc.

Origin and Growth. MNCs started functioning even before the process of colonisation in the world by the European nations. East India Company was set-up in India before the British rule could establish itself in the country. Similarly the Dutch East Indonesian Company, the Royal African Company and the Hudson Bay Company started their business in early phase of the period of colonisation. Their main purpose was to find out new markets in different countries and exploit their potential. These companies started procuring raw materials from their markets to feed their industries at home. At the same time they found ready market for their furnished products in the countries under their control. Thus a totally new economic and political system was evolved and the era of colonisation began.

After the Second World War, most of the colonial countries became independent nations and started developing their own economies. During this period, the U.S.A. become the world's largest industrial nation and started spreading its influence in larger parts of the world through Direct Foreign Investment. So far so, the U.S.A. became a net investor in addition to being a major exporter.

According to estimates made by the U.N.O., about 35,000 corporates have nearly 1,70,000 companies doing business in countries other than their own country.

TABLE 25.29. Top Ten Multinational Companies in India

Name	Corporate Office	Turn Over (Billion dollars)	Employees	Business
1. Microsoft	Redmond, Washington, U.S.	74	97,000+	Software
2. IBM	Armonk, New York	107	4,34,246	Computer hardware, software, IT services and consulting.
3. Nokia Corporation	Espoo, Finland	39	97,800+	Telecommunications, equipment, Internet, Software.
4. Pepsi Co.	New York, U.S.A.	67	2,97,050+	Food and Beverage
5. Nestle	Vevy Switzerland	86	3,25,000	Food processing
6. Ranbaxy Laboratories Ltd.	Gurgaon Haryana (India)	2	10,000	Pharmaceuticals
7. Coca Cola	Midtown Atlanta Georgia	—	1,50,500+	Beverage
8. Procter & Gamble	Cinceinnati, Ohio, USA	84	1,25,000+	Consumer goods
9. Sony Corporate	Minato Takyo, Japan	80	1,62,000+	Conglomerate Corporation
10. Citigroup Inc.	Manhattan, New York, U.S.A.	70	2,58,500+	Banking and Financial services

Source **:** https/www.google.co. in/search.

The quantum of business carried on by them can be judged from the fact that in 1998 about 200 big Multinational companies of the world accounted for 28.3 per cent of the world's GDP. Currently, their total sales are equivalent to the GDP of 182 countries of the world (excluding the U.S.A., Japan, Germany, France, Britain, Brazil, Canada, China and Italy).

Effects of MNCs. MNCs have both good and bad effects in India. For example, most industries were producing consumer goods at the time of Independence. There were only three iron and steel companies (TISCO, IISCO and MISCO) and capital goods were almost absent. At present, India has developed almost all types of Industries largely with the help of foreign finances, technology and expertise. In spite of all these achievements, MNCs are not flawless and have their own ill effects. In the year 1975-76, Dr. S.K. Goel studied 133 out of 171 companies and arrived at certain conclusions. Some of the conclusions can be summed up as follows :

1. Capital Investment. Some MNCs made some capital investment in the beginning to exploit the rich natural resources of India.

2. New Technology. Before Independence, most industries in India were using old and obsolete technology which gave low level of production of inferior goods. MNCs introduced new advanced technology to Indian industries which improved the quality of industrial products and also helped in increasing their production.

3. Damage to Cottage and Small-Scale Industries. India had a rich tradition of cottage and small-scale industries which were based on traditional methods of production. These industries could not compete with modern industries of MNCs which started producing better goods in larger quantities and at cheaper prices. Thus these industries suffered a great set-back at the hands of MNCs and may totally disappear in future if proper steps are not taken to safeguard the interest of these industries.

4. Low Level of Foreign Investment. Dr. S.K. Goel has rightly pointed out that most foreign subsidiaries have raised financial resources from within India by exploiting the natural resources of the country. Thus MNCs invested very little capital form their parent countries and total foreign investment has been only marginal.

5. Multi-Industry Pattern. Many MNCs have acquired multi-product and multi-industry pattern adding considerably to their original industry. For example, the Imperial (now India) Tobacco Company (ITC) has diversified its activities and ventured into hotel industry, constructing a chain of hotels in different parts of the country. This company has also entered into some allied industries such as salt, flour, biscuits, match boxes, agarbathi, etc.

6. Heavy Remittance Abroad. According to the Reserve Bank of India, 537 foreign companies have reported average rate of profit at 23.8 per cent during the period 1972 to 1993. This rate is reported to have increased to about 25 per cent now. This is a huge amount of money remitted outside the country causing heavy strain in India's economic resources.

7. Transfer of Technology—A Myth. According to Dr. S.K. Goel, 'the assumption that entry of multinational corporations would ensure transfer of latest sophisticated technology to developing countries has not been found valid in practice and has proved to be a myth.

LIBERALISATION

Liberalisation means to liberate the Indian industries from undue interference of the government agencies and to remove the bureaucratic control which have been hampering the proper growth of industries in the country. It was also aimed at enabling the Indian industries to successfully face the market forces and provide guidelines for their future growth. The process of liberalisation started on 24th July, 1991 when Dr. Manmohan Singh, the then Finance Minister in Mr. P.V. Narasimha Rao ministry introduced the new Industrial Policy. Following are the salient features of policy of liberalisation.

1. Under the policy of liberalisation, the bureaucratic control on the industries was removed as it was creating barriers in the industrial development in the country. As a matter of fact, this policy implies deregularisation of the industrial sector by cutting down the minimum administrative interference in operation, instead, letting the market forces operate through the profit motive of the producers and free competition among them to regulate and guide the future development of the industry sector.

2. The Industrial Policy of 1991 was slightly modified in March, 1993 according to which requirement of industrial licensing was abolished except for 18 industries namely, (1) coal and lignite, (2) petroleum (other than crude) and its distillation products, (3) distillation and brewing of alcoholic drinks, (4) sugar, (5) animal fats and oils, (6) cigars and cigarettes of tobacco and manufactured tobacco substitutes, (7) asbestos and asbestos based products (8) plywood, decorative veneers and other wood based products like particle board, medium density fibre board, black board, (9) raw hides and skins, leather, chamois leather and patent leather, (10) tanned or dressed furskins, (11) motor car, (12) paper and newspaper except bagasse-based units, (13) electronic aerospace and defence equipment—all types, (14) industrial explosives, including detonating fuse, gun powder, nitrocellulose and matches, (15) hazardous chemicals, (16) entertainment electronics (VCRs) Colour TVs, CD players, tape recorders), (17) drugs and pharmaceuticals and (18) white goods (domestic refrigerators, domestic dish washing machines, programmable domestic washing machines, microwave oven, airconditioners).

3. Gates for direct foreign investment (DFI) were opened and subsidies were reduced.

4. Restriction on export and import of a large number of items were abolished.

5. Import tariffs were substantially reduced and restrictions of foreign investment were totally removed.

6. The government share in industries was restricted to 51 per cent and the process of disinvestment in public sector was initiated. This led to reduction of delays in taking decisions at the government level and the industrialists become free to take their own-decisions without any loss of time.

7. Under the policy of liberalisation, the industrialists were encouraged to take active part in the fields of road, power, communication and petroleum so that centre and state governments could pay more attention to social and economic development programmes.

Impact of Liberalisation

Liberalisation has left both good and bad effects on Indian economy.

Good Effects

Indian economy in general and industries in particular have been benefited a lot by the policy of

liberalisation as is clear from the following few points :

1. Increase in Foreign Direct Investment (FDI). The policy of liberalisation has provided congenial atmosphere for investment and given a boost to FDI. This provides great opportunities for development of industries and other spheres of economy. From a meager amount of ₹ 534.11 crore in 1991, the cumulative FDI flow from April, 2000 to November, 2012 stood at US $ 277.86 billion. During 2012-13, services, hotels and tourism, metallurgical industries, automobile industry, construction, drugs and pharmaceuticals, industrial machinery were the sectors that attracted maximum FDI inflows. In FDI equity investments, Mauritius tops the list of first ten investing countries, followed by Singapore, the U.K., Japan, the U.S. the Netherlands, Cyprus, Germany, France and the U.A.E.

2. Increase in GDP (Gross Domestic Product). There had been significant increase in GDP after the policy of liberalisation was adopted by the government. In the year 1991, GDP was ₹ 6,92,871 crore which rose to ₹ 1,00,28,118 crore in 2012-13.

3. Reduction in Industrial Recession. Before liberalisation, Indian industries were passing through the phase of recession. Foreign investment and technology started flowing in immediately after adoption of policy of liberalisation. Old industries were rejuvenated and new industries were established. All these developments resulted in reduction of recession. In 1991, Indian industries faced serious recession but its effect was reduced to a great extent by 1994. Industrial index increase from 4 per cent in 1994 to 12 per cent in 1995-96. Industries like automobiles, autoparts, coal mining, consumer electronics, textiles, petrochemicals, software, sports-goods recorded a growth rate of 20 per cent in 1994. Besides, fertilizers, crude oil, tyres, tubes, etc. also recorded a 10 per cent growth at the same time. In the year 2007-08, the whole world was passing through a serious economic recession but India was one of the least effected nations in the world. However, some slowdown in the Indian industrial growth rate has been observed in the recent past. For example, growth rate in manufacturing fell from 9.0 per cent in 2010-11 to 3.0 in 2011-12. With 100 as base in 2004-05, the general index of industries increased to 172.1 in 2013-14.

4. Increase in employment. Liberalisation has opened the doors for domestic and foreign investment amounting to over ₹ three lakh crores. This will definitely strengthen the industrial base in the country and create 32 lakh jobs.

5. Development of Infrastructure. Before liberalisation, major components of infrastructure such as transport and electricity were in a bad shape and were adversely affecting the economic growth in general and industrial growth in particular. Liberalisation provided congenial atmosphere for heavy investment in infrastructure which facilitated the rapid economic and industrial growth in the country.

6. Rise in Exports. Liberalisation led to economic and industrial growth which in turn, boosted India's exports considerably. For example, India's total exports amounted to ₹ 32,553 crores in 1990-91 which rose to ₹ 18,94,182 in 2013-14.

Bad Effects

Although liberalisation has helped in developing economy and has led to industrial growth, it has its own bad effects, some of which are briefly described as under :

1. Increase in Regional Disparities in Industrial Growth. The policy of liberalisation and New Industrial Policy have increased the pre-existing regional disparities instead of reducing them. Both the Indian and the foreign investors invested money only in those regions which were already advanced from the industrial point of view. The maximum investment was made in industrially advanced states of Maharashtra, Gujarat, Rajasthan, West Bengal, Andhra Pradesh, Tamil Nadu and Karnataka and industrially backward states like Bihar, Himachal Pradesh, Uttarakhand, Jammu and Kashmir, Meghalaya, Mizoram, Tripura, Nagaland, Odisha, Uttar Pradesh, etc. are lagging behind. In the year 1994, Maharashtra was at the top with an investment of ₹ 3,744.71 crores. West Bengal with ₹ 2,844 crores was at the second place. **Ghum** and **Ghuman** recognised four regions with respect to investment. These are : (*i*) Maharashtra-Gujarat, (*ii*) Andhra Pradesh, Tamil Nadu, Karnataka, Madhya Pradesh and Odisha, (*iii*) Haryana and Rajasthan and (*iv*) West Bengal. Uttar Pradesh, Himachal Pradesh, Uttarakhand and Bihar are the least benefited states. Increase in regional disparities has given birth to a large number of socio-economic and political problems. The Naxal Movement in a large number of states extending from Darjeeling in West Bengal to Kanniyakumari in Tamil Nadu. ULFA in Assam, and political turmoil in Jammu and Kashmir may be partly explained due to regional disparities in industrial growth.

2. Increase in Regional Disparities in Infrastructure. Along with regional disparities with respect to industrial growth, regional disparities in infrastructural development have also increased. For example, out of 33 sanction electricity projects (based on coal, gas lignite and water) in 1994, the state-wise sanction was 6 to Odisha, 5 in Karnataka, 3 each to Tamil Nadu, Andhra Pradesh and Maharashtra, 2 each to Haryana, West Bengal and Andhra Pradesh and the remaining seven were sanctioned to other states. Madhya Pradesh, Uttar Pradesh, Bihar, Mizoram, Nagaland, and Delhi were totally deprived of these projects.

3. Damage to Cottage and Small-scale Industries. A developing country like India has an old and rich tradition of cottage and small-scale industries. These industries form an important segment of our economy and provides employment to millions of artisans at the village level. Liberalisation opened the floodgates for investment by Indian as well as foreign companies in large scale industries. This give much need boost to large-scale industries but cottage and small-scale industries suffered heavily because they could not compete with rich financial and technological resources of big companies. The revival of these industries requires help from the government in the form subsidies, technology, and proper facilities for exports.

4. Increase in Unemployment. Although liberalisation facilitated the smooth flow of foreign investment, it also encouraged the use of labour saving new work efficient technology. Thus in spite of heavy investment and rapid increase in industrial production, the employment opportunities were drastically reduced and unemployment increased.

5. Comparatively Little Direct Investment. The foreign investors are more interested in portfolio investment rather than in direct investment. The main reason for such a situation is portfolio investment can be withdrawn at will without much hurdles, thus adversely affecting the economy of the country.

6. Problem of Inflation. Since the adoption of policy of liberalisation, the rate of inflation has been almost consistently high, sometimes soaring to double digits. This often upsets the budget of a middle class family. Moreover, money is concentrated to a few rich persons and the gap between the poor and the rich widens. This type of situation creates a lot of economic and social problems often leading to social tension.

7. Excess of foreign money. Liberalisation has allowed large scale inflow of foreign money which could not be properly invested due to low level economy and poor base in the country. Investment for exports is limited and foreign trade is adversely affected.

8. Investment in Selected Industries. Most of the foreign investment comes to white-goods instead of wage-goods sector. Thus it may be useful in improving the high priority sector and bringing in the latest technology while ignoring the other sector. This can be counterproductive and is not in the interest of overall economic development.

9. Economic and Political Freedom at Stake. Liberalisation attracts more and more of foreign investment also involving a lot of foreign exchange. Thus there is a danger that the whole economy may be handed over to the multinationals putting our economic and political freedom of a great risk.

10. Agriculture is ignored. Liberalisation has given impetus to industries but has badly ignored agriculture. Agriculture is the **'back-bone'** of our economy which provides livelihood to more than 55 per cent of our population. If the trend of encouraging industries at the cost of agriculture continues unabated it will bring imbalance in the economy and the country will be confronted with a serious economic crisis.

SPECIAL ECONOMIC ZONE (SEZ)

Introduction and Definition

Special economic zone (SEZ) is a geographical region in which economic laws are more liberal than laws prevailing in other parts of a country and which is designed to export goods. SEZ may be exempt from laws regarding taxes, quotas, Foreign Direct Investment (FDI) loans, labour laws and other restrictive laws in order to make the goods manufactured in the SEZ at globally competitive price. The SEZ includes Free Trade Zones (FTZ), Export Processing Zones (EPZ), Free Zones (FZ), or Free Economic Zones (FEZ), Industrial Parks or Industrial Estates, Free Parks, Bonded Logistics Parks and Urban Enterprise Zones. The operating definition of an Economic Zone is determined by each country's trade and customs administration. For a well organised SEZ there should be atleast 1000 hectares of land and a minimum investment of ₹ 10,000 crore.

Objectives. SEZ is established with the following objects in mind :

(*a*) Generation of additional economic activity.

(*b*) Promotion of exports of goods and services.

(*c*) Promotion of investment from domestic and foreign sources.

(*d*) Creation of employment opportunities.

(*e*) Development of infrastructure facilities.

Historical Perspective

In the opinion of Robert C. Hayward, Director, World Economic Processing Zones Association, the concept of free economic zones dates back to 300 B.C. He noted that such enclaves were found in the city of tyre in the Greek island of Delos. The city became rich due to such policies and was considered as a challenge to the centralism of the Roman Empire. In the modern context, the most famous SEZs were established by the government of China under Deng Xiaoping in the early 1960s. This was followed by setting up of SEZs in a large number of countries including Brazil, India, Iran, Jordan, Kazakhistan, Pakistan, Philippines, Poland, Russia and Ukraine.

Special Economic Zones of India

India was one of the first countries in Asia to recognise the effectiveness of Export Processing Zone (EPZ) model in promoting exports with Asia's first EPZ set-up in Kandla in 1965. In order to overcome the shortcomings due to multiplicity of controls and clearances, absence of world class infrastructure, and an unstable fiscal regime and for attracting larger foreign investments in India, the Special Economic Zones (SEZs) Policy was announced in April, 2000.

In 2004, the Government of Gujarat, amended the Industrial Disputes Act to create special exemption for SEZs so that companies can terminate work with only one month's notice. This flexibility helped in growing manufacturing jobs in Gujarat by 60% from 2000 till 2012.

The SEZ Act, 2005, was a very important bill passed by the Government of India. This bill was passed with the aim to instil confidence in investors and signal the Government's commitment to a stable SEZ policy regime with a view to impart stability to SEZ regime thereby generating greater economic activity and employment through their establishment. This Act come into effect on February 10, 2006 and provided for drastic simplification of procedures and for single window clearance on matters relating to central as well as state governments. The remaining part of India, not covered by SEZ rules is known as *Domestic tariff area*. Exports from Indian SEZ totalled ₹ 2.2 trillion in 2009-10. It grew by a stupendous 43% to reach ₹ 3.16 trillion in 2010-11. Indian SEZs have generated 8,40,000 jobs as in 2010-11. Despite all odds, exports through Indian SEZs grew further by 15.4% to reach ₹ 3.64 trillion in 2011-12.

INCENTIVES AND FACILITIES TO SEZ DEVELOPERS

- Exemption from customs/excise duties for authorised operations.
- Income Tax exemption on income derived from business of development of SEZ.
- Exemption from minimum alternative tax.
- Exemption from dividend distribution tax.
- Exemption from sales tax.
- Exemption from service tax.

There were 143 SEZs as of June, 2012 operating throughout India. An additional 634 SEZs (as of June 2012) have been formally/principally approved by the Government of India (**Table 25.30**).

TABLE 25.30. Number of Special Economic Zones in India (as of June, 2012)

State/Union Territory	No. of Operational SEZs	No. of SEZs formally approved	Total
1. Andhra Pradesh	36	116	152
2. Tamil Nadu	28	77	105
3. Karnataka	22	60	82
4. Maharashtra	18	119	137
5. Gujarat	13	53	66
6. Kerala	7	29	36
7. Uttar Pradesh	6	35	41
8. West Bengal	5	24	29
9. Rajasthan	4	11	15
10. Haryana	3	2	5
11. Chandigarh	1	2	3
12. Madhya Pradesh	1	17	18
13. Odisha	1	10	11
14. Punjab	0	8	8
15. Goa	0	7	7
16. Chattisgarh	0	3	3
17. Delhi	0	3	3
18. Dadra & Nagar Haveli	0	2	2
19. Nagaland	0	2	2
20. Puducherry	0	2	2
21. Uttarakhand	0	2	2
22. Jharkhand	0	1	1

Source : en-wikipedia.org/wiki/special economic zone#India.

INDUSTRIAL/ECONOMIC CORRIDORS

Industrial/economic are corridors along the main transport routes which have been selected for special thrust to be given for industrial/economic development in the country. The corridors involve multiple development projects including development in transport, socio-economic impact, urban development, environmental management, increase in exports, growth in employment opportunities and above all revolutionise the industrial growth. Currently following four industrial/economic corridors are proposed to be developed (**Fig. 25.17**).

1. Delhi-Mumbai Industrial Corridor (DMIC)
2. Amritsar-Delhi-Kolkata Industrial Corridor (ADKIC)
3. Chennai-Bengaluru Industrial Corridor (CBIC).
4. Bengaluru-Mumbai Industrial Corridor (BMIC)

1. Delhi-Mumbai Industrial Corridor (DMIC). This is the most ambitious industrial development plan of the Government of India for which 'in principle' approval was accorded in August 2007. This 1483 km long industrial corridor will be developed along the *Western Dedicated Freight*

Corridor of the Indian railways with view to using the high-capacity of this dedicated freight corridor as a backbone for creating a global manufacturing and investment destination. The project seeks to develop a series of futuristic infrastructure endowed smart industrial cities that can compete with the best international manufacturing and industrial regions. The master plan has a vision for 24 manufacturing

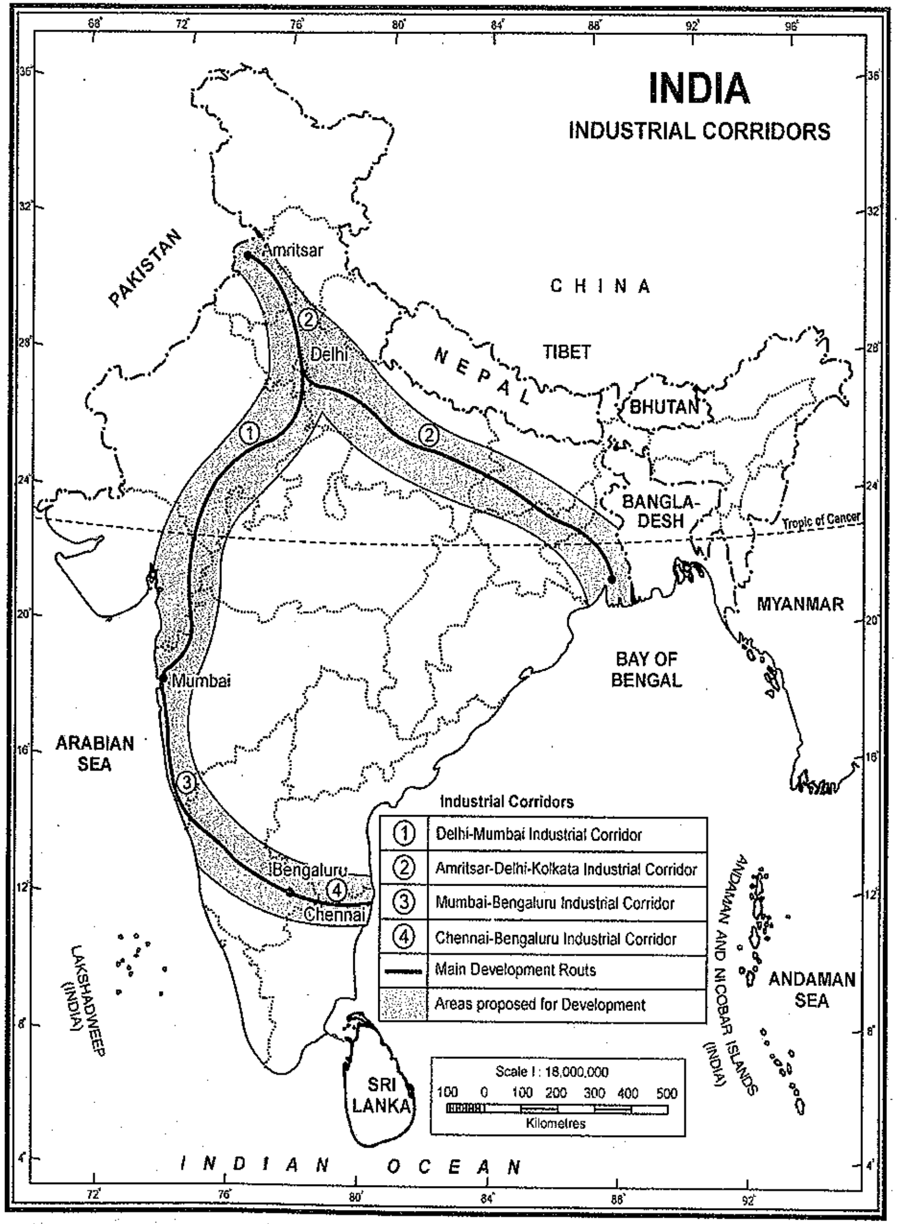


FIG 25.17. India : Industrial Corridors

cities. Potential production sectors include general manufacturing, IT/ITES components, electronics, agro and food processing, heavy engineering, pharmaceuticals, biotechnology, and services. The project involves a total investment of $ 90 billion and will be completed with Japanese assistance.

The project with involve a total area of 4,36,486 sq km which is about 13.8 per cent of the total land area of India. It extends over seven states and two union territories *viz.* Delhi, Uttar Pradesh, Haryana, Rajasthan, Madhya Pradesh, Gujarat, Maharashtra, Daman and Diu and Dadra and Nagar Haveli (Delhi has been treated as a state in this context). The distribution of length of the corridor indicates that Rajasthan (39%) and Gujarat (38%) together constitute 77% of the total length of the freight corridor followed by Haryana and Maharashtra 10% each and Uttar Pradesh and National Capital of Delhi 1.5% each) About 17 per cent of India's total population will be affected. The projects goals are to double employment potential in seven years, triple industrial output in nine years, quadruple exports from the region in 8-9 years and target 13-14 per cent growth per annum for the manufacturing sector on a sustainable basis. The project is expected to generate employment for 3 million persons. The Western Dedicated Freight corridor will have nine junction stations along which other railroad networks will connect allowing the system to extend its reach across a wide swatch. Other infrastructure plans include logistic hubs, feeder roads, power generation facilities, up-gradation of existing ports and air-ports, developing greenfield ports, environment protection and social infrastructure. It will include three seaports and six airports in addition to connectivity with the existing ports. The major power inputs will come

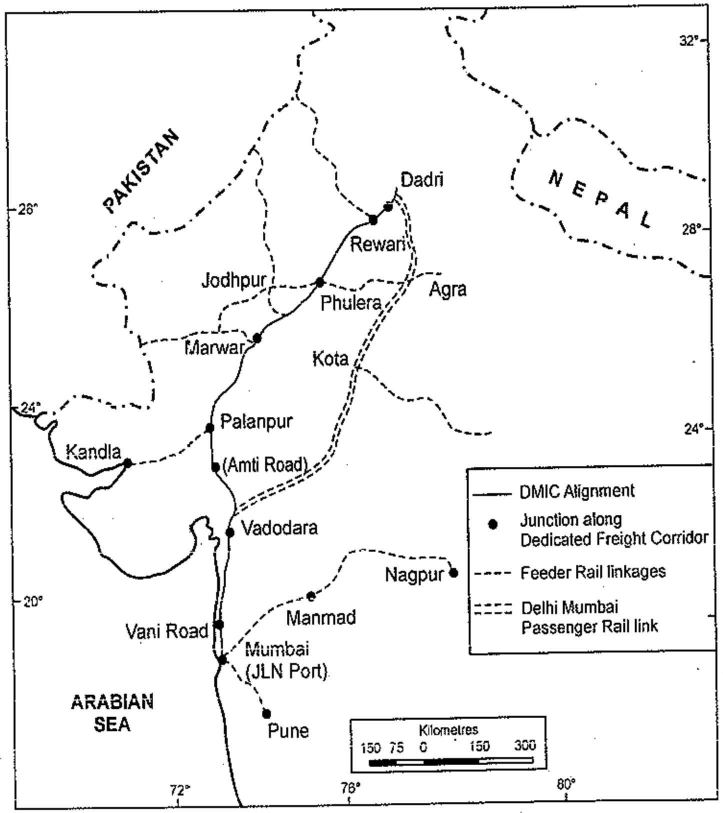


FIG 25.18. Delhi-Mumbai Industrial Corridor

from six gas-based projects of around 1000-12000 MW each. Other power options include the use of renewable energy sources integrated through a smart grid.

The project seeks to upgrade the existing industrial clusters and also develop new industrial facilities. These will be developed on the concept of node-based development based on Investment Regions (IRs) and Industrial Areas (IAs). These are proposed as self-sustaining industrial townships with world class infrastructure. IRs will have a minimum area of 200 sq km and IAs will have 100 sq km. In all 24 IRs and IAs are planned.

Six mega investment regions are Dadri-Noida (U.P.), Manesar-Palwal (Haryana), Khushera-Bhiwadi-Neemra (Rajasthan), Ptampura-Dhar-Mhow (Madhya Pradesh), Bharuch-Dahej (Maharashtra) and Igatpuri-Nashik-Sinnar (Maharashtra) Five industrial areas are Meerut-Muzaffarnagar (Uttar Pradesh), Faridabad-Palwal (Haryana), Jaipur-Dausa (Rajasthan), Vadodara-Ankleshwar (Gujarat) and Alewari-Dighi Port (Maharashtra).

2. Amritsar-Delhi-Kolkata Industrial Corridor. This corridor will be structured around the Eastern Dedicated Freight Corridor (EDFC) and also along the existing highway transport route. It will also leverage the Inland Water Transport System being developed along the Ganga river from Allahabad to Haldia. It will cover the states of Punjab, Haryana, Uttar Pradesh, Uttarakhand, Bihar, Jharkhand and West Bengal. This is one of the most densely populated regions of the world and is the home for about 40% of India's population. It will cover the cities of Amritsar, Jalandhar, Ludhiana, Amabala, Saharanpur, Delhi, Roorkee, Moradabad, Bareilly, Aligarh, Kanpur, Lucknow, Allahabad, Varanasi, Patna, Hazaribagh, Dhanbad, Asansol, Durgapur and Kolkata.

3. Chennai-Bengaluru Industrial Corridor (CBIC). This 560 km long corridor between Chennai-Bengaluru-Chitradurga will benefit the states of Karnataka, Andhra Pradesh and Tamil Nadu. Comprehensive plan for the CBIC was decided in December 2011, and it will be completed with Japanese financial help. Steel, cement, food processing, information technology, automobiles, readymade garments, petroleum, chemicals, and petrochemicals are some of the industries that would be benefited from this corridor. Karnataka government has proposed to extend this corridor upto Mangalore and reposition this corridor as West seaport to East seaport connectivity corridor. A new proposal has been put forward where the corridor will have 2 seaports at the extreme ends and 3 international airports on the way. Commencement of preparatory work for the corridor has been approved in budget announcement for 2013-14. It will boost India's trade with both eastern and western countries.

4. Bengaluru-Mumbai Economic Corridor. Decision to develop this corridor was taken in February, 2013 and will be developed with the financial and technical help from the UK. This corridor is intended to facilitate development of a well-planned and efficient industrial base served by world-class connectivity infrastructure. It will also increase the possibility of private investments in manufacturing and industrial activities in Maharashtra and Karnataka.

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Transport, Communication and Space

INTRODUCTION

Transport is a system in which passengers and goods are carried from one place to another. Development of cheap and efficient means of transport is necessary for the progress of a large and developing country like India. Transport routes are the basic economic arteries of the country. Transport system is regarded as the sinews of the national economy and provides a very important link between production and consumption. The amount of traffic moving in a country is a measure of its progress. In the modern age, even ideas and skills move from one place to another with the help of transport systems.

India is a vast country with long distances from Kashmir in the north to Kanniyakumari in the south and from Kandla in the west to Kohima in the east. She has vast natural resources of great diversity. In addition, India has great diversity in economic, social, cultural and ethnic structure. A well-knit transport system is essential to bring about unity in diversity in the Indian fabric.

All types of transport including railways, roadways, waterways, airways and pipelines are available in India.

RAILWAYS

Indian railway system is the main artery of the country's inland transport. Railways virtually form the life-line of the country, catering to its needs for large scale movement of traffic, both freight and passenger, thereby contributing to economic growth and also promoting national integration. In fact, railways constitute the backbone of surface transport system in India.

Development and Growth of Indian Railways

The first railway line in India was opened for public traffic on 16 April, 1853 between Mumbai and Thane over a distance of 34 km. This line was extended to Kalyan on 1 May, 1854 and to Khopoli

on 12 May, 1856. The Khandala-Pune section was opened to traffic on 14 June, 1858.

Meanwhile, the construction of the railway lines was going on in eastern part of the country and the first section of the East Indian Railway, from Haora to Hugli, a distance of 37 km was inaugurated on 15 August, 1854. The Haora-Hugli section was extended to Pundooah on 1 Sept, 1854 and to Raniganj Coal Mines on 3 Feb, 1855. The line from Kanpur to Allahabad was opened in 1859 and the Haora-Khana-Rajmahal section was completed in 1860. Mughal Sarai also appeared on the railway map of India in 1862. In 1860, the Kanpur-Etawah section was opened to traffic and between 1862 and 1866, all the gaps between Haora and Delhi were filled.

The southern part of the country did not lag behind and got its first 105 km long railway line from Royapuram to Arcot in 1856. This line was extended to Kadalundi (near Calicut) on the west coast in 1861. The Jolar Pettai-Bangalore Cantonment section was opened in 1864.

In 1870, the all-rail route between Kolkata and Mumbai started functioning and the main line from Mughal Sarai to Lahore (now in Pakistan) was completed. In 1871, the Mumbai-Chennai route was also opened. Thus within a short span of 18 years from 1853 to 1871, most of the important cities of India were connected by rail. The total route kilometreage in 1870 was 7,680 km which rose to 39,834 km by the turn of 19th century and to 66,234 by 31 March, 1940. As on 15 August 1947, Indian Railways consisted of 65,217 km out of which 10,523 km went to Pakistan, leaving India with 54,694 km.

Phenomenal growth of Indian Railways has taken place in the post-Independence era as is clear from **table 26.1**.

At present, India has the second largest railway network in Asia and the fourth largest in the world after the USA (2,27,736 km), Russia (2,22.293 km), and China (87,157 km). But India tops world's leading countries with regard to passenger/kilometre carried. It is the largest public sector undertaking of the country comprising a vast network of 7,146 stations spread over a route length of 64,600 km with a fleet of 9,549 locomotives, 55,339 passenger services vehicles, 6,560 other coaching vehicles and 2,39,321 vagons as on 31st March, 2012. The growth of Indian Railways since its incaption in 1853 has been phenomenal. It has played a vital role in the economic, industrial and social development of the country.

Factors affecting Railways

The pattern of Indian railway network has been influenced by geographical, economic and political factors.

TABLE 26.1. Progress of Railways in India

Year	Route-length (kilometre)			Running track (kilometres)		
	Electrified	Non-electrified	Total	Electrifield	Non-electrified	Total
1950-51	388	53,208	53,596	937	58,378	59,315
1960-61	748	55,499	56,247	1,752	61,850	63,602
1970-71	3,706	56,084	59,790	7,447	64,222	71,669
1980-81	5,345	55,895	61,240	10,474	65,386	75,860
1990-91	9,968	52,399	62,367	18,954	59,653	78,607
2000-01	14,856	48,172	63,028	27,937	53,928	81,865
2007-08	18,274	44,999	63,273	34,700	50,458	85,158
2008-09	18,559	45,456	64,015	35,471	51,466	86,937
2009-10	18,927	45,047	63,974	35,811	57,276	87,087
2010-11	19,607	44,863	64,460	36,000	51,040	87,040

Source: Data computed from Statistical Year Book, India, 2013.

1. Geographical factors. The North Indian plain with its level land, high density of population and rich agriculture presents the most favourable conditions for the development of railways. However, the presence of large number of rivers makes it necessary to construct bridges which involves heavy expenditure. There are practically no railways in the flood plains of many rivers in Bihar and Assam. The plateau region of south India is not as much suitable for railways as the North Plain area. The Himalayan

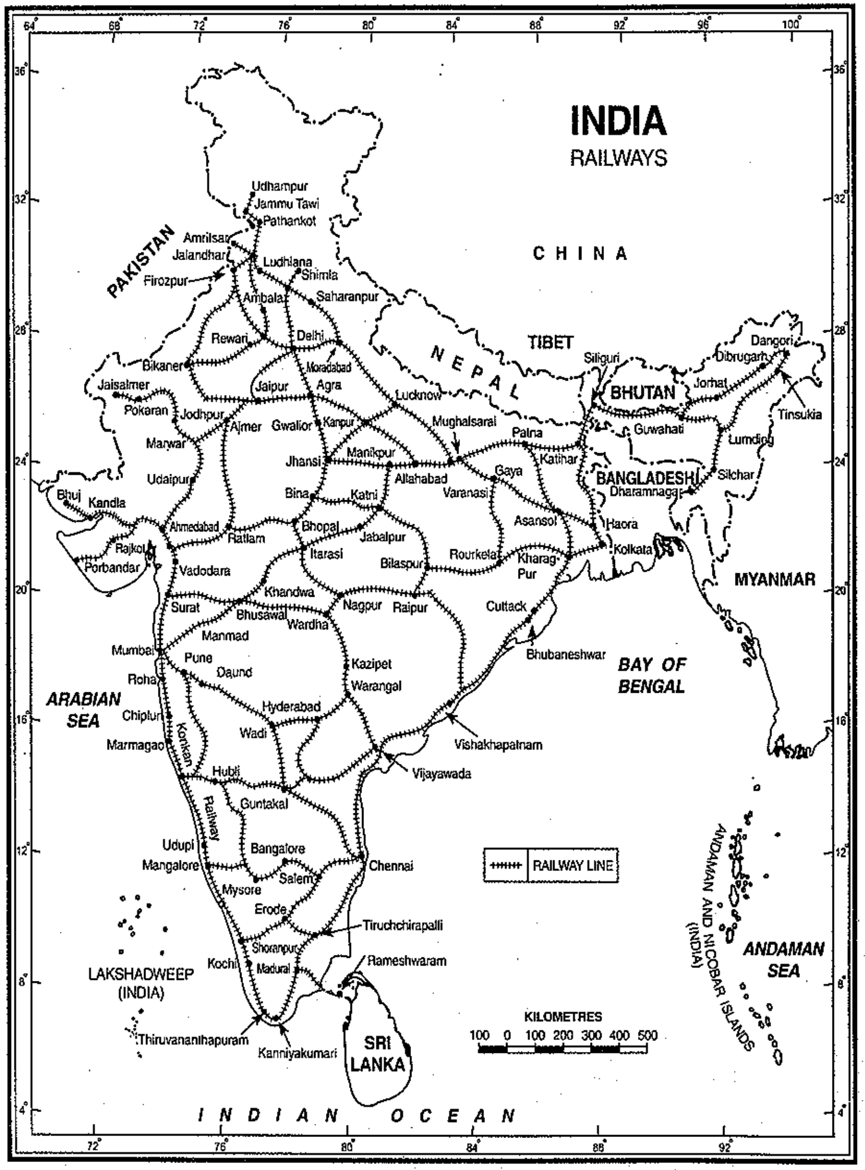

FIG. 26.1. India : Railways

region in the north is almost entirely devoid of railways due to its rugged topography. Some railway terminals such as Hoshiarpur, Kotdwar, Dehra Dun, Kathgodam, etc. are found on the foothills. Some narrow gauge railway tracks are found in the Himalayan region. A railway link between Jammu and Kashmir valley is being planned at a very high cost. The sandy areas of Rajasthan are also not much favourable for railways. There was no railway line between Jodhpur and Jaisalmer till 1966. Similarly, forested areas of Madhya Pradesh and Odisha, deltaic swamps of West Bengal, marshy areas of Rann of Kachchh and hilly tract of Sahyadri are also unfavourable for the development of railways. Sahyadri can only be crossed through gaps like Thalghat, Bhorghat and Palghat to reach coastal rail heads like Mumbai, Vasco-de-Gama, Mangalore and Kochi. Obviously, the *railways tend to follow the path of least resistance.*

2. Economic factors. Railways develop more in the economically advanced areas where the need for railway network is felt more. Conversely, railways bring economic prosperity to the areas through which they pass. This is because of the economic linkages that we find the highest density of railways near big urban and industrial centres and in areas which are rich in mineral and agricultural resources.

3. Political and Administrative factors. The present railway system in India is the legacy of the British rule. The British administration planned the direction and pattern of the railway lines in such a way that they could exploit the valuable raw materials of India for the benefit of their industries and flood the Indian markets with the finished goods from Britain. Besides, the Britishers wanted to maintain their military supremacy, for which quick movement of troops, arms and ammunition was necessary and construction of railways became unavoidable. Thus, top priority was given to the big ports of Mumbai, Kolkata and Chennai. These ports were connected with their hinterlands by railway lines to facilitate imports and exports. It is from the ports that the railway network spread to the other parts of the country.

Distribution of Indian Railways

Fig. 26.1 shows the following distribution pattern of Indian railways :

1. The North Indian Plain. This region has a dense network of railways from Amritsar to Haora. This is a plain area which is very much suitable for the construction of railways. This densely populated region has highly developed agriculture and industry. Large scale urbanisation has also helped in the development of the railways. The density of railway network is closely related to the agricultural and industrial development. There are a few focal points such as Delhi, Kanpur, Mughal Sarai, Lucknow, Agra and Patna. However, Delhi is the main point from where railway lines radiate in all directions. For political, administrative and economic reasons, Delhi is connected with major ports like Mumbai, Kolkata, Haora and Chennai through superfast trains.

2. The Peninsular Plateau. The whole of Peninsular plateau has hilly and plateau terrain which hinders the development of railways. The population density is also moderate. For such reasons, excepting, Saurashtra and Tamil Nadu, a relatively open and more loose network has developed here. However, some trunk routes cross the peninsula and provide efficient rail service between Mumbai-Chennai, Chennai-Kochi, Chennai-Delhi, Mumbai-Kolkata, Chennai-Hyderabad and Mumbai-Thiruvananthapuram.

3. The Himalayan Region. Railways are conspicuous by their absence in the Hinmalayan region. The rugged terrain, hill and valley topography, backward economy and sparse population are the factors responsible for the sparse rail network in this region. There are only three narrow gauge railway lines in the Himalayan region. These are Kalka-Shimla, Pathankot-Kangra and Siliguri-Darjeeling. The Kalka-Shimla Railway, built in 1903 winds itself through picturesque country from Kalka to Shimla over a distance of 96.6 km. It has 103 tunnels, totalling 8 km in length, the longest tunnel is 1,144 metre. The railway track from Kalka to Shimla passes over 869 bridges. The Siliguri-Darjeeling Railway is 82 km long and was constructed in 1878. There is practically no railway line in the north-eastern states of Meghalaya, Tripura, Arunachal Pradesh, Mizoram, Manipur and Nagaland. These areas have rough terrain covered with thick forests. The population is sparse and the economy is in a backward state. Construction of railways under these conditions is a difficult and costly affair.

However, plans are afoot to provide rail links to Meghalaya, Arunachal Pradesh and Tripura, although at a very heavy cost. A vital rail link to Kashmir valley has already made much headway.

4. The Coastal Plains. There is a distinct contrast in the rail network between eastern coastal plains and western coastal plains. The eastern coastal plain is quite wide and permits the construction of railways, as a result of which, there is a long trunk route along the east coast from Kolkata to Chennai. But such a route has been eluding the western coastal plain since long. This is due to the structure and relief of the area. The outcrops of the Western Ghats are very close to the coast, especially near Goa and make the construction of railway lines a difficult task. However, the completion of Konkan Railway Line from Roha to Mangalore is a dream come true. It passes through several tunnels and over numerous bridges. This line has one of the longest tunnels in the country 6.5 km long, about 23 km south of Ratnagiri. It has become the life line of the western coastal plain. The total saving in travel distances are Mangalore-Mumbai (1,050 km), Mangalore-Ahmedabad (1,218 km), Mangalore-Delhi (707 km) and Kochi-Mumbai (437 km).

The above description leads us to the conclusion that railway services are unevenly distributed in India. The maximum concentration of railway network is found in the Indo-Gangetic plain followed by the peninsular plateau. The railways are practically absent from the Himalayan region. Such a lop-sided railway development has kept many areas away from the railway routes.

Railway Zones

At the time of Independence, there were as many as 42 different railway systems administered by 37 different companies. Immediately after the Independence, the Railway Board prepared a plan in 1950 for regrouping the Indian Railways into six zones, namely the Southern Zone (9,654 route km), Central Zone (8,689 route km), Western Zone (9,122 route km), North Zone (9,667 route km), North-Eastern Zone (7,726 route km) and Eastern Zone (9,109 route km). These zones were formed between 14 April 1951 and 14 April 1952. The Eastern railway was split into two zones *viz.*, Eastern Railway (3,735 route km) and South-Eastern Railway (5,374 route km). The North-Eastern Railway was also bifurcated on 15 January 1958 and new zones were inaugurated. They were North-east Frontier Railway (2,797 route km) and the North-Eastern Railway (4,929 route km). Another zone known as the South-Central Railway zone (6,072 route km) was carved out of Southern and Central railways on 2 Oct., 1966. These nine railway zones remained operative for about three decades and proved very effective in administrating the railway system. The administrative requirements of the railways became more pressing with the passage of time. Currently the railway network consists of 17 zones (**Table 26.2**).

TABLE 26.2. India : Railway Zones and their Headquarters

Zonal Railways	Headquarters
1. Central Railway	Mumbai CST
2. Eastern Railway	Kolkata
3. Northern Railway	New Delhi
4. North Eastern Railway	Gorakhpur
5. Northeast Frontier Railway	Maligaon (Guwahati)
6. Southern Railway	Chennai
7. South Central Railway	Secunderabad
8. South Eastern Railway	Kolkata
9. Western Railway	Church Gate, Mumbai
10. East Central Railway	Hajipur
11. East Coast Railway	Bhubaneshwar
12. North Central Railway	Allahabad
13. North Western Railway	Jaipur
14. South East Central Railway	Bilaspur
15. South Western Railway	Hubli
16. West Central Railway	Jabalpur
17. Metro Railway	Kolkata

Source : India 2014, A Reference Annual pp. 842-43.

1. Railway Gauges. 'Gauge' is the name given to the distance between the inner faces of the pair of rails in the track. Indian railways comprise three gauges *viz.*, broad gauge (1.675 metre), metre gauge (1.000 metre), and narrow gauge (0.762 metre and 0.610 metre). Different gauges had been the legacy of the British rulers. They constructed broad gauge railways on trunk routes connecting the port cities of

JAMMU-BARAMULA RAILWAY LINE

The Government of India has launched the most ambitious and at the same time most challenging programme to provide railway link connecting Baramula with Jammu-Tawi. When completed this 292 km long railway route will pass over 165 big and 650 small bridges. The bridge over the Chenab river is 1.3 km long and 359 metre tall which happens to be the tallest bridge in the world. Its 120.44 km stretch will pass through nearly 21 tunnels. The longest 11 km long tunnel is the PirPanjal tunnel which is the second largest tunnel of Asia after Wushaoling Tunnel (20 km) in Gansu, China. This tunnel has a maximum overburden (height of mountain strata above the tunnel) of 1,100 metres. This is 190 km away from Jammu and provides railway link between Qazigund in Kashmir valley and Jammu in the Jammu region. The work on the project started in 1984 most of the work has already been done and the work on the remaining portion is likely to be completed in due course of time. Work on the prestigious railway line is often hampered by unwanted law and order position, terrorism, sabotages, land acquisition, difficult terrain, landslides, etc. This railway line is expected to usher into a new era of economic growth and national integration by bring people of the Kashmir valley into the main stream of the country.

Mumbai, Kolkata and Chennai and some other major cities. In areas lying beyond the frame work of trunk routes, only metre gauge lines were constructed. Thus, the area lying north of the Ghagra-Ganga alignment, whole of Rajasthan and Gujarat as well as large parts of the peninsular India were covered by metre gauge.

Different gauges create serious hinderance in the smooth flow of traffic. Passengers have to change trains at the *break of gauge* station and are put to great inconvenience. Goods have to be transhipped which results in loss of time, increased cost of transportation, pilferage and damage to consignments. The Government of India have, therefore, adopted a policy of gauge conversion, mainly from metre gauge to broad gauge. *The unigauge system of railways assures larger capacity, higher speed and cheaper transportation*. The process of gauge conversion was initiated immediately after Independence but significant achievement has been recorded in recent years (**Table 26.3**). Such a large scale gauge conversion is rightly called the *Operation Gauge Conversion or Operation Uni-Gauge*.

Track Electrification. It has been estimated that use of electric locomotives increases the capacity by as much as 100 per cent. But the use of electric locomotives is possible only if the railway tracks are electrified. Track electrification is a major thrust area by virtue of which efficiency of the railways can be increased considerably. Track electrification was introduced in early 1920s and the first two sections from Victoria Terminus to Kurla and from Victoria Terminus to Bandra, totalling 16 route km were electrified in 1925. Thus the Indian railways entered the push button era. In the first four decades from 1920-21 to 1960-61, the process of track electrification was rather slow and the length of electrified track stood at 388 km in 1950-51 and 748 km in 1960-61. After that the electrification of railway tracks picked up and the length of electrified track increased to 3,706 km in 1970-71, and 19,607 km in 2010-11. The percentage of electrified track was a meager 1.33 in 1960-61 which increased to 30.42 in 2010-11.

TABLE 26.3. Gaugewise Route Length of Railway in India

Year as on 31st March	Broad gauge		Metre gauge		Narrow gauge		Total
	Length in km	Percentage of total route length	Length in km	Percentage of total route length	Length in km	Percentage of total route length	
1992	35,109	56.21	23,283	37.28	4,066	6.51	62,458 (100)
2002	45,099	71.43	14,776	23.40	3,265	5.17	63,140 (100)
2012	55,956	88.62	6,347	9.82	2,297	3.56	64,600 (100)

Source : Data computed from Statistical Abstract, India, 2003, p. 213.

RAIL TRAFFIC

Rail traffic is broadly divided into two segments, *viz.*, passenger traffic, and (*ii*) goods traffic.

Passenger Traffic

Railway journey particularly long journey is preferred because it is cheaper and more convenient. The number of passengers has risen from 1,284 millions in 1950-51 to 8,420.7 millions in 2012-13. Passenger kilometres represent the real indices of the volume of passengers handled. These are arrived at by multiplying the total number of passengers carried by the respective number of kilometres over which they are moved. The passenger kilometres increased from 66.5 billion in 1950-51 to 1,098.1 billion in 2012-13. For passenger service five types of trains are run by the Indian Railways, based on their speed and comfort levels— Ordinary Passenger trains, Express/Mail trains, superfast trains, Rajdhani Express, and Shatabdi and Jan Shatabdi trains. Sampark Kranti Express trains have been introduced to connect the national capital, Delhi, with the state capitals and other important places. Further, Indian Railways have introduced computer reservation system making it possible to get instant reservation between any two stations from any booking office.

The above developments have resulted in phenomenal growth in passenger earning by railways. The passenger earnings increased from ₹ 98.2 crore in 1950-51 to ₹ 31,322.8 crore in 2012-13 (**Table 26.4**). On an average, 14 million people are moved by the Indian railways.

There are plans to introduce high speed trains on following routes.

1. Delhi-Agra.
2. Delhi-Chandigarh
3. Delhi-Kanpur
4. Nagpur-Bilaspur
5. Mysore-Bengaluru-Chennai
6. Mumbai-Goa
7. Mumbai-Ahmedabad
8. Chennai-Hyderabad
9. Nagpur-Secuderabad

Further, a bullet train has been planned between Mumbai and Ahmedabad.

The Railway Ministry has also drawn a blue print of '**Diamond Quadrilateral**' of high speed trains like the Golden Quadrilateral with reference to road transport. This diamond quadrilateral will provide high-speed trains service to important cities such as Amritsar, Delhi, Agra, Lucknow, Varanasi, Patna, Haora, Haldia, Jaipur, Ajmer, Ahmedabad, Mumbai, Thiruvananthapuram, Bengaluru, Chennai, Vijaywada, Hyderabad, etc.

Frieght Traffic

Along with passenger traffic, the freight traffic also increased tremendously. Development in industrial and agricultural sectors has generated high demand for rail transport. Major commodities transported by railways include coal, iron and steel, ores, petroleum products and such essential commodities as food grains, fertilizers, cement, sugar, salt, edible oils, etc. Consequently, freight traffic increased from 73.2 million tonnes in 1950-51 to 1008.1 million tonnes in 2012-13. Transport effort measured in terms of net tonnes kilometres increased from 37.6 billion in 1950-51 to 691.7 billion tonnes kilometres in 2012-13. Tonne kilometres are arrived at multiplying the total tonnage of goods carried by the number of kilometers over which they are moved.

Table 26.4 shows that railways earnings from goods carried is always higher than the passenger earnings. Earning from freight, traffic increased from ₹ 139.3 crore in 1950-51 to 84,378.8 in 2012-13.

Following measures have been taken to improve freight traffic by the Indian Railways :

(*i*) line capacity augmentation on certain critical sectors and modernization of signalling system.

(*ii*) improve in unit train operation for bulk commodities like coal.

(*iii*) increase in roller-bearing equipped wagons.

(*iv*) increase in tracking loads to 4,500 tonnes.

(*v*) operation uni-gauge on Indian Railways.

(*vi*) strengthening the track structure by providing heavier and stronger rails and concrete sleepers.

(*vii*) production of prototype electric locomotive of 5,600 HP for freight operation by Chittaranjan Locomotive Works.

TABLE-26.4. Operations of Indian Railways

Year	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2009-10	2010-11	2011-12	2012-13
Originating traffic (million tonnes)	73.2	119.8	167.8	195.9	318.4	473.9	887.8	921.7	969.01	1,008.1
Goods carried (billion tonnes km.)	37.6	72.3	110.7	147.7	235.8	312.4	600.6	625.7	667.61	691.7
Passengers originating (million)	1,284.0	1,594.0	2,431.0	3,613.0	3,858.0	4,833.0	7,245.8	7,651.1	8,224.4	8,420.7
Passengers kilometres (billion)	66.5	77.7	118.1	208.6	295.6	457.0	903.0	978.5	1,046.5	1,098.1
Earnings from goods carried (₹ crore)	139.3	280.5	600.7	1,550.9	8,247.0	23,045.4	56,937.3	60,687.1	67,761.41	83,478.8
Passengers earnings (₹ crore)	98.2	131.6	295.5	827.5	31,44.7	10,575.1	23,488.2	25,792.6	28,296.9	31,322.8

Source : Economic Survey 2013-14, Statistical Appendix, p. 29.

Dedicated Freight Corridor Project

A very ambitious plan of Dedicated Freight Corridors (DFC) was initiated in the year 2009 which aims at improving the freight carrying capacity of the Indian Railways, reducing the unit cost of transportation and improving service quality. It consists of two corridors *viz.* Eastern Dedicated Freight Corridor (EDFC) and Western Dedicated Freight Corridor (WDFC). The EDFC is 1,839 route kilometres (RKM) and extends from Dankuni near Kolkata to Ludhiana in Punjab while the WDFC is 1,499 route kilometre (RKM) and extends from Jawahar Lal Nehru port in Mumbai to Dadri in Haryana. A special purpose vehicle, the Dedicated Freight Corridor Corporation of India Limited has been set-up to implement the project. Out of 10,703 hectares of land to be acquired for the project 7,768 hectares (73 per cent) has already been awarded under the Railway Amendment Act (RAA) 2008. Following are the salient features of this project.

- Only goods trains will be allowed to operate on these corridors. These trains will run at a speed of 100 kilometres per hour.
- These corridors are planned to run along the existing railway routes, but will provide services to railway junctions.
- With a view to keep minimum impact on social and environmental aspects, these corridors will have provision of bypasses for thickly populated big cities.
- Rail track on DFCs will strengthened by providing heavier and stronger rails on concrete sleepers.
- Transport cost will be reduced by increasing work efficiency.
- Efforts will be made to deliver the goods at their destinations well in time and minimise losses due to delayed deliveries of goods.
- Give impetus to industrial growth by providing cheap and efficient transport.
- Bring freight carrying capacity at par with world's best currently, long distance carrying capacity of Indian Railways is only 5,000 tonnes as against 20,000 tonnes in China and 35,000 tonnes in Australia.

Significance of the Indian Railways

1. Railways provide the cheapest and most convenient mode of passenger transport both for long distance and suburban traffic.

2. Railways have played a significant role in development and growth of industries. Growth of textile industry in Mumbai, jute industry in areas surrounding Kolkata, coal industry in Jharkhand, etc. is largely due to

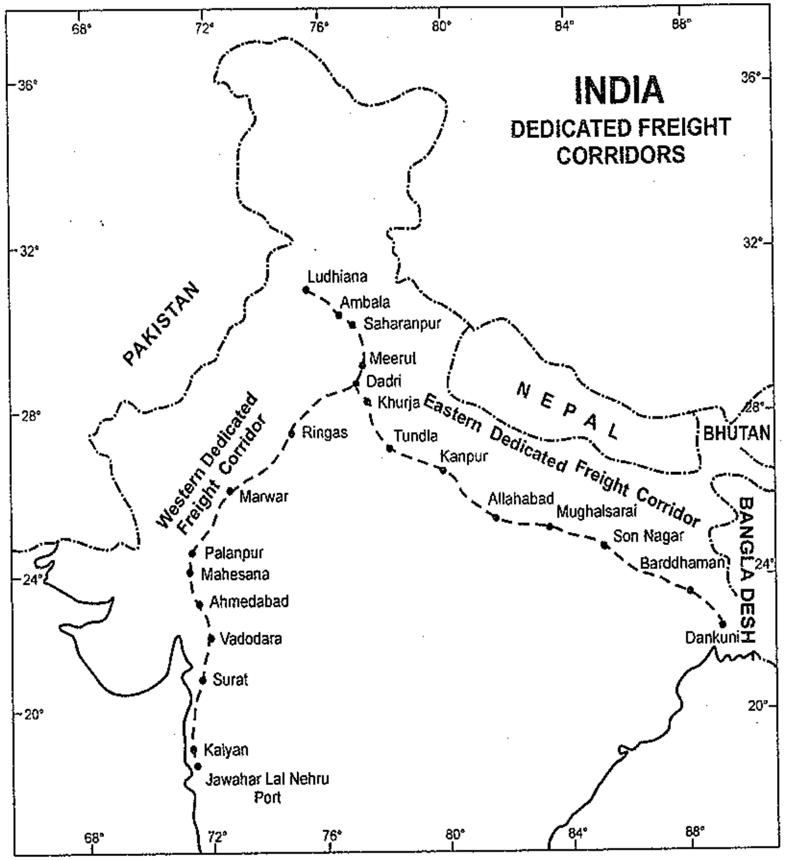

FIG. 26.2. Dedicated Freight Corridors.

the development of railway network in these areas. Railways help in supplying raw materials and other facilities to the factory sites and finished goods to the market.

3. Agriculture also owes its growth to railways to a great extent. Now farmers can sell their agricultural produce to distant places and even sell them in the world market at remunerative prices.
4. Railways are also helpful in removing isolation between cities and countryside and have played a significant role in disseminating innovations and new ideas.
5. Railways are particularly suited to long distance journey and provide a strong medium of national integration.
6. Railways play a vital role in mitigating the sufferings of the people in the event of natural calamities like droughts, floods, famines, earthquakes, etc. This is done by carrying relief and rescue teams and essential items to the affected areas and save people from sufferings and starvation.
7. Railways also help in facing man-made calamities like social, political, religious disturbances, insurgency, etc. It facilitates easy movement of police, troops, defence equipment, etc. The importance of railways to save the country's freedom and integrity from external aggression has proved at several occasions.
8. Railways carry the British

connect major ports to their hinterlands, thereby lending a helping hand to the overall prosperity of the coastal areas.

9. Introduction of superfast trains and container services in major cities of India have ensured quick movement of men and material.
10. Railways are specially suited to long haulage of bulky materials like coal, petroleum and ores.

Problems of Indian Railways

Although Indian Railways have progressed a lot, both quantitatively and qualitatively, during the last few years, this system is still plagued by a number of problems which require immediate attention. A lot has been done, but a lot more is yet to be done. Some of the major problems faced by the Indian Railways are briefly discussed as under :

1. Safety. Indian Railways have been in the news albeit for wrong reasons. With the rapid increase in passenger and goods traffic, the frequency of train accidents is increasing very fast. This has raised serious doubts in the public mind about safety of rail travel and the general health of the railway network. The credibility of an organisation with a long and proud history of nation building has been seriously eroded. On an average the Railways report 20 major collisions, 350 derailments and around 80 level crossing accidents in a year. Approximately 3000 passengers have lost their lives in ten years from 2003 to 2013.

There are several factors which are responsible for increasing number of railway accidents; some outstanding being overaged tracks, wagons, coaches, bridges and signaling system. According to the Khanna Railways Safety Review Committee Report, nearly 25 per cent of the total railway track in India is overaged and is due for replacement. The tracks suffer from fatigue and wear and tear in due course of time, and their replacement should be carried on side by side. In several derailments poor condition of tracks had been found responsible. The condition of tracks becomes more significant when one looks at the other assets of the Railways. The Khanna Railways Safety Committee had reported that Indian Railways have 34,000 overaged wagons, 1,322 overaged coaches, and 1,560 stations with overaged signalling. Moreover, 262 bridges are listed "distressed." The white paper released by the Railway in April, 2003 acknowledges that over 51,000 bridges are of 19th century vintage. Out of a total of 1,27,154 bridges in India, 56,178 are more than 80 years old. Thus 44.17 per cent of the bridges have outlived their life. According to the review conducted by the Comptroller General of India on various aspects of bridge management between 1997-98 to 2001-02, these old bridges include 339 important, 4,210 major and 51,629 minor bridges built before 1920. The Khanna Committee had further reported that 76 per cent of all rail accidents are due to derailments, 7 per cent due to collisions, 16 per cent take place at level crossings and 1 per cent are due to fires. Resource crunch is said to be the main cause of all these happenings in the Indian Railways.

Worried about the increasing rate of accidents and loss of life and property resulting from these accidents, the Indian Railways have come out with Anti-collision Devices (ACDs) or '*Raksha Kavach*' to get rid of such happenings. World's first Networked Anti-collision Devices (ACDs) *Raksha Kavach,* invented by Konkan Railway is a microprocessor system comprising of a central processing unit, a Global Position System (GPS) Receiver and a digital radio modem for communication between ACDs. When fitted to a guard van it becomes a Guard ACD. When fitted at stations it becomes a Station ACD and when fitted at level crossing gates, it becomes a Gate ACD. They all network among themselves, exchange information and take decision to prevent collision type of dangerous situations well in time automatically, without mannual inputs, forming *Raksha Kavach* against collisions.

Extensive field tests of *Raksha Kavach* have been conducted successfully on Indian Railways. Survey for implementation of ACDs has already been completed for 3,300 route km on Indian Railways and 760 km on Konkan Railway. About 1,770 ACDs on 1,736 km route length of North East Frontier Railways covering 183 stations have been installed at the cost of ₹ 50 crore.

Modern signalling like panel inter-locking, route relay inter-locking, centralised traffic control, automatic signalling and multi-aspect colour light signalling, are being progressiv

2. Cost and Revenue Problems. As is the case with most of the government organisations, Indian Railways face chronic financial crisis. The annual rate of increase in cost has overtaken that of revenues during the last few years. A study of Railways finances from 1998 to 2004 revealed that the revenues increased at an average annual rate of 8.7 per cent against the 9.65 per cent average annual growth in costs. While the Indian Railways' input costs increased by 10.6 per cent per annum between 2004-05 and 2010-11, passenger fairs remained unchanged or were even reduced in lower classes thereby constraining internal resource generation, essential for replacement/renewal of assets, operation and maintenance activities and critical safety and amenity works. In certain years, the revenue growth rate does exceed that of cost. But this position is achieved by providing inadequacy for replacements and severely controlling the costs. Such a situation has long term implications as it affects the internal generation of resources. Following are the main causes of costs and revenue problems. In 2013-14, half of the 17 railway zones reported an operating ratio (rupee spent against every rupee earned) of more than 100 per cent which means that the railways are spending either equal or more than the money earned.

(i) Low level of employee productivity. Indian Railways face a serious problem of low level of employee productivity. Transport output in terms of passengers and freight tonne kilometres per employee on Indian Railways is only 400 as compared to 500 for Chinese and 570 for French Railways. An estimated 30 per cent surplus workforce and operation of a number of lines with low traffic and assets not essential for the Railways are contributory factors.

(ii) Staff Wages. With the implementation of the recommendations of the Sixth Pay Commission, staff wages have increased tremendously and have put heavy strain on the financial resources of the Railways. With life expectancy going up and wage escalations taking place periodically, the position will only worsen leaving little scope for development plans. The recommendation of the Seventh Pay Commission will put further heavy burden on the financial resources of the railways.

(iii) Increase in lease charges. Paucity of funds forces the Indian Railways to resort to market borrowings which results in increased lease charges. Market borrowings started in 1986 and the trend is increasing. At present payout of lease charges constitute about 8.5 per cent of the revenue.

3. Slowdown in Revenue Growth. With saturation of trunk routes and low quality of services and reliability, the revenue growth has registered a slowdown. The railways are increasingly becoming a transporter of bulk commodities for public sector (coal, iron ore, foodgrains, etc.) and are consistently loosing to roadways. Most of the national highways run parallel to railways and are consistently snatching revenues from the railways.

4. Social Burden. Indian Railways have to play a dual role of revenue earning as well as meeting the social obligations. The Expert Group, constituted in December 1998 to study the railway sector, termed it as the 'split personality'. On one hand, the Railways are seen as a commercial organisation and on the other hand, it is treated as a social organisation which must fulfil its social obligations. The two functions are diametrically opposite and difficult to reconcile. There are several social obligations on the railways which are always running below cost. Suburban passenger services, concessionary travel to certain section of travellers, concessional freight movement of certain commodities, particularly to remote and inaccessible areas like the North-east region, providing rail services to backward regions are some of the outstanding social obligations on the Indian Railways.

5. Other Problems. A large number of miscellaneous problems include late running of trains, lack of passenger facilities including cleanliness at the railway stations, lack of security arrangement on the railways resulting in thefts and dacoities, etc. Political pressure and interference is a very big problem which the Indian Railways are facing with increasing impact. Several projects which are not economically viable have been initiated for political considerations.

METRO RAIL

Mero rail offers fast, cheap and comfortable journey in metropolitan cities of India. It helps in reducing pressure on the existing road transport and provides clean and eco-friendly transport at the local level. With the introduction of metro rail in the big cities, traffic jams on road crossings have reduced

considerably. It is a part of rapid mass transport and is of recent origin in India. The first rapid transit system in India was the Kolkata Metro, which started operations in 1984. The Delhi Metro was India's first modern metro and third rapid transit system in India, after the Kolkata Metro and Chennai Mass Rapid Transit System. The Delhi Metro Rail started its operations in 2002 and is now providing transport facilities to most parts of the capital city. It also provides metro rail lines to most of the satellite towns

TABLE 26.5. Metro Rail in India

City	System	Start Operation	System length in km		
			In operation	Planned	Under construction
1. Kolkata	Kolkata Metro	24 October, 1984	28.4	—	90
2. Chennai	Chennai MRTS	1 November, 1995	19.34	—	—
3. Delhi	Delhi Metro	24 December, 2012	192.27	—	—
4. Bengaluru	Mamma Metro	20 October, 2011	16.6	114.39	42.3
5. Gurgaon	Rapid Metro Rail, Gurgaon	14 November, 2013	5.1	—	—
6. Jaipur	Jaipur Metro	2014	—	32.5	—
7. Chennai	Chennai Metro	20.14	45.1	—	—
8. Mumbai	Mumbai Metro	2014	146.5	—	—
9. Navi Mumbai	Navi Mumbai Metro	2016	106.4	—	—
10. Kochi	Kochi Metro	2016	25.6	—	—
11. Lucknow	Lucknow Metro	2017	36	—	—
12. Hyderabad	Hyderabad Metro	2015	71.6	—	—
13. Ahmedabad and Gandhinagar	Metrolink Express Gandhinagar and Ahmedabad (MEGA)	2017	83	—	—
14. Bhopal	Bhopal Metro	—	—	—	—
15. Chandigarh	Chandigarh Metro	2018	37.5	—	—
16. Indore	Indore Metro	2020	30	—	—
17. Kanpur	Kanpur Metro	2018	84	—	—
18. Ludhiana	Ludhiana Metro	2017-18	—	—	—
19. Nagpur	Nagpur Metro	—	39.8	—	—
20. Nashik	Greater Nashik Metro	—	—	—	—
21. Patna	Patna Metro	2016	60	—	—
22. Pune	Pune Metro	2018	82	—	—
23. Surat	Surat Metro	2018	—	—	—
24. Mumbai	Western Railway Elevated Corridor	2020	63.27	—	—
25. Guwahati	—	—	44.2	—	—
26. National Capital Region	National Capital Region Metro	2021	381	—	—

Source : en.wikipedia.org/wiki/rapid_transit-in-India.

like Gurgaon, NOIDA, Faridabad, Bahadurgarh, etc. Rapid Metro Rail Gurgaon is India's first privately owned and operated metro rail system. In started its operations in November, 2013. After the grand success of Delhi Metro Rail, other cities like Bengaluru, Hyderabad, Lucknow, Kanpur, Ludhiana, and many more are planning to have metro rails and in many cities this rail system is already in operation. The Government has planned to provide metro rail facilities in all cities of India having a population over two billion. **Table 26.5** gives details of metro rail system in different cities of India.

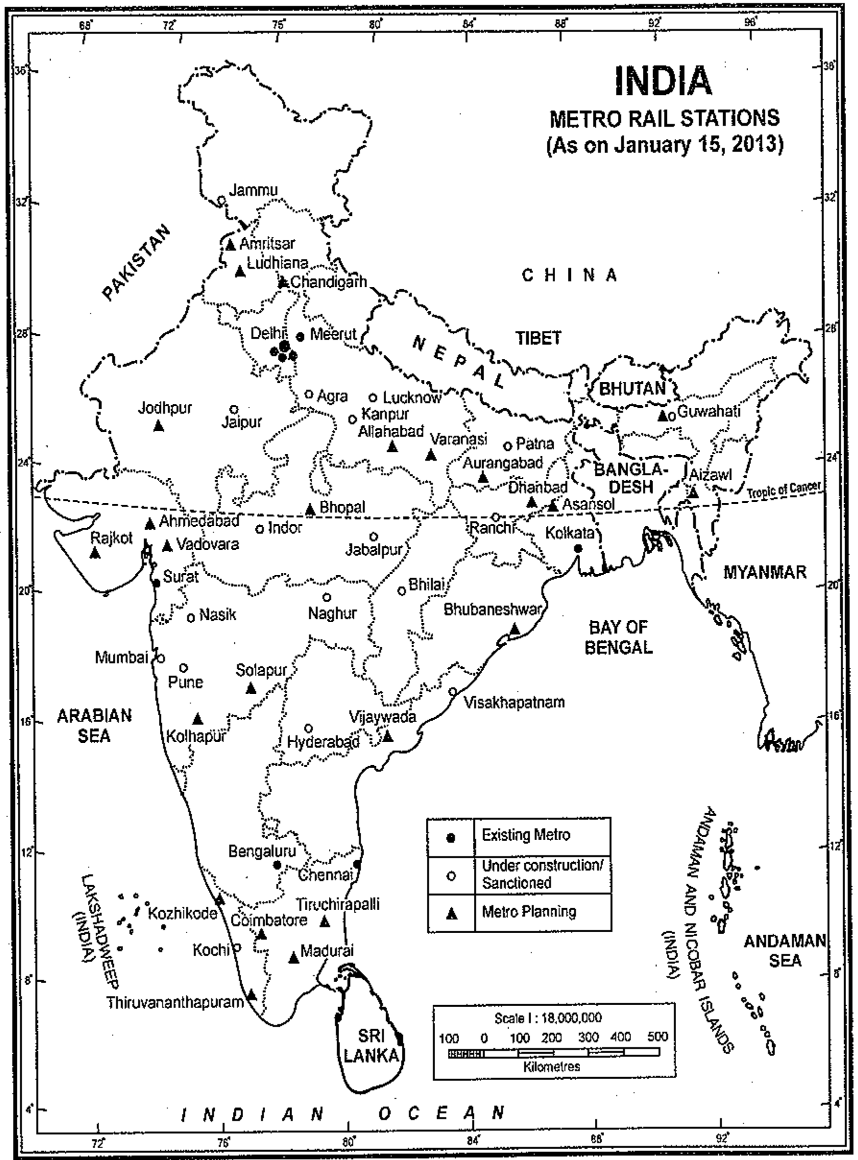

FIG. 26.3. Metro Rail Status (as on January 15, 2013)

ROADWAYS

Roads have been existing in India for the last 5000 years. In early stages of Indian history, Ashoka and Chandragupta made efforts to construct roads. But the real progress was made during the Mughal period. A number of roads were laid during the Sultanate and Mughal periods. Most of the present trunk routes follow the Mughal routes. These routes were essential for strengthening and consolidating the empire. One such road was constructed by Sher Shah Suri which connected Peshawar to Kolkata. It was named as Grand Trunk (G.T.) Road and joined Amritsar with Kolkata after partition of India in 1947. Presently, it is known as 'Sher Shah Suri Marg'.

Importance of Roads

1. Roads play a very important role in the transportation of goods and passengers for short and medium distances.
2. It is comparatively easy and cheap to construct and maintain roads.
3. Road transport system establishes easy contact between farms, fields, factories and markets and provides door to door service.
4. Roads can negotiate high gradients and sharp turns which railways cannot do. As such, roads can be constructed in hilly areas also.
5. Roads act as great feeders to railways. Without good and sufficient roads, railways cannot collect sufficient produce to make their operation possible.
6. Road transport is more flexible than the railway transport. Buses and trucks may be stopped anywhere and at any time on the road for loading and unloading passengers and goods whereas trains stop only at particular stations.
7. Perishable commodities like vegetables, fruits and milk are transported more easily and quickly by roads than by railways.

Due to above-mentioned advantages, the road transport has become very popular and its share in traffic is constantly increasing.

Growth and Development

Road transport in modern sense *i.e.* vehicles driven by internal combustion engines using petrol or diesel as fuel was practically negligible in India before World War II. Following plans have been drawn to develop roadways in India.

1. **Nagpur Plan.** First serious attempt to develop roadways was made in 1943 when *Nagpur Plan* was drawn. This plan envisaged increasing of the kilometreage of major roads to 1,96,800 km and of other roads to 3,32,800 km by 1953. The highlight of the plan was that no village in a developed agricultural region should be more than 8 km from a major road or 3 km away from any other road while the average distance of villages from a major road should be less than 3.2 km. In a non-agricultural region, these distances were fixed at 32, 8 and 10 km respectively. This plan could not be implemented immediately because the country was ruled by a number of princely states outside British India. The concerted efforts to achieve the objectives of this plan were made only after the reorganisation of the states. The targets of this plan were more or less achieved by 1961.

2. **Twenty Year Plan.** After achieving the objectives of the Nagpur Plan, another plan known as ***Twenty Year Road Plan*** was drawn in 1961. It aimed at increasing the road length from 6.56 lakh km to 10.60 lakh km and the density to 32 km of road per 100 sq km by 1981. The other objectives of the Twenty Year Road Plan were (*i*) to bring every village in a developed agricultural area within 6.4 km of a metalled road and 2.4 km of any other road, (*ii*) to bring every village in a semi-developed area within 12.8 km of a metalled road and (*iii*) to bring every village in an undeveloped and uncultivated area within 19.2 km of a metalled road and 8 km of any other road.

3. **The Rural Development Plan** includes construction of rural roads under Minimum Needs Programme (MNP), Rural Landless Employment Guarantee Programme (RLEGP), Jawahar Rojgar Yojana (JRY) and Command Area Development (CAD) programmes to connect all villages having a population of 1,500 or more with all weather roads and those having less than 1,500 population with link roads.

4. **Build Operate Transfer (BOT)** is a scheme under which private operators are invited to construct roads and bridges. They are allowed to collect toll tax

from the vehicles using these roads and bridges for a specific period of time after which these assets are transferred to the government. The National Highways Act has been amended to facilitate private investment in real construction under BOT scheme.

5. Central Road Fund (CRF) is being raised for the betterment of roads by imposing additional excise/customs duty at the rate of ₹ 1.50 per litre on petrol with effect from 2 June 1998 and on High Speed Diesel (HSD) with effect from February 28, 1999. The annual accrual through this source was to be about ₹ 5,500 crore. A part of this (₹ 0.4 per litre against sale of high speed diesel oil and ₹ 0.86 per litre against sale of petrol) goes to fund the NHDP. (National Highway Development Projects).

The Central Road Fund Act 2000 was enacted in December, 2000 with the primary objective of providing regular and adequate flow of funds for development of the road sector. This is a non-lapsable fund. The Act empowers the Centre to administer, manage and allocate the accrued amount to the following :

(*i*) Development of rural roads. About 43 per cent of the levy on diesel is to be spent on improving road connectivity,

(*ii*) Development and maintenance of National Highways,

(*iii*) Construction of road under/over bridges and safety works at unmanned railway crossings, and

(*iv*) Development and maintenance of State roads.

Categorywise Growth in Road Length. Table 26.6 shows that the length of National Highways rose from 19,811 kilometres as on 31 March 1951 to 70,934 kilometres as on 31 March 2011 and to 79,116 kilometres as on 31st March, 2013 reflecting a compound annual growth rate (CAGR) of 2.1 per cent during the period. During the same period, the combined network of State Highways and Other Public Works Department (PWD) posted a seven-fold expansion in length. The combined length of State Highways and Other PWD roads stood at 11.69 lakh kilometres as on 31 March 2011. The highest CAGR of 4.4 per cent during 1951 to 2011 was registered by rural roads comprising Panchayati roads, and roads constructed under Jawahar Rozgar Yojana (JRY) and Pradhan Mantri Gram Sadak Yojana (PMGSY). The length of rural roads increased more than 13 times from 2.06 lakh kilometres in 1951 to 27.50 lakh kilometres in 2011. Urban roads grew by a CAGR of 4.5 per cent between 1961 and 2011. Their length stood at 4.12 lakh kilometres as on 31 March 2011. The length of Project roads grew by CAGR of 2 per cent during 1971 and 2011 and was 2.88 lakh kilometres as on 31 March 2011.

TABLE 26.6. Road Network by Categories (in kilometres) 1951 to 2011

Road Category	1951	1961	1971	1981	1991	2001	2011
1	2	3	4	5	6	7	8
National Highways	19,811 (4.95)	23,798 (4.54)	23,838 (2.61)	31,671 (2.13)	33,650 (1.45)	57,737 (1.71)	70,934* (1.51)
State Highways	1,73,723 (43.44)	257,125 (49.02)	56,765 (6.20)	94.359 (6.35)	1,27,311 (5.47)	1,32,100 (3.99)	1,63,898 (3.49)
Other PWD Roads	^	^	2,76,833 (30.26)	4,21,895 (28.40)	5,09,435 (21.89)	7,36,001 (21.82)	10,05,327 (21.43)
Rural Road	2,06,408 (51.61)	1,97,194 (37.60)	3,54,530 (38.75)	6,28,865 (42.34)	12,60,430 (54.16)	19,72,016 (58.46)	27,49,805 (58.63)
Urban Road	0 (0.00)	46.361 (8.84)	72.120 (7.88)	1,23,120 (8.29)	1,86,799 (8.03)	2,52,001 (7.12)	4,11,840 (8.78)
Project Roads	0 (0.00)	0 (0.00)	1,30,893 (14.31)	1,85,511 (12.49)	2,09,737 (9.01)	2,23,665 (6.32)	2,,88,539 (6.15)
Total	**3,99,942**	**5,24,478**	**9,14,979**	**14,85,421**	**23,27,362**	**33,73,520**	**46,90,342**

Note : Figures within parentheses indicate per cent to total road length in each road category.
*79,116 kilometres as on 31st March, 2013.
^ Included in State Highways
Source : Statistical Year Book, India 2013, p. 301.

Classification of Roads

The main significance of the Nagpur Plan lies in the fact that it classified roads into four categories on the functional basis. They are : (*i*) National Highways (*ii*) State Highways (*iii*) District Roads and (*iv*) Village Roads. A brief description of each category is given as under :

1. National Highways

The main roads which are constructed and maintained by the Central Public Works Department (CPWD) are known as the National Highways. These roads are meant for inter-state and strategic defence movements and connect the state capitals, big cities, important ports, big railway junctions and link up with border roads. The length of National Highways increased from 19,811 km in 1951 79,116 km in 2013. National Highways form the lifeline of road transport and constitute the framework of road system in India. Although the percentage share of the National Highways to the total road length has decreased considerably from 4.95 per cent in 1951 to only 1.7 per cent in 2013, they carry nearly 40 per cent of the road traffic of India.

The National Highways have been classified on the basis of carriage way width of the highway. Generally, a lane has a width of 3.75 m in case of single lane and 3.5 m per lane in case of multi-lane. National Highways. The percentage of National Highways in terms of width is as under :

Single Lane	19,330 km (24%)
Double Lane	40,658 km (52%)
Four Lane/Six Lane/Eight Lane	19,128 km (24%)

Source : India 2014, A Reference Annual, p. 845.

The Government has embarked upon a massive National Highways Development Project (NHDP) in the country. The NHDP is the largest highway project ever undertaken in the country. The NHDP is being implemented mainly by NHAI in phases I to VII.

- **NHDP Phase I & II:** Envisage 4/6 laning of about 14,000 km of National Highways, at an estimated cost of about ₹ 65,000 crore at 2004 prices. These two phases comprise Golden Quadrilateral (GQ), North-South and East-West corridor (NSEW), Port Connectivity and Other Projects. The GQ consists of 5,846 km and connects four major cities, *viz*., Delhi, Mumbai, Chennai and Kolkata. The NSEW corridor comprising a length of 7,142 km connects Srinagar in the North to Kanniyakumari in the South including a spur from Salem to Kochi and Silchar in the East to Porbandar in the West, respectively. The NHDP also includes Port Connectivity Project comprising a length of 380 km for improvement of roads connecting 12 major ports in the country alongwith other projects involving a length of 965 km are also included.
- **NHDP Phase III:** NHDP Phase-II involves 4-laning of 12,109 km of NHS having high density corridor connecting State capitals, important tourist places, economically important areas, etc. on PPP basis at an estimated cost of ₹ 80,628 crore.
- **NHDP Phase IV:** It involves upgradation/ strengthening of 20,000 km of single/ intermediate /two lane National Highways to two lanes with paved shoulders on BOT (Toll) and BOT (Annuity) basis.
- **NHDP Phase V:** It involves six laning of 6,500 km of NHs comprising 5,700 km of GQ and balance 800 km of other sections of NHs at a cost of ₹ 41,210 crore.
- **NHDP Phase VI:** It involves construction of 1,000 km of expressways with hill access control on new alignments at a cost of ₹ 16,680 crore.
- **NHDP Phase VII:** It involves construction of 700 km of ring roads of major towns and bypasses and construction of other stand-alone structures such as flyovers, elevated roads, tunnels, undespasses, grade separated interchanges etc. on National Highways at a cost of ₹ 16,680 crore.

SpecialW Accelerated Road Development Programme for North Eastern region (SARDP-NE). It envisages improvement of road connectivity to the State Capitals with District Headquarters in the North Eastern region. The proposed programme includes improvement of 10,141 km of roads comprising National Highways (4,798 km) and state roads (5,343 km), to be implemented under Phase-A, Phase 'B' and Arunachal Pradesh Package for 'Road & Highways. Phase-A now consists improvement of 2,041 km of National Highways and 2,058 km of State Roads. Phase-B has now been modified to cover 2 laning of 1,285 km of NHs and 2 laning/ improvement of 2,438 km of State roads for preparation of Detailed Project Reports (DPRs). Arunachal Pradesh Package of roads and highways comprises 1,472 km of National Highways and 847 km of State Roads.

Development of Roads in Left Wing Extremism affected areas

The Government of India, approved the Road Requirement Plan (RRP) on 26 February, 2009 for upgrading 5,565 km long roads out of which 1,202 km are the national highways and 4,363 km are state roads. The upgradation is with respect to two-lane provision in 34 core districts affected by left-wing extremism (LWE). These districts are in the states of Andhra Pradesh, Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Maharashtra, Odisha and Uttar Pradesh. The project is expected to cost ₹ 7,300 crores. Development of 2,929 km length had been completed till 2013-14 and the rest is likely to be completed by March 2015. RRP-E covering a length of 5,624 km at an estimated cost of ₹ 9,900 crore is under consideration of the government.

1. Golden Quadrilateral Super Highway. National Highways Development Project (NHDP) has taken up a massive programme of road building in the country. Launched on January 2, 1999, this is perhaps one of the largest programmes of road development ever taken up in the country. The project is being implemented by National Highways Authority of India (NHAI). NHDP has following two components.

(i) Phase I—Golden Quaderilateral. Comprising National Highways connecting Delhi-Mumbai-Chennai-Kolkata-Delhi by six-lane super highways. This component has a total length of 5,846 km. The four sides of the quadrilateral have varying length. The side of quadrilateral between Delhi and Mumbai is 1,419 km long, Mumbai to Chennai is 1,290 km long, Chennai to Kolkata is the longest side which is 1,684 km long. The side between Kolkata and Delhi is 1,453 km long.

TABLE 26.7. Overall Progress of NHDP as on 31st May, 2011

Phases	Total (km)	4/6 laned (km)	km	Contracts (No)	Balance for award
GO (Golden Quadrilateral)	5,846	5,827 (99.67%)	19	8	—
NS & EW corridors	7,142	5,733.	988	87	421
Port Conductivity	380	318	62	4	0
Other NHs	1,383	936	427	6	20
SARDP-NE	388	—	112	2	276
NHDP Phase					
III	12,109	2,351	5,925	82	3,833
IV	20,000	—	873	6	19,127
V	6,500	619	2,018	19	3,863
VII	700	—	41	2	659
Total	54,448	15,784	10,465	216	28,199

(ii) Phase II—North-South Corridor. Comprising the National Highways connecting Srinagar to Kanniyakumari including Kochi-Salem Spur and *East-West corridor* comprising the National Highways connecting Silchar in Assam and Porbandar in Gujarat. The project has a total length of about 7,300 km, out of which the North-South corridor is 4,000 km and East-West corridor is 3,300 km long.

Main components of the Golden Quadrilateral are shown in **Fig. 26.4**.

Distribution of National Highways. A number of national highways run across the country in all directions linking important places to one another. The historically important Sher Shah Suri Marg is known as National Highway 1. It links Delhi and Amritsar. National Highway 2 links Delhi and Kolkata. National Highway 3 runs between Agra and Mumbai via Gwalior, Indore and Nasik. National Highway 7 is the longest one which links Varanasi with Kanniyakumari via Jabalpur, Nagpur, Hyderabad, Bangalore and Madurai. It traverses a distance of 2,325 km. National Highway 5 and 17 run along the eastern and western coasts respectively. National Highway 15 represents the border road in Rajasthan desert and runs through Kandla, Jaisalmer, Bikaner and joins the border road in the Punjab. **Fig. 26.5** shows the important national highways.

TABLE 26.8. Length of Various Sections of the Golden Quadrilateral

Name	Length of sides of the Golden Quadrilateral (Length in km)
Delhi-Mumbai	1,419
Mumbai-Chennai	1,290
Chennai-Kolkata	1,684
Kolkata-Delhi	1,453
Total	**5,846**
	Length of Corridors
North-South corridor Connecting Srinagar with Kanniyakumari	4,000
East-West corridor connecting Silchar with Porbandar	3,300
Total	**7,300**

Some of the important National Highways are listed in **Table 26.9**

TABLE 26.9. India : Some Important National Highways

No.	Route	Length (km)
1.	Delhi-Ambala-Jalandhar-Amritsar	456
1A.	Jalandhar-Madhopur-Jammu-Srinagar-Baramula-Uri	663
1B.	Batot-Doda-Kishtwar	107
2.	Delhi-Mathura-Agra-Kanpur-Allahabad-Varanasi-Mohania-Barhi-Kolkata	1,490
3.	Agra-Gwalior-Shivpuri-Indore-Dhulia-Nashik-Thane-Mumbai	1,161
4.	Thane-Pune-Belgaum-Hubli-Bengaluru-Ranipet-Chennai	1,235
4A.	Belgaum-Anmode-Ponda-Panaji	153
5.	Bahargagora-Cuttack-Bhubaneshwar-Vishakhapatanam-Vijyawada-Chennai	1,533
6.	Dhule-Nagpur-Raipur-Sambalpur-Baharagora-Kolkata	1,645
7.	Varanasi-Rewa-Jabalpur-Nagpur-Hyderabad-Bangalore-Madurai-Kanniyakumari	2,369
8.	Delhi-Jaipur-Ajmer-Udaipur-Ahmadabad-Vadodara-Mumbai	1,428
9.	Pune-Solapur-Hyderabad-Vijayawada	791
10.	Delhi-Fazilka	403
11.	Agra-Bharatpur-Jaipur-Bikaner	582
12.	Jabalpur-Bhopal-Kota-Bundi-Japiur	890
13.	Solapur-Chitradurga	491
14.	Beawar-Sirohi-Radhanpur	450

15.	Pathankot-Bathinda-Bikaner-Jaisalmer	1,526
16.	Barmer-Samkhiyali-Jagdalpur	460
17.	Panvel-Mangalore-Edapalli	1,269
18.	Kurnool-Nandyal-Cuddapah-Chittoor	369
20.	Pathankot-Mandi	220
21.	Chandigarh-Ropar-Mandi-Kulu-Manali	323
22.	Ambala-Kalka-Shimla-Narkanda-Rampur-Chini	462
23.	Chas-Ranchi-Rourkela-Talwar	459
24.	Delhi-Bareilly-Lucknow	438
25.	Lucknow-Kanpur-Jhansi-Shivpuri	319
26.	Jhansi-Lakhnaden	396
27.	Allahabad-Mangawan	93
28.	Barauni-Muzaffarpur-Gorakhpur-Lucknow	570
28A.	Pipra-Sagauli-Razaul	68
29	Gorakhpur-Ghazipur-Varanasi	198
30.	Mohania-Patna-Bakhtiyarpur	230
31.	Bakhtiyarpur-Siliguri-Nalbari-Aminagaon	1,125
31A.	Sivok-Gangtok	92
32.	Govindpur-Dhanbad-Jamshedpur	179
33.	Barhi-Ranchi	352
34.	Dalkhola-Barasat-Kolkata	443
35.	Barasat-Bangaon	61
36.	Nagaon-Dabaka-Dimapur	170
37.	Goalpara-Guwahati-Kamargaon-Saikhoa Ghat	680
38.	Makum-Ledo-Lekhapani	54
39.	Numiligarh-Imphal-Palel	436
40.	Jorhat-Shillong-Dawki	161
41.	Kolaghat-Haldia	51
42.	Sambalpur-Angul-Cuttack	261
43.	Raipur-Vizianagaram	560
44.	Shillong-Passi-Badarpur-Agartala	495
45.	Chennai-Tiruchchirappalli-Dindigul	387
46.	Krishnagiri-Ranipet	132
47.	Salem-Coimbatore-Thiruvananthapuram-Kanniyakumari	640
48.	Bangalore-Hassan-Mangalore	328
49.	Kochi-Madurai-Dhanushknodi	440
50.	Nashik-Pune	192
51.	Pekana-Tura-Dalu	149
52.	Baihata-Charali-Tezpur-Lakhimpur-Sekhoaghat	850
53.	Badarpur-Zirighat-Imphal-Silchar	320
54.	Silchar-Aizawl	560
55.	Siliguri-Darjeeling	77
56.	Lucknow-Varanasi	285

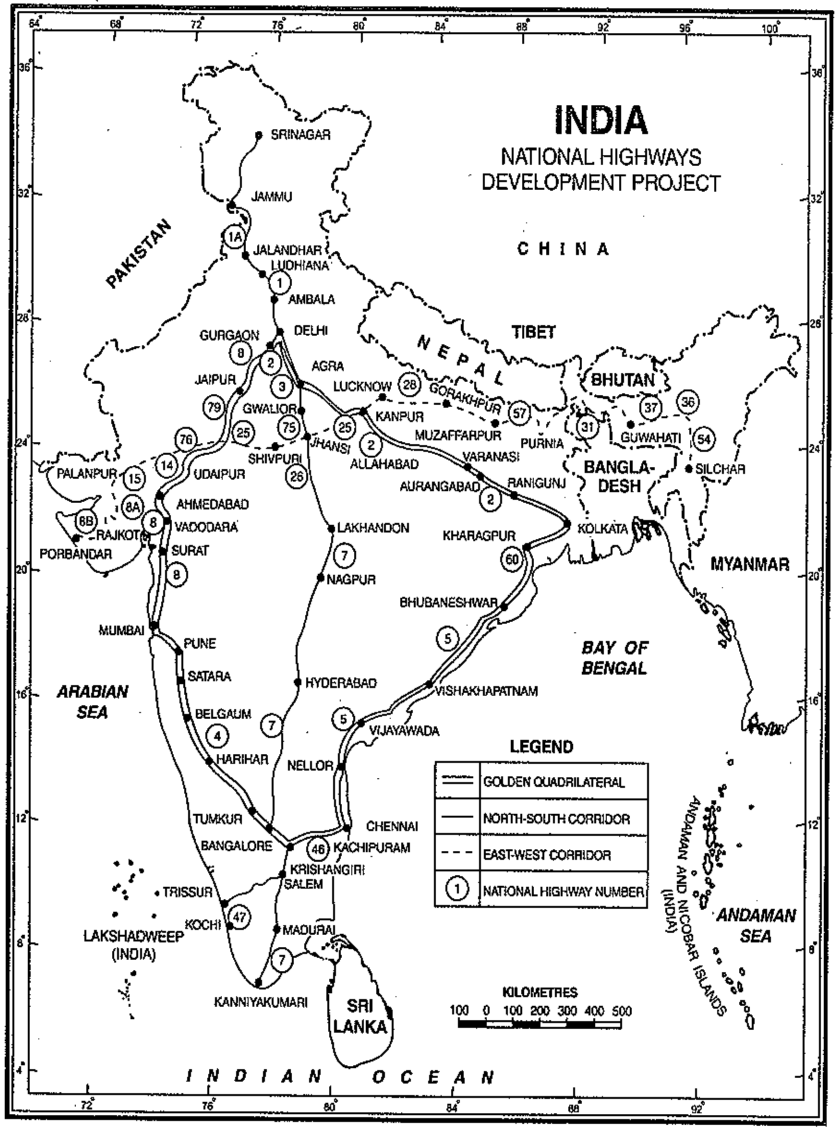

FIG. 26.4. India : National Highways Development Project.

Table 26.10 depicts the state-wise distribution of National Highways. This table shows that Uttar Pradesh has the longest length of National Highway covering a distance of 5,874 km. This is followed by Rajasthan (5,585 km), Madhya Pradesh (4,670 km), Andhra Pradesh and Telangana (4,472 km) and Tamil Nadu (4,462 km).

The Government of India declared the following new National Highways in August, 2014.

NEWLY DECLARED NATIONAL HIGHWAYS

- **NH-11** Narnaul—Rewari
- **NH-54** Dabwali—Hanumangarh—Goluwala
- **NH-248A** Nuh—Gurgaon
- **NH-344B** Sonepat—Jhajjar—Joharu
- **NH-703** Sirsa—Haryana/Punjab border

TABLE 26.10. List of State-wise National Highways in India

Sl. No.	Name of State	National Highway No.	Total Length (in km)
1	Andhra Pradesh (including Telangana)	4, 5, 7, 9, 16, 18, 43, 63, 202, 205, 214, 214A, 219, 221 & 222	4,472
2	Arunachal Pradesh	52, 52A & 153	392
3	Assam	31, 31B, 31C, 36, 37, 37A, 38, 39, 44, 51, 52, 52A, 52B, 53, 54, 61, 62, 151, 152, 153 &154	2,836
4	Bihar	2, 2C, 19, 28, 28A, 28B, 30, 30A, 31, 57, 57A, 77, 80, 81, 82, 83, 84, 85, 98, 99, 101, 102, 103, 104, 105, 106, 107 & 110	3,642
5	Chandigarh	21	24
6	Chhattisgarh	6, 12A, 16, 43, 78, 111, 200, 202, 211, 216 and 217	2,184
7	Delhi	1, 2, 8, 10 & 24	72
8	Goa	4A, 17, 17A & 17B	269
9	Gujarat	NE-I, 6, 8, 8A, 8B, 8C, 8D, 8E, 14, 15, 59, 113 & 228	3,245
10	Haryana	1, 2, 8, 10, 21A, 22, 64, 65, 71, 71A, 71B, 72, 73, 73A , & NE-II	1,512
11	Himachal Pradesh	1A, 20, 21, 21A, 22, 70, 72, 73A & 88	1,208
12	Jammu & Kashmir	1A, 1B, 1C & 1D	1,245
13	Jharkhand	2, 6, 23, 31, 32, 33, 75, 78, 80, 98, 99 & 100	1,805
14	Karnataka	4, 4A, 7, 9, 13, 17, 48, 63, 67, 206, 207, 209, 212 & 218	3,843
15	Kerala	17, 47, 47A, 47C, 49, 208, 212, 213, & 220	1,457
16	Madhya Pradesh	3, 7, 12, 12A, 25, 26, 26A, 27, 59, 59A, 69, 75, 76, 78, 86 & 92	4,670
17	Maharashtra	3, 4, 4B, 4C, 6, 7, 8, 9, 13, 16, 17, 50, 69, 204, 211 & 222	4,176
18	Manipur	39, 53.150 & 155	959
19	Meghalaya	40, 44, 51 & 62	810
20	Mizoram	44A, 54, 54A, 54B, 150 & 154	927
21	Nagaland	36, 39, 61, 150 & 155	494
22	Odisha	5, 5A, 6, 23, 42, 43, 60, 75, 200, 201, 203, 203A, 215, 217 & 224	3,704
23	Puducherry	45A & 66	53
24	Punjab	1, 1A, 10, 15, 20, 21, 22, 64, 70, 71, 72 & 95	1,557
25	Rajasthan	3, 8, 11, 11A, 11B, 11C, 12, 14, 15, 65, 71B, 76, 79, 79A, 89, 90, 112, 113, 114 & 116	5,585
26	Sikkim	31A	62
27	Tamilnadu	4, 5, 7, 7A, 45, 45A, 45B, 45C, 46, 47, 47B, 49, 66, 67, 68, 205, 207, 208, 209, 210, 219, 220, 226 & 227	4,462
28	Tripura	44 & 44A	400
29	Uttar Pradesh	2, 2A, 3, 7, 11, 12A, 19, 24, 24A, 24B, 25, 25A, 26, 27, 28, 28B, 28C, 29, 56, 56A, 56B, 58, 72A, 73, 74, 75, 76, 86, 87, 91, 91A, 92, 93, 96, 97, 119 & NE-II	5,874
30	Uttarakhand	58, 72, 72A, 73, 74, 87, 94, 108, 109, 121, 123 & 125	1,991
31	West Bengal	2, 2B, 6, 31, 31A, 31C, 31D, 32, 34, 35, 41, 55, 60, 60A, 80, 81 & 117	2,524
32	Andaman & Nicobar	223	300

Source : India 2014, A Reference Annual, pp. 1065-66.

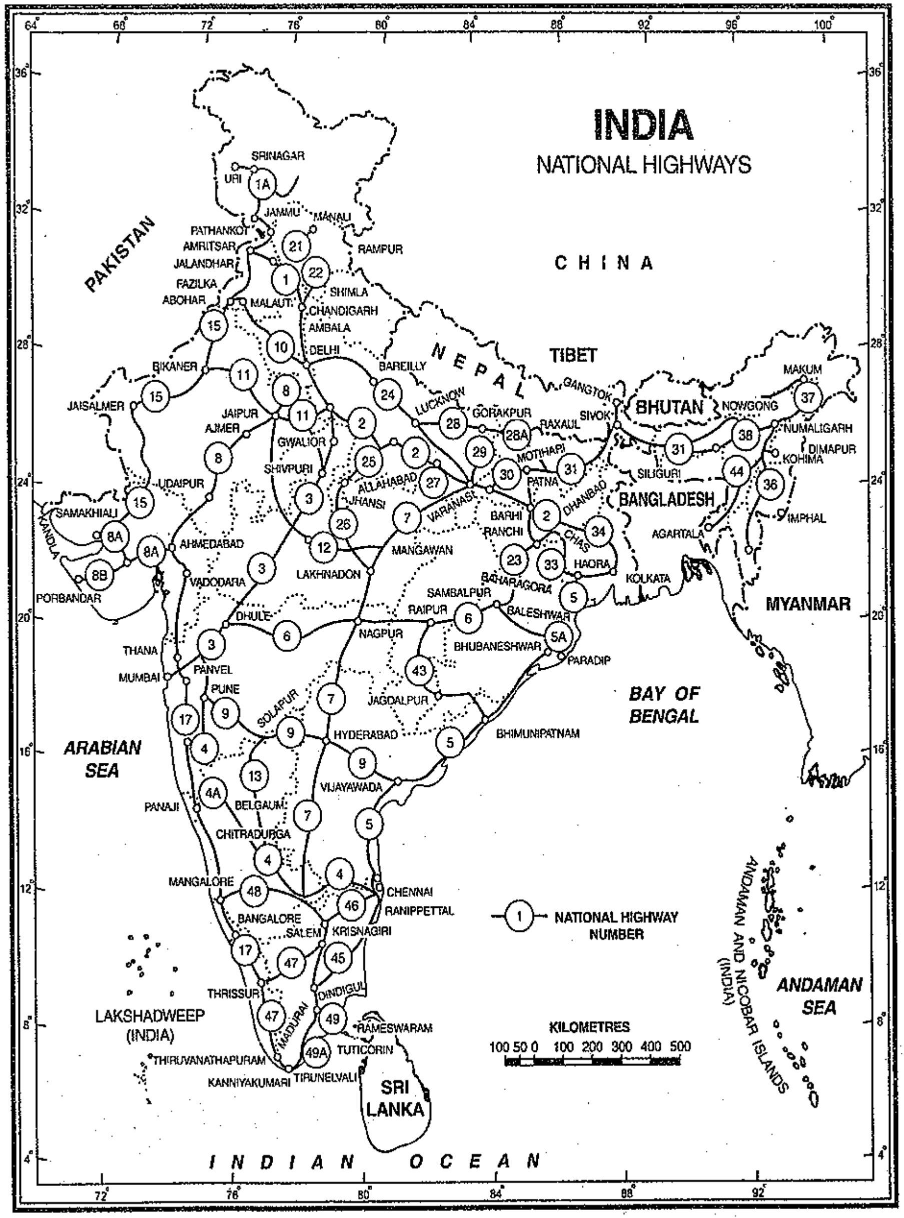

FIG. 26.5. India : National Highways

2. State Highways

These are constructed and maintained by state governments and join the state capitals with district headquarters and other important towns. These roads are also connected to the national highways. The length of state roadways in India has almost tebled within a span of about four decades and has increased from 56,765 km in 1971 to 1,6

These roads constitute about 3.5 per cent of the total road length of India.

Although construction and maintenance of state highways is the responsibility of the concerned state governments, yet with the revamping of the Central Road Fund (CRF) in 2000, the Centre provides financial assistance for development of state roads. Further, to promote inter-state facilities and also to assist the State Governments in their economic development through construction of roads and bridges, Central Government provides 100 per cent grant for inter-state connectivity and 50 per cent grant for projects of economic importance from CRF. Loan assistance from external funding agency is also taken by some states.

The distribution of State Highways is very uneven. Maharashtra has the maximum length of state highways. This is followed by Gujarat, Madhya Pradesh, Rajasthan, and Andhra Pradesh (including Telangana). Smaller states such as Goa, and states in hilly areas like Mizoram, Sikkim, Nagaland, Tripura, etc. have less than five hundred km length of State Highways.

3. *District Roadways*

These roads join the district headquarters with the other places of the district. Development and maintenance of these roads fall within the purview of Zila Parishads. There has been more than five times increase in the length of district roadways. Formerly most of the district roads were unsurfaced and lacked bridges and culverts. But now the situation has changed and most of these roads are surfaced. Such a situation has improved connectivity and paved way for economic development.

Maharashtra is at the top followed by Uttar Pradesh, Madhya Pradesh, Rajathan, Punjab, Karnataka, Assam, Himachal Pradesh, Haryana and Kerala.

4. *Village Roads*

The village roads are mainly the responsibility of village panchayats and connect the villages with the neighbouring towns and cities. These are generally dusty tracks and are usable only during the fair weather. They become muddy and unserviceable during the rainy season. Efforts have been made in the recent past to connect the villages with metalled roads. The length of these roads has increased by about 13 times from 2,06,408 km in 1951 to 27,49,805 km in 2011. These roads accounted for over 58.6 per cent of the total road length of the country in 2011. Still about 10 per cent of the villages having a population of 1,000 or more and 60 per cent of the villages with less than 1,000 people are not connected by all-weather roads. The network needs expansion and upgradation of existing roads to all-weather roads.

A new thrust was given to village roads when the Pradhan Mantri Gram Sadak Yojna (PMGSY) was launched in December 2000. This is a 100% Centrally Sponsored Scheme to provide rural connectivity to unconnected habitations with a population of 500 persons or more (250 persons in case of hilly, desert and tribal areas) in rural areas by the end of the Tenth Plan period. The scope of PMGSY has been expanded to include both construction of new links and upgradation of existing through routes associated with such link routes to form one complete sub-network for providing connectivity between the village and the market. A survey undertaken to identify the "core network" as part of PMGSY showed that over 1.70 lakh unconnected habitations needed to be undertaken under this programme. This would require new construction of 3.68 lakh kilometres of rural roads at a total cost of ₹ 1,33,000 crore.

Border Roads. Border Roads Organisation (BRO) Board was set up in May 1960 for accelerating economic development and strengthening defence preparedness through rapid and co-ordinated improvement of roads in the north and north-eastern border areas. This organisation has constructed world's highest road joining Chandigarh with Manali in Himachal Pradesh and Leh in Ladakh. This road runs at an average altitude of 4,270 metres above sea level and negotiates four passes at heights ranging from 4,875 to 5,485 metres. It is a vital road link in the western Himalayas and has considerably reduced the distance between Chandigarh and Leh. The Border Roads Organisation has now spread its activities throughout the country and is presently working in states of Rajasthan, Jammu and Kashmir, Himachal Pradesh, Maharashtra, Tamil Nadu, Andhra Pradesh, Uttar Pradesh, Sikkim, Assam, Meghalaya, Nagaland, Tripura, Manipur, Mizoram, Arunachal Pradesh, Bihar and Andaman and Nicobar Islands.

IMPORTANT MILESTONES

- Entrustment of construction of 8.8 km long Rahtag tunnel, related access roads to its portals and a 292 km long Alternate Route to Leh.
- Entrusted with four-laning of a stretch of NH-IA from Jammu to Vijaypur as part of NHDPs North-South Corridor on behalf of NHAI.
- Part of Phase 'A' of Special Accelerated Road Development Programme for North-East (SARDP-NE) has been entrusted to BRO. The work involves construction of new roads and improvement of existing roads along with widening of 1,103.58 km.
- Upgradation of 94 km long Srinagar-Uri Road (NH-1A) and 17.25 km long Uri-LOC road, double laning of 265 km long Batote-Kishwar-Anantnag road (NH-1B) and 422 km long Srinagar-Leh road Uri Kargil (NH -1D), construction of 290 km long Nimer-Padum-Darcha road, and widening of 14.14 km long Domel-Katra (NH-1C).
- Completed 120 metre long cut and cover tunnel at NH-44 near Sonapur in Meghalaya in 2008. It facilities uninterrupted communication at Sonapur landslide prone area during monsoons for forward areas of Meghalaya, Mizoram, Tripura and Cachar region of Assam.

A prestigious project of developing the 160 km long Tamu-Kalemyo-Kalewa road in Myanmar was taken up in 1997 and completed in 2001. Another important work is the construction of Indo-Bangladesh Border (IBB) Roads and fencing of the border.

Urban Roads. A road within the limits of the area of municipality, military cantonment, port or railway authority is called an urban road. There has been a phenomenal growth in urban roads from a meagre 46,361 km in 1961 to 4,11,840 km in 2011 as a result of accelerated growth in urbanization.

Project Roads. A road within the limits of the area of a development project of a public authority for the exploitation of resources such as forests, irrigation, hydro-power, coal, sugarcane, etc. is called a project road. Various developmental projects have been undertaken as a result of which the length of project road has increased from 1,30,893 km in 1971 to 2,88,539 km in 2011.

International Highways

The roads which are financed by the World Bank and connect India with neighbouring countries are called international highways. There are two categories of such highways. (*a*) the main arterial routes linking the capitals of neighbouring countries. Some of the important routes of this category are (*i*) the Lahore-Mandalay (Myanmar) route passing through Amritsar-Delhi-Agra-Kolkata-Golaghat-Imphal (*ii*) Agra-Gwalior-Hyderabad-Bengaluru-Dhanushkodi road and (*iii*) Barhi-Kathmandu road. (*b*) Routes joining major cities, ports etc. with arterial network such as : (*i*) Agra-Mumbai road (*ii*) Delhi-Multan road (*iii*) Bengaluru-Chennai Road and (*iv*) Golaghat-Ledo road.

Geographical Distribution of Roads

The network of roads is more or less similar to that of railways, although former far excels the later with respect to kilometreage. A look at **Figure 26.5** and shows that there are great variations in the distribution pattern of roads in India. Uttar Pradesh, Rajasthan, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Maharashtra, Karnataka, Gujarat, Odisha and Bihar have much longer length of national highways. Incidently these are larger states with high density of population and comparatively advanced stage of industrial growth. However, length of National Highways passing through a state is not always a true index of economic well being of a state as they serve only the main routes. For example, Madhya Pradesh and Bihar have longer route length of the national highways and still have some of the most backward areas which are located far away from the main road routes.

The length of state highways could be a better index of road accessibility at the state level. The picture is slightly different with regard to state highways when compared to that of the national highways.

Maharashtra is the best served state by the state highways. Gujarat is a distant second with respect to length of state highways. The other states with sufficiently long route length of state highways are Madhya Pradesh, Rajasthan, Karnataka, Uttar Pradesh and Andhra Pradesh. The north-eastern states do not have sufficient route length of state highways.

The nature of roads, rather than their total length is more significant from the utility point of view. The largest concentration of roads is found in the Northern

Plain, especially in West Bengal and in the Punjab-Haryana plain. But the ratio of surfaced road to the total road length is lower in the Northern Plain than the national average. For example, Bihar and West Bengal are the two large states in the plain but have only 42.32 per cent and 56.48 per cent of surfaced roads to the total length of roads respectively. Uttar Pradesh with 68.74 per cent of the surfaced roads is in a slightly better position. Punjab and Haryana are the two richest states of the country and have 100 per cent and 94.83 per cent of the surfaced roads respectively. The main cause of small proportion of surfaced roads in the Northern Plain is that it is made up of sand, silt and clay and there is shortage of stone for constructing surfaced roads. In contrast, the proportion of surfaced roads is much higher in the Peninsular plateau area because it is composed of hard rocks and stone for constructing roads is readily available here in plenty. Gujarat (93.95%), Maharashtra (79.68%), Goa (61.00%) are some of the states having higher than the national average of 60.33 per cent. Odisha presents an anomaly and is the poorest of all the states where surfaced roads account for less than one-third of the total length of roads. Among the Himalayan states Sikkim with 86.11 per cent is at the top and this is followed by 70.97 per cent in Jammu and Kashmir. All other Himalayan states have surfaced roads less than the national average. Among the union territories, Chandigarh, Dadra and Nagar Haveli, Daman and Diu, Delhi and Lakshadweep have 100 per cent surfaced route. This is followed by 97.47 per cent in Andaman and Nicobar Islands and 77.09 per cent in Pondicherry.

Density of Roads

A still better index of road accessibility is the *density of roads* which is defined as the length of roads per 100 sq km of surface area.

The Himalayan region, western Rajasthan and North-eastern states have low to very low density of road network. Most of these parts are served by roads constructed by Border Roads Organisation.

It varies from 10.0 km per 100 sq km in Jammu and Kashmir to 526.9 km per 100 sq km in Kerala with a national average of 96.5 km per 100 sq km (2013). Density of 200 to 400 km per 100 sq km is found in Assam, Goa, Tripura and West Bengal. Andhra Pradesh, Bihar, Karnataka, Nagaland, Odisha,

TABLE 26.11. State-wise Road Density per 100 sq km (2013)

State	Length of roads per 100 sq km
1. Andhra Pradesh (including Telangana)	125.4
2. Arunachal Pradesh	19.6
3. Assam	293.6
4. Bihar	127.5
5. Chhattisgarh	55.0
6. Goa	285.5
7. Gujarat	74.8
8. Haryana	67.2
9. Himachal Pradesh	65.2
10. Jammu & Kashmir	10.0
11. Jharkhand	21.9
12. Karnataka	133.2
13. Kerala	526.9
14. Madhya Pradesh	53.8
15. Maharashtra	72.6
16. Manipur	73.2
17. Meghalaya	43.9
18. Mizoram	29.2
19. Nagaland	134.5
20. Odisha	138.4
21. Punjab	89.7
22. Rajasthan	50.1
23. Sikkim	26.4
24. Tamil Nadu	139.3
25. Tripura	302.6
26. Uttar Pradesh	118.2
27. Uttarakhand	76.7
28. West Bengal	238.6
All States	**95.8**
Union Territories	
1. Andaman & Nicobar Islands	15.8
2. Chandigarh	1,857.9
3. Dadra & Nagar Haveli	128.7
4. Daman and Diu	200.0
5. Delhi	1,993.2
6. Lakshadweep	525.0
7. Puducherry	562.8
All Union Territories	**334.8**
All India	**96.5**

Tamil Nadu and Uttar Pradesh have road density varying from 100 to 200 km per 100 sq km. These two sets of states have moderate to high road density due to high level of urbanization and industrialisation. Level land of the Great Plain of North India provides ideal conditions for road construction but building material for road has to be transported from hilly region of the Himalayas or from the northern part of the plateau region as this plain is entirely made up of sand, silt and clay. On the other hand, the Himalayan region abounds in building material but rugged topography and rough terrain hampers the process of

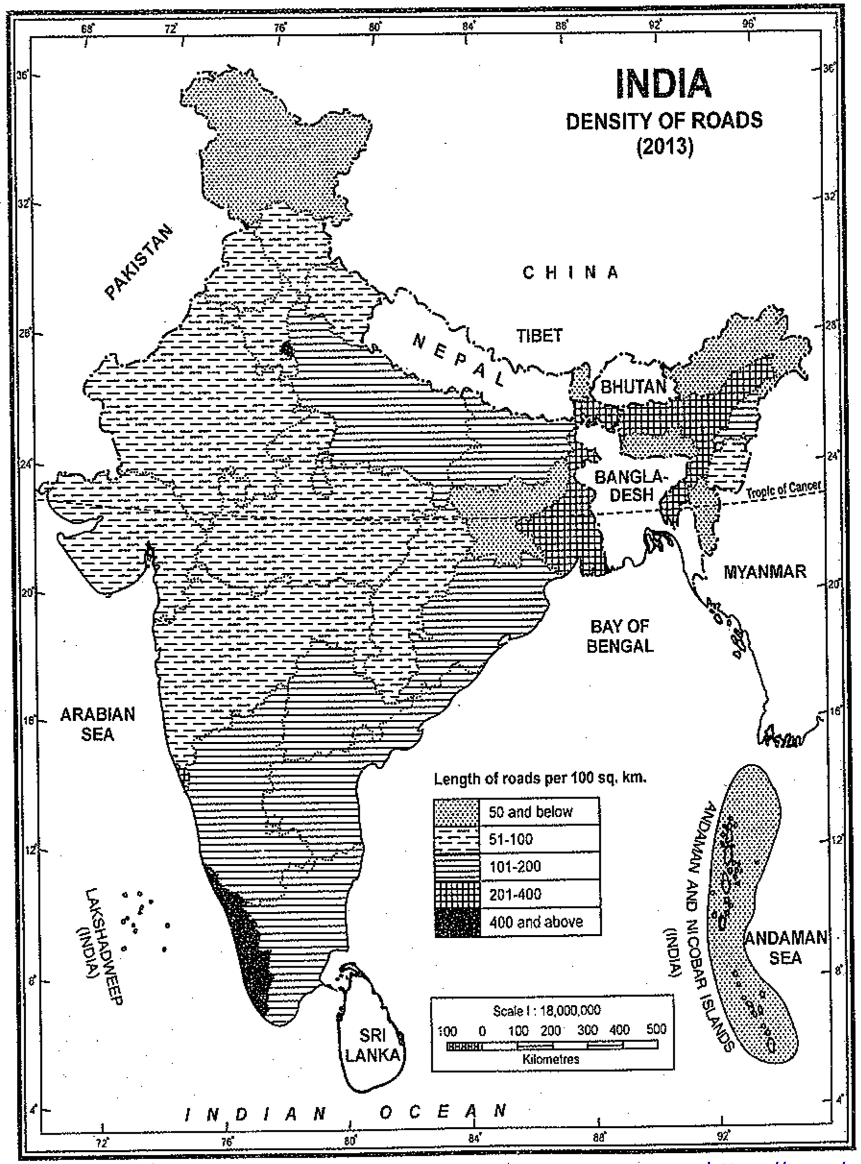

FIG. 26.6. India : Road Density (2013)

road building. This is the reason that most of the Himalayan states like Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Meghalaya, Manipur etc. have low density of roads. Most of the Union Territories are of small size and some of them are highly urbanized. As such they have high road density except Andaman and Nicobar Islands.

Problems and Prospects

Road transportation in India faces a number of problems. Keeping in view the vastness of the dimensions of the country, her physiography, her unlimited natural resources and the fast growing passenger and freight traffic, inadequacy of road network is quite glaring. India's road length of 96.5 km per 100 sq km of area is desperately low as compared to 294.6 km in Japan, 131.2 km in Austria, 451.8 km in Belgium, 147.2 km in France and 172.2 km in Switzerland. Again, India has low road length of 379.3 km per one lakh population as against 893.6 in Japan, 497.2 in Malaysia, 1277.7 in Saudi Arabia, 1392.4 in Austria, 1556 in Hungary, 1572.4 in Sweden, 2494.5 in the USA, 3184.9 in Canada, 4635.4 in Australia and 2705.7 in New Zealand. Lakhs of villages in remote areas are still awaiting a road to reach them.

Another problem is that a little less than half of the roads (40%) are unsurfaced. They can be used only in fair weather and become muddy and unfit for transportation during the rainy season. Efforts need to be made to construct as many surfaced roads as is practically possible.

The national highway network will have to be improved to meet the growing traffic of men and materials. A large section has insufficient road pavement thickness. Other deficiencies are inadequate capacity; poor riding quality, weak and distressed bridges/culverts, congested city sections, too many railway level crossings, lack of wayside amenities and weak road safety measures. About 20 per cent of national highways need widening from single to double lanes and 70 per cent of two lane roads have to be strengthened and selected corridors on national highways need conversion into *expressways*. This is clearly an enormous task and needs huge capital investment which is beyond the capacity of the public sector. Consequently, National Highway Act was amended in 1995 for encouraging private sector to participate in the construction, maintenance and operation of roads on Build, Operate and Transfer (BOT) basis.

The future challenge in road sector revolves around building all-weather roads connecting each and every village to a State Highway or a National Highway. It is imperative to strengthen the road infrastructure for carrying rapidly increasing volumes of agricultural produces to the consuming centres in the near future. *Rural development is closely associated with road development.*

Another very important factor to be considered is the rapidly growing population of motor vehicles and increasing commerce. The number of registered vehicles increased from 306 thousand in 1950-51 to 1,59,491 thousand in 2011-12, thereby registering over 521 times increase in a span of six decades (**Table 26.12**). However, carrying capacity of our roads has not been able to keep with the increase in vehicles. This has led to traffic jams, delays and environmental pollution. The most disturbing factor is that population of motor vehicles is likely to increase at an accelerated rate in the near future. As such there is an urgent need to take steps to increase the capacity of roads.

Building adequate road infrastructure to accelerate the pace of economic progress is an uphill task and requires huge sums of money. The current estimates suggest that the cost of a four-lane highway works out at roughly ₹ 4.5 crore per kilometre and the cost of a protected access, six-lane express way works out at roughly ₹ 8.5 crore per kilometre. Funds on such a gigantic scale are managed by encouraging private participation, World Bank and imposing cess on fuel, etc.

TABLE 26.12. Number of Registered Vehicles in India

(in thousands)

Year	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2008-09	2009-10	2010-11	2011-12
All vehicles	306.0	665.0	1,865.0	5,391.0	21,374.0	54,991.0	1,14,051	1,27,746	1,41,866	1,59,491
Goods vehicles	82.0	168.0	343.0	554.0	1,356.0	2,948	6,041	6,432	7,064	7,658
Buses	34.0	57.0	94.0	162.0	331.0	634.0	1,486	1,527	1,604	1,677

Source : The Economic Survey 2013-14, Statistic Appendix, p.31.

AIR TRANSPORT

Air transport is the fastest mode of transport which has reduced distances and has led to drastic shrinking of the world. This mode of transport is indispensable when speed and time are the main constraints. One can easily cross and reach remote, inaccessible and hostile areas like lofty mountains, thick forests, marshy areas and sandy deserts by air transport which is almost impossible by other modes of transport. Air transport plays a vital role in times of emergency as well as in the event of natural and man-made calamities like floods, famines, epidemics and wars. Air transport is very essential for a vast country like India where distances are so long and the terrain and climatic conditions so diverse. The weather conditions in India are also quite congenial to air transport. Poor visibility due to clouds, fog and mist hinders air transport but India is lucky to have clear weather for most part of the year except for a short duration in rainy season and foggy winters particularly in North India.

Air transportation in India made a humble beginning in 1911 when air mail operation commenced over a very short distance of 10 km between Allahabad and Naini. The British, French and Dutch introduced air transport in 1929-30. Indian National Airways was formed in 1933 and it introduced air service between Karachi and Lahore. By the end of the World War II, major cities like Karachi, Mumbai, Delhi, Kolkata, Lahore and some other places were provided with air services. At the time of partition of the country in 1947, there were four companies namely Tata Sons Ltd./Air India, Indian National Airways, Air Services of India and Deccan Airways. By 1951, four more companies *viz.* Bharat Airways, Himalayan Aviation Ltd., Airways India and the Kalinga Airlines also came up. In 1953, the air transport was nationalised and two corporations were formed: Air India International and the Indian Airlines. The face of Indian aviation is changing and is poised for a vibrant growth. India can definitely boast of a boom in air travel. Economic liberalisation has totally changed the outlook of a perspective air passenger. Now, he thinks in terms of time and gone are the days when he used to ponder over advantages and disadvantages of air travel.

The civil aviation sector in India has recorded an unprecedented growth in the recent years. Currently there are large number of companies providing passenger transport and cargo handling services in the country. The Air Transport Companies are both in public sector and in the private sector. In the public sector, there is Air India Limited, and its subsidiaries *viz.* Alliance Air, Air India Charters Ltd. (Air India Express etc.) Among the private players, Jet Airways (India) Ltd., Jetlite Airlines, Go Airlines (Indigo) Pvt. Ltd., Spice Jet Ltd., Inter Global Aviation Ltd. (Indigo) and Air Asia are operating on the domestic sector providing wide choice of flights and connectivity to various parts of the country.

The market share of major airlines is shown in **table 26.13.**

TABLE 26.13. The market share of major airlines

Name	Percentage Share
1. Indigo	27.2
2. Air India (Domestic)	19.3
3. Spice Jet	18.5
4. Jet Airways	18.1
5. Go Air	7.6
6. Jet Lite	5.7
7. King Fisher	3.5
8. Mantra	0.1
Total	100.00

Source : Statistical Year Book India 2013, p. 320.

Three Cargo airlines *viz.* Blue Dart Aviation Pvt. Ltd., Deccan Cargo and Export Logistics (Pvt. Ltd. and M/s Quickjet are operating scheduled cargo services. Besides there are 139 companies (as on 18-6-2012) holding non-scheduled air transport operators permit.

1. Air India is responsible for international air services. It operates from international airports and connects India with almost all the continents of world through its services. Its main services are to the USA, Canada, Europe, the Russian Confederation, the

Gulf/Middle East, East Asia, Far East, Africa and Australia. Its fleet has almost trebled from 13 air craft in 1960-61 to 34 in 2005-06. The number of passengers carried by Air India has increased manifold from 1.25 lakh in 1960-61 to 44.40 lakh in 2005-6. Endeavour has been made to enhance the operation of international sectors especially the Gulf routes which yield more profits.

TABLE 26.14. Growth of Civil Aviation in India

Year	Unit	1960-61	1970-71	1980-81	1990-91	1999-00	2004-05	2010-11	2011-12	2012-13	2013-14
1. Total fleet strength											
(*i*) Air India		13	10	17	24	26	36				
(*ii*) Indian Airlines		88	73	49	56	53	61				
(*iii*) Air India Ltd. (Erstwhile National Aviation Company of India Ltd.)								98	91	95	99
2. Revenue tonne kilometers	(₹ crore)										
(*i*) Air India		7.56	27.52	98.01	138.10	145.65	221.80				
(*ii*) Indian Airlines		10.00	20.00	40.03	69.92	74.03	101.73				
(*iii*) Air India Ltd. (Erstwhile National Aviation Company of India Ltd.)								367.70	360.30	3346.00	3910.00
3. Number of passengers carried	(Lakh)										
(*i*) Air India		1.25	4.87	14.18	21.61	33.50	44.40				
(*ii*) Indian Airlines		7.90	21.30	54.29	78.66	59.30	71.32				
(*iii*) Air India Ltd. (Erstwhile National Aviation Company of India Ltd.)								127.80	134.30	141.83	154.06
4. Passengers handled at	(Lakh)										
AAI Airports		na	na	107.38	177.23	390.35	592.84	596.43	684.00	683.87	717.8
Joint Venture Int'l Airports								837.87	939.00	910.14	972.68
Total at Indian Airports								1434.3	1623.1	1594.0	1690.48
5. Cargo handled at	(Thousand										
AAI Airports	tonnes)										
AAI Airports		na	na	178.70	377.33	797.41	1278.47	726.52	703.43	650.41	636.48
Joint Venture Int'l Airports								1621.92	1576.56	1540.14	1641.43
Total at Indian Airports								2348.44	2279.99	2190.55	2277.91

na : data not available

Source : Economic Survey 2013-14, Statisical Appendix, p. 31.

The Government of India approved a Turn Around Plan (TAP) and Financial Restructuring Plan (FRP) for improving the operational and financial performance of Air India in April 2012. The company took several initiatives towards cost-cutting and revenue enhancement during 2011-12. Some of the major steps taken are route rationalization, phasing out and grounding of old fleet, freezing of employment in non-operational areas, leveraging assets of the company to increase MRO (maintenance, repair and overhaul) revenue and revenue form real estate properties of the company.

2. Indian Airlines handles domestic traffic and carries passengers, cargo and mail to different places in the country. It also provides services to 12 countries, *viz*., Pakistan, Maldives, Nepal, Sri Lanka, Malaysia, Bangladesh, Thailand, Singapore, U.A.E.,

TABLE 26.15. Distribution of International Airports in India as on March 31, 2014

State	City Served	Name of the Airport
1. Andaman and Nicobar Islands	Port Blair	Veer Savarkar International Airport
2. Andhra Pradesh	Vishakhapatnam	Vishakhapatnam Airport
3. Assam	Guwahati	Lakpriya Gopinath Bordoloi International Airport
4. Chhattisgarh	Raipur	Swami Vivekanand Airport
5. Delhi	New Delhi	Indira Gandhi International Airport
6. Goa	Whole state	Goa International Airport
7. Gujarat	Ahmedabad	Sardar Vallabhbhai Patel International Airport
8. Jammu and Kashmir	Srinagar	Srinagar Airport
9. Karnataka	Bengaluru	Kempegowda International Airport
10. Karnataka	Mangalore	Mangalore International Airport
11. Kerala	Kochi	Cochin International Airport
12. Kerala	Kozhikode	Calicut International Airport
13. Kerala	Thiruvananthapuram	Trivandrum International Airport
14. Madhya Pradesh	Bhopal	Raja Bhoj Airport
15. Madhya Pradesh	Indore	Devi Ahilyabai Holkar Airport
16. Maharashtra	Mumbai	Chhatrapati Shivaji International Airport
17. Maharashtra	Nagpur	Dr. Babasaheb Ambedkar International Airport
18. Manipur	Imphal	Tulibal International Airport
19. Odisha	Bhubaneshwar	Biju Patnaik International Airport
20. Punjab	Amritsar	Sri Guru Ram Das Jee International Airport.
21. Rajasthan	Jaipur	Jaipur International Airport
22. Rajasthan	Udaipur	Maharana Pratap Airport
23. Tamil Nadu	Chennai	Chennai International Airport
24. Tamil Nadu	Coimbatore	Coimbatore International Airport
25. Tamil Nadu	Tiruchirappali	Tiruchirapalli International Airport
26. Telangana	Hyderabad	Rajiv Gandhi International Airport
27. Uttar Pradesh	Lucknow	Chaudhary Charan Singh Airport
28. Uttar Pradesh	Varanasi	Lal Bahadur Shastri Airport
29. West Bengal	Kolkata	Netaji Subhash Chandra Bose International Airport
30. West Bengal	Silguri	Bagdogra Airport

Source : Airport Authority of India, 2014.

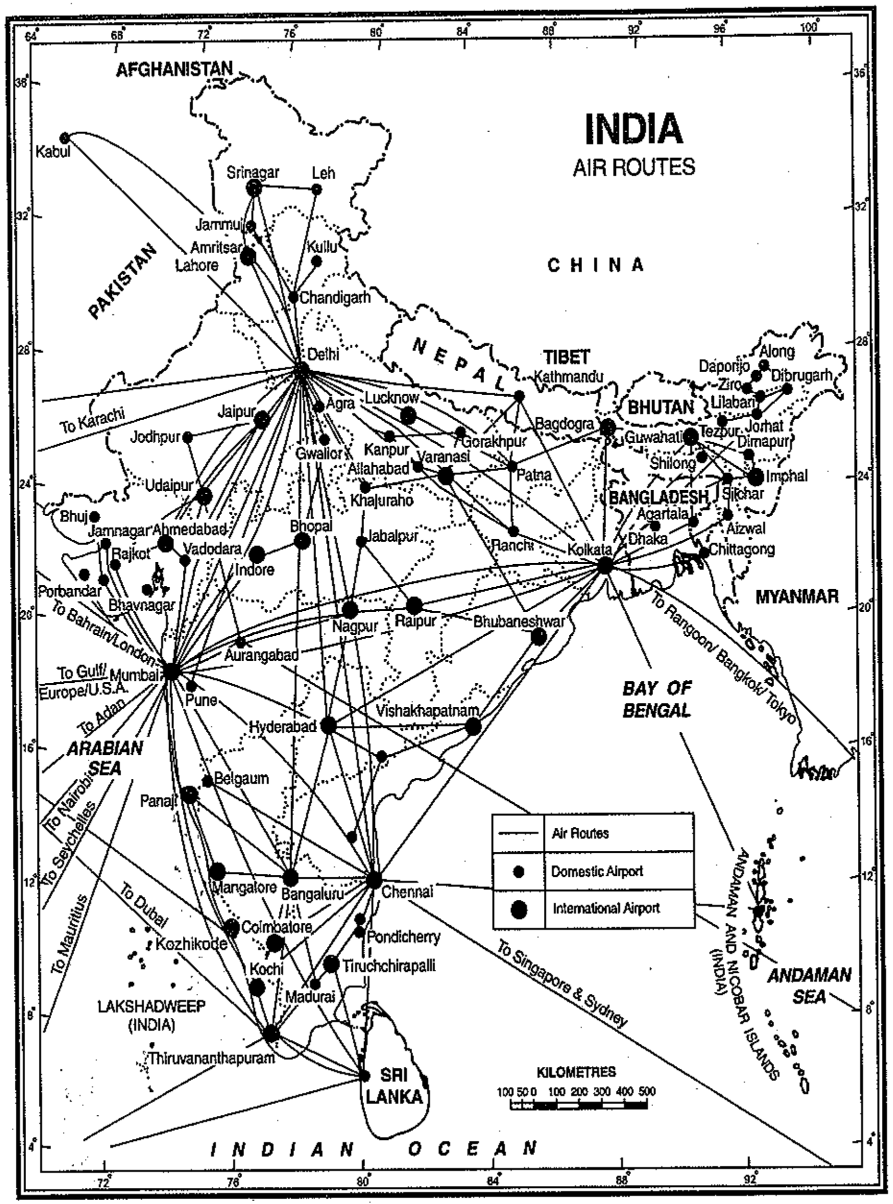

FIG. 26.7. India : Air Routes

Oman, Myanmar and Kuwait. Its operations cover 69 destinations including 15 abroad. Its fleet strength has shown varying trends, falling from 88 in 1960-61 to 73 in 1970-71 and 49 in 1980-81. It rose to 53 in 1999-2000. In 2005-06, its fleet stood at 64. The current projections indicate additional aircraft requirements for replacement of ageing aircraft as well as for growth. The number of passengers carried

by Indian Airlines rose dramatically from a modest of 7.9 lakh in 1960-61 to 78.66 lakh in 1990-91 but fell to 78.61 lakh in 2005-06.

3. Vayudoot was set up in 1981 to augment the air transport in the country. It provided links with remote and inaccessible areas which were not covered by Indian Airlines. It commenced its services in February, 1981. The Government had initially approved air services to 14 stations in the North-Eastern region. Subsequently, 23 stations outside this region were added for linking by Vayudoot. Its fleet rose from 1 in 1981 to 20 in 1988-89 but fell to 16 in 1992-92 after which it was merged in Indian Airlines. Its network which linked remote, inaccessible and thickly forested areas of the North-Eastern region has been taken over by the newly created Short Haul Operations Deptt. of Indian Airlines.

4. Pawan Hans Limited was established in 1985. It provides helicopter services to the petroleum sector including ONGC, Oil India Ltd. and Enron Oil and Gas, Mumbai High and connects remote and inaccessible areas. The company has a strong presence in North-East having its helicopters deployed in the states of Arunachal Pradesh, Meghalaya, Sikkim and Tripura. Apart from this it also provides services to certain state governments such as Punjab, M.P., Lakshadweep and public sector undertakings like NTPC., GAIL, and BSF.

Private Sector. Private taxis started their services in 1990 and played feeder role to Indian Airlines. Only four parties ventured in this area at that time due to the restrictive environment. In a major policy change, the Government repealed the Air Corporation Act 1953 on March 1, 1994, thereby ending the monopoly of Indian Airlines and Air India on the scheduled operations. Private operators, who were hitherto operating as air taxis, have since been granted scheduled airlines status. The new policy on air taxi services provides for a route dispersal plan to ensure operation of a minimum number of services in the North-Eastern Region, Andaman and Nicobar Islands, Lakshadweep and Jammu and Kashmir. This policy has infused competitive environment between Indian Airlines Ltd., a public sector enterprise, on one hand and private operators on the other hand. The policy on domestic air transport service was approved in April 1997 according to which barriers to entry and exit from this sector have been removed.

Airport Authority of India (AAI)

International Airports Authority of India and National Airports Authority were merged on 1 April, 1995 to form Airports Authority of India (AAI). This authority is responsible for providing safe and efficient air traffic services and aeronautical communication services for effective control of air traffic in the Indian air space. It controls and manages the entire Indian space even beyond the territorial limits of the country in accordance to the norms set by International Civil Aviation Organisation (ICAO). It comprises of International Airport Division (IAD) and National Airports Division (NAD).

At present India has 450 air ports/air ships of which 30 are international. There are 26 Civil Enclaves (3 international, 4 customs and 19 domestic) as well as 31 non-operational domestic airports. The distribution of international airports is given in **table 26.15**.

The International Airports Division (IAD) of AAI operates and develops international airports. It has undertaken construction of terminal complexes at various international airports and improvement and upgradation of runways and terminal buildings. National Airport Division (NAD) looks after domestic airports. A number of projects like modernisation of air traffic services at Mumbai and Delhi airports, installation of airport surveillance radar at Ahmedabad, Guwahati, Hyderabad and Thiruvananthapuram, development of 12 model airports for upgradation of facilities and improvement in the quality of services at airports have been taken up. Development works in other remote areas like Jammu and Kashmir, Lakshadweep, Himachal Pradesh and Andaman and Nicobar Islands are also being taken up.

The improvement of infrastructure at the airports needs heavy capital investment which the government cannot afford of its own. Therefore, private domestic and foreign investors including NRIs have been encouraged to participate in the process of improvement. Improvement and modernization of Indira Gandhi International Airport at Delhi and Shivaji Maratha International Airport at Mumbai Chennai International Airport and Netaji Subhash Chandra Bose International Airport are some of the outstanding examples.

WATER TRANSPORT

Inland waterways were the chief mode of transportation before the advent of railways. Waterways are the cheapest means of transport and are most suitable for carrying heavy and bulky materials having low specific cost. Water transport is a fuel efficient and environment friendly mode of transportation which has vast employment generation potential. Water transport suffered a great deal at the hands of roads and railways because it could not compete with the speed of road and rail transport. Although efforts are being made to revive the inland waterways, yet this mode of transportation is at its initial stage. Waterways provide only one per cent of total transport of India. The total length of navigable waterways in India comprising rivers, canals, backwaters, creeks, etc. is 14,500 km, out of which only 3,700 km is navigable by mechanised boats. Only 2,000 km is actually used. As regards canals, we have a network of about 4,300 km of navigable canals, of which a stretch of 900 km is navigable by mechanised crafts. The emerging scenario shows that the inland waterways are greatly underutilised.

National Waterways

In order to increase the significance of inland waterways and to improve their efficiency, the Government has identified 10 important waterways which are to be given the status of National Waterways. Some headway has already been made in this regard.

Followng five inland waterways have so far been declared as national waterways (NW).

In addition, declaration of Barak river from Lakhpur to Bhanga (121 km) as sixth National Waterway is under consideration of the Government.

Ganga is the most important inland waterway in India. It is navigable by mechanised boats upto Patna and by ordinary boats upto Hardwar. It has been declared as National Waterway No. 1. The entire route has been divided into three parts for development purposes. These parts are Haldia-Farakka (560 km), Farakka-Patna (460 km) and Patna-Allahabad 600 km). The National Waterways (Allahabad-Haldia stretch of Ganga-Bhagirathi-Hooghly River system) Act, 1982 has the provision that the regulation and development of this waterway is the responsibility of the Central Government.

Brahmaputra is also navigable by steamers upto Dibrugarh for a distance of 1,384 km which is shared by India and Bangladesh. Its 891 km long stretch from Sadiya to Dhubri in Assam has been declared as a National Waterway and is being developed as an important inland waterway.

Rivers of South India are seasonal and are not much suited for navigation. However, the deltaic areas of the Godavari, the Krishna and the Mahanadi, lower reaches of the Narmada and the Tapi, back waters of Kera Mandovi and Juari rivers of Goa serve as waterways. The Godavari is navigable upto a distance of 300 km from its mouth. The Krishna is used as a waterway upto 60 km from its mouth.

There are some navigable canals also which serve as inland waterways. Buckingham canal in Andhra Pradesh and Tamil Nadu is one such canal which provides water transport for a distance of 413 km. It runs parallel to the eastern coast and joins all the coastal districts from Guntur to South Arcot. The other navigable canals are Kurnool-Cuddapah Canal (116.8 km), Son Canal (326 km), Odisha Canal (272 km), Medinipur Canal (459.2 km), Damodar Canal

TABLE 26.16. National Waterways of India

Waterways	Stretch	Specification	Date of declaration
NW 1	Allahabad-Haldia stretch (1,620 km)	It is one of the most important waterways in India, which is navigable by mechanical boats up to Patna and by ordinary boats up to Haridwar. It is divided into three parts for developmental purposes — (*i*) Haldia-Farakka (560 km), (*ii*) Farakka-Patna (460 km), (*iii*) Patna-Allahabad (600 km).	27.10.1986
NW 2	Sadiya-Dhubri stretch (891 km)	Brahmaputra is navigable by steamers up to Dibrugarh (1,384 km) which is shared by India and Bangladesh.	26.10.1988
NW 3	Kottapuram-Kollam stretch (205 km)	It includes 168 km of west coast canal along with Champakara canal (23 km) and Udyogmandal canal (14 km).	01.02.1991
NW 4	Kakinada Puducherry (1995 km)	Stretch of canal and Kalurelly Tank stretches of river Godavari and Krishna.	2008
NW 5	Talcher Dhamra (585 km)	Stretch of river Brahmani Geonkhali Cherbatia stretch of East coast canal, Charbectia Dharma. Stretch of Matai river alongwith Mahanadi delta river system	2008

Source : Compiled from India 2012 *A Reerence Annual*, p. 1090-91.

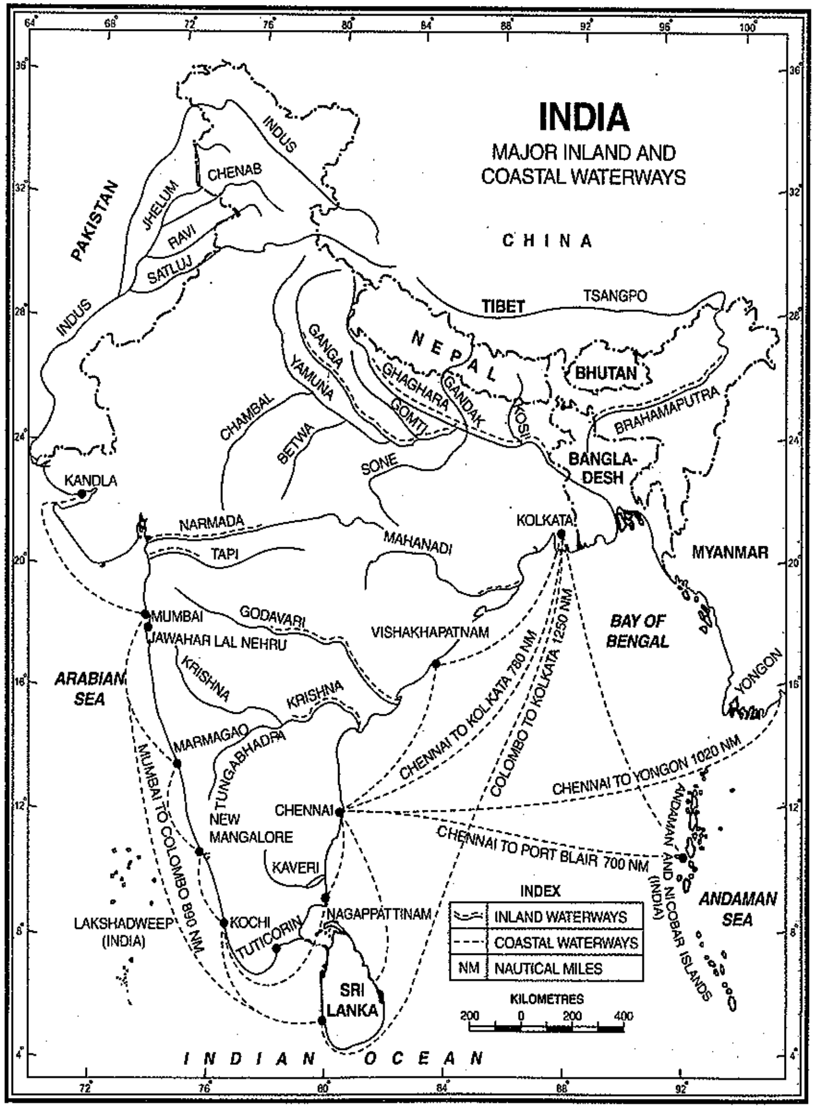

FIG. 26.8. India : Major Inland and Coastal Waterways

(136 km). Some of the irrigation canals of Uttar Pradesh and Punjab are also utilised for local transport.

The Inland Waterways Authority of India (IWAI) was set up at Noida (Uttar Pradesh) on 27 October, 1987 for development and regulation of inland waterways. The Authority undertakes various schemes for development of Inland Water Transport (IWT) related infrastructure on National Highways.

Factors affecting Inland Waterways

1. The rivers and canals should have regular flow of sufficient water.

2. The presence of waterfalls, cataracts and sharp bends in the course of river hinders the development of waterways.

3. Silting of the river bed reduces the depth of water and creates problems for navigation. Desilting of river beds is a costly affair.

4. Diversion of water for irrigation purposes reduces the quantity of water in the river channel and should be done carefully.

5. There should be sufficient demand for waterways to make it economically viable mode of transportation.

SHIPPING

India had a glorious past with respect to shipping. Indian maritime trade flourished in ancient times. Indian boats and ships have been sailing in the Indian Ocean for the last 4,000 years taking merchandise to East Indies and Middle East. The Indian shipping got a serious setback with the arrival of European companies. However, necessity to develop shipping was realised during the First World War. Consequently, the Scindia Steam Navigation Co. was set up in 1919. At the time of Independence, there were only 59 ships with less than 2 lakh tonnes of GRT (Gross Registered Tonnage). Shipping in India has made considerable progress in the post-independence period.

Currently shipping plays a significant role in the transport sector of the country's economy. Nearly 90 per cent of India's trade volume (77 per cent in terms of value) is moved by sea making shipping the backbone of trade and economic growth. Today, India has the largest merchant shipping fleet among the developing countries and ranks 17th amongst the countries with the largest cargo carrying fleet. As on 31st January, 2013, Indian tonnage stood at 10.45 million GRT (Gross Registered Tonnage) with 1,158 ships. It is estimated that the present fleet strength is not adequate to support the trade flow in shipping sector. Therefore, there is an urgent need for augmenting the tonnage capacity in the coastal sector to meet the increasing demand.

Coastal Shipping. Coastal shipping involves movement of goods and passengers from one port to another port within a country. It is quite distinct from overseas (shipping from one country to another) or offshore that implies shipping to locations of the shore such as oil rigs and platforms. Developing coastal shipping has many advantages. It decongests the railways and roadways, is relatively pollution free, is less capital intensive, provides large employment, involves continuous vigilance of the coasts and promotes sea based industries such as fisheries and luxury tourism.

The peninsular shape of south India offers great opportunities for coastal shipping. The 7516.6 km long coastline of India is studded with 13 major and 200 non-major ports providing congenial and favourable conditions for the proper development of coastal shipping. Indian ports have a vast hinterland of about 3,80,000 sq km which provides sufficient support for shipping. Most of the medium and minor ports of India are underutilised in terms of their potential. Proper utilisation of the potential of these ports can result in large scale saving. The eastern and western coasts of India can operate as two independent coastal area zones, sailing north-south to take advantage of long coastline and the multitrade of ports on each side. It is important to note that most of the large and industrialised states like Gujarat, Maharashtra, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Odisha and West Bengal have a long coastline and a large number of minor ports. As such these states have great potential for improving coastal shipping.

Land transport involves huge capital expenditure —both initially and subsequently on maintenance— on roads and tracks, mobile equipment with high fuel consumption. A recent study of fuel costs involved in moving general or bulk cargo from Mumbai to Goa showed that sea mode was nine times less expensive than the road route.

Action plan for the development of coastal shipping is already on the anvil with the Central Government with a view to promote coastal shipping and sailing vessel industry, the home trade vessels and sailing vessels have been exempted from the payment of lighthouse dues. Meanwhile, a study has already been completed by the Tata Consultancy Services (TCS) to assess the potential of coastal shipping and the role of minor ports keeping in view the feasibility of routes and supporting environment needed for its development. Its report has been accepted by the Government in principle.

PORTS

There are 13 major and 200 medium and small ports in India. The major ports are under the supervision of the Central Government while the minor ones are managed by the concerned State Governments. The 13 major ports handle about 90% of our foreign trade. The major ports on the west coast are Mumbai, Jawaharlal Nehru, Kandla, Marmagao, Mangalore and Kochi while on the east coast are Kolkata/Haldia, Paradwip, Vishakapatnam, Chennai, Ennor and Tuticorin. The number of cargo vessels handled at major ports is about 16,000 per annum. The aggregate cargo handled at major ports during 2012-13 was nearly 545790 thousand tonnes which increased to 555448 thousand tonnes in 2013-14 (**Table 26.17**).

TABLE 26.17. Traffic handled at Indian Ports ('000 tonnes)

	Traffic handled		Growth over previous year	
	2012-13	2013-14	2012-13	2013-14
Major ports	545790 (58.5)	555488 (56.7)	-2.6	1.8
Non-major ports	387867 (41.5)	425000 (43.3)	9.8	9.6
All ports	933657 (100)	980488 (100)	2.2	5.0

Note : Figures in parenthesis are in percentages.
Source : Economic Survey 2013-14, p. 203.

A brief description of major ports of India is given here :

1. Mumbai. It is a magnificent natural harbour on the West Coast of India. The deep 10-12 metre sea adjoining the harbour with no sand banks enables big ships to enter the port easily. It handles approximately one-fifth of India's foreign trade with predominance in dry cargo and mineral oil from the Gulf countries. It is the biggest port of India. It handles foreign trade with the Western countries and East African countries. The opening of the Suez Canal in 1869 brought it much closer to the European countries.

This port has a fully integrated multipurpose port handling container, dry bulk, liquid bulk and break bulk cargo. It has extensive wet and dry dock facilities to meet the normal needs of ships using the port. There are three enclosed wet docks having a total area of 46.30 hectares and quayage of 7,776 metres inside the wet basin and 853 metres along the harbour wall.

Mumbai has a vast hinterland covering the whole of Maharashtra and large parts of Madhya Pradesh, Gujarat, Rajasthan and Delhi. This hinterland is very rich in agricultural and industrial resources. The entire hinterland has undergone large scale economic improvement which has helped in the rapid growth of this port. A dense network of roads and railways connects the port with its hinterland.

Mumbai is the gateway to India from the west and handles large scale trade of great variety. The major items of export are cotton textiles, leather, tobacco, manganese, machinery, chemical goods etc. while the imports include crude oil, superior quality raw cotton, latest machines, instruments and drugs. This port is likely to progress further with the economic development of its hinterland.

2. Jawaharlal Nehru Port. Formerly known as *Nhava Sheva port*, this port was opened on 26th May, 1989. This new port has been built at an island named Nhava Sheva across the famous Elepthanta caves, about 10 km from Mumbai. Built at the cost of ₹ 880 crore, this port is named Jawaharlal Nehru port as a tribute to the first prime minister of India. The main purpose of this port is to release pressure on the Mumbai port. The port is equipped with the most modern facilities having mechanised container berths for handling dry bulk cargo and service berth etc. Most of the operations are conducted with the help of computers. The port is linked by road and rail to other railway routes and National Highways avoiding Mumbai city altogether. The initial capacity of the port was 5.9 million tonnes in 1995-96 which was raised to 9.9 million tonnes in 1997-98. The first private sector project Nhava Sheva International Container Terminal (NSICT) became operational in 2000. This terminal has already captured a substantial share of container handling not only in the region but also among all the major ports of the country. The sea is quite deep near the port and there is no need for dredging in this port.

Jawaharlal Nehru Port Trust (JNPT) Navi Mumbai, signed an agreement with P&O Australia, for development of a two berth container terminal on

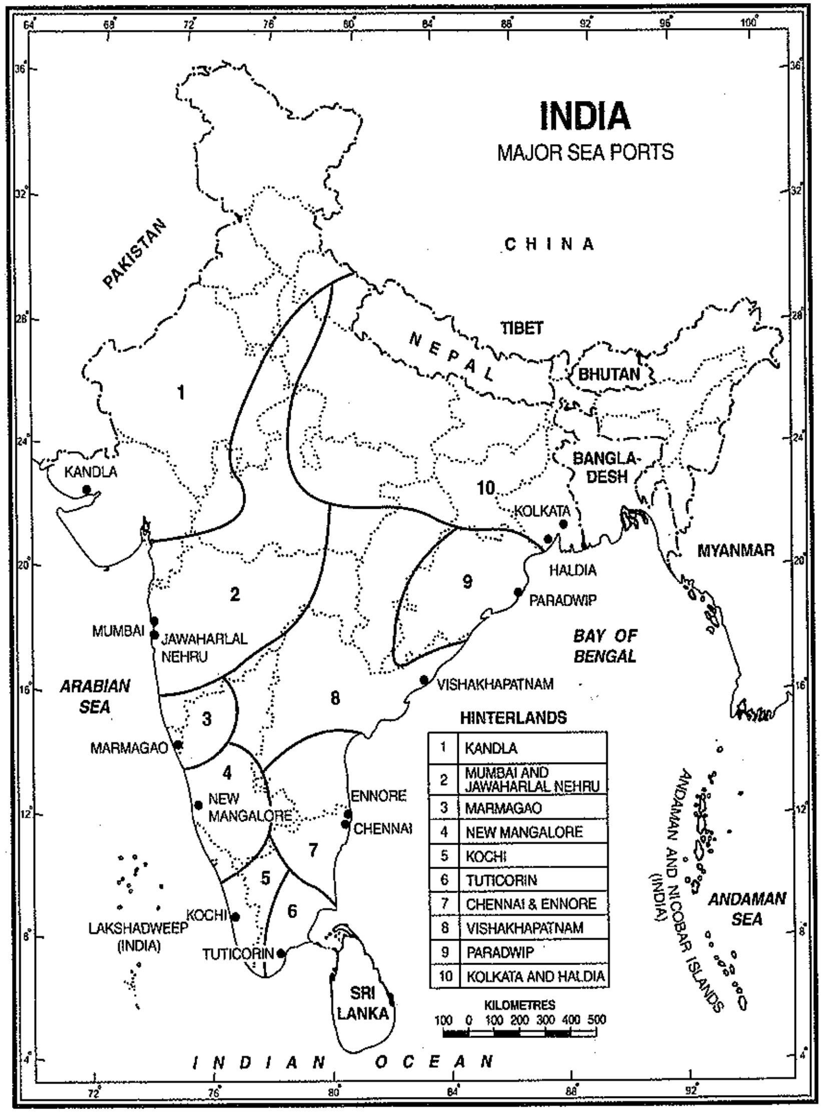

FIG. 26.9. India : Major Sea Ports

'Build, Operate and Transfer' (BOT) basis for a period of 30 years in July, 1997. The work was completed in April 1999 at the cost of ₹ 900 crore. Another agreement was signed on August 10, 2004 with Gateway Terminals India Pvt. Ltd. for development of the third container terminal which will result in addition of 1.3 million TEUs (twenty feet equivalent units) container handling capacity of the port. JNPT is also taking preparatory action for setting up of fourth container terminal.

As a result of the above mentioned initiatives taken to enhance its capacity, Jawaharlal Nehru port has come to rank 28th among the world class container ports. Currently the port handles 55-60 per cent of the country's containerised cargo. This port handled vessels having drought upto 12.5 metres in 2011-12.

It is a twin port of Mumbai so far its hinterland is concerned.

3. Kandla. This port is located at the eastern end of Gulf of Kachchh about 48 km away from Bhuj. It is a natural sheltered harbour in Kandla creek with average depth of 10 m. The port is equipped with all the modern facilities and state-of-the-art technology. The traffic handled at Kandla consists of crude oil, petroleum products, fertilizers, food grains, salt, cotton, cement, sugar, edible oils and scrap. Kandla has a capacity of handling a total traffic of 23.3 million tonnes. This port has been developed after independence to relieve congestion on Mumbai port. With the loss of Karachi to Pakistan as a result of partition of the country in 1947, the necessity of constructing a port on the Gujarat coast was keenly felt. Consequently this port was constructed in 1951.

This port has a vast hinterland covering large parts of Gujarat, Rajasthan, Haryana, Punjab, Delhi, Himachal Pradesh, Jammu and Kashmir and Uttarakhand. The port is well connected by roads and railways and has a bright future.

4. Marmagao. It is an important port of Goa located at the entrance of Zuvari estuary and occupies fifth position in handling the traffic. Its harbour is protected and holds about 50 steamers in fair season and 15 steamers in rainy season. It has the capacity to handle 16.1 million tonnes of cargo traffic. For a long period, it handled the export of iron-ore from Goa. Currently the major items of exports are iron ore, manganese, coconut and other nuts, cotton etc. Imports through this port are very few. It has a comparatively small hinterland covering the whole of

TABLE 26.18. Contribution of major ports

Name	Cargo Handled (2010) in 000 tonnes	Vassel Traffic (2009-110)	Container Traffic (2009-10) '000 TEUs ranges
Kandla	74,521	2,756	147
Vishakhapatnam	65,501	2,406	98
Chennai	61,057	2,131	1,216
Navi Mumbai	60,741	3,096	4,062
Mumbai	54,542	1,639	38
Paradeep	57,011	1,531	4
Marmagao	48,847	465	17
Kolkata	46,295	3,462	302
Mangalore	35,528	1,168	31
Tuticorin	23,787	1,414	440
Kochi	17,429	872	290
Ennore	10,713	273	—

Source : Indians Ports Association, 2012.

Goa and parts of north Karnataka coastal region and southern Maharashtra.

With the opening of the Konkan railway, the importance of this port has increased significantly and it is fast emerging as a multi-commodity port. Four new harbours are being constructed in the Vasco Bay for handling container traffic and general cargo.

5. New Mangalore. New Mangalore port was declared as the 4th Major port on 4th May, 1974 and was formerly inaugurated on 11th January 1975. This is an important port located at the southern tip of the Karnataka coast north of the Gurpur river. Initially it was designed for small ships. However, it was upgraded in the Fourth Five Year Plan to accommodate larger ships. A harbour was constructed so that business could be carried on throughout the year. Its hinterland lies in Karnataka and northern part of Kerala. Tea, coffee, rice, maize, wheat. cashew kernels, fish, rubber, oil products, iron ore pallets, granite etc. are exported through this port. The major items of import through this port are crude oil, coal, iron ore fines, LPG, limestone, wooden logs, cement, liquid chemicals, fertilizers, edible oils etc. Its main importance lies in export of iron ore from the Kudremukh mines. The port is well linked through broad gauge rail line and NH-17 with Mumbai and Kanniyakumari.

6. Kochi. It is another natural harbour on the west coast of India and is located on the coast of Kerala. Kochi has sheltered backwater bay. Located at Willlington island on the South-west coast of India about 930 km south of Mumbai and about 320 km north of Kanniyakumari. Kochi was given the status of Major Port in 1936. With its strategic location within the proximity of the international sea route between Europe in the west and the Far East and Australia in the east, it is capable of attracting a large number of container liners offering immense business opportunities. It handles the export of tea, coffee and spices and imports of mineral oil and chemical fertilizers. The Kochi Oil Refinery receives crude oil through this port. It is also a ship-building centre. Imports through this port far excel the exports. In fact, imports are about five times more than the exports.

The hinterland of this port includes the whole of Kerala and ports of Tamil Nadu and Karnataka. About 97 per cent of the total volume of traffic is accounted for by Kerala alone. The port is the natural gateway to the vast industrial and agricultural market of south-west India.

7. Kolkata. It is a riverine port located on the left bank of river Hugli about 128 kms inland from the Bay of Bengal. Kolkata port handles goods coming from South-East Asian countries, Australia and New Zealand. Kolkata port is called the 'Gateway to Eastern India.' It is the world's most important centre of jute industry. Kolkata is the main port for exporting jute products, tea, coal, steel, iron ore, copper, leather and leather products, textiles, manganese and many more items. The imports consist mainly of machinery, crude oil, paper, fertilizers and chemical products.

Kolkata port suffers from a number of problems. It is located on the bank of the River Hugli, which suffers from the problem of silting as tidal bores enter this port frequently. Sandy bars and islands have been formed at several places. The river is in its old stage and bends at several places creating lot of problems for the ships because they do not find a straight passage from the coast to the port. To sum up *Kolkata port has a serious problem of 'bends', 'bars' and 'bores'*. The depth of water is gradually declining. This has necessitated constant dredging so that larger vessels are able to enter the port. Expert pilots are required to conduct the ships and the cost of mainitaining the port has become prohibitive.

To rid the Kolkata port of some of the problems mentioned above, a barrage has been constructed across the Ganga at Farakka. This barrage is designed to divert water along the Bhagirathi-Hugli. However, with the signing of water treaty between India and Bangladesh, adequate water is not available in the Hugli river. Only a change in the treaty can improve the situation.

Steps have been taken for modernising and replacing port craft; strengthening of cargo handling equipment; better utilisation of dry docks and deap drafted areas and promotion of ship-breaking activities.

Kolkata port has a vast hinterland. Almost whole of the eastern and north-eastern parts of the country are included in the hinterland of this port. The main areas comprising the hinterland of Kolkata are West Bengal, Bihar, Jharkhand, Uttar Pradesh, Uttaranchal, Sikkim, Assam, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Meghalaya, Tripura and northern parts of Chhattisgarh and Madhya Pradesh. Two landlocked countries *viz*. Nepal and Bhutan are also parts hinterland of this port.

8. Haldia port has recently been developed on the confluence of rivers Hugli and Haldi about 105 km downstream from Kolkata. Its main purpose is to release congestion at Kolkata. It receives larger vessels which otherwise would have to go to Kolkata. Some of the large vessels which cannot enter the Kolkata port can easily come upto Haldia. Haldia has an oil refinery and a fertilizer factory. A large integrated petro-chemical plant has also been set up here. An important rail link connects Haldia with Kharagpur. The main items of trade are mineral oil and petroleum products. Haldia-Dock complex has plans to develop a berth on BOT basis. The hinterland of Haldia covers the same territories as that of Kolkata although to a much lesser extent.

The Bhagirathi river has changed its course recently as a result of which Haldia's future has become uncertain. With the large-scale deposition of silt near the port (Nayachar), the entry of large ships has become difficult.

9. Paradwip. It is a deep water (depth 12 metres) and all weather port located on the Odisha coast about 100 km east of Cuttuck. Because of its great depth, this port is capable of handling bulk carriers of over 60,000 DWT. Construction of an exclusive oil jetty to handle about 6 to 8 million tonnes of petroleum products and crude tankers of 85,000 DWT was completed recently. Constructed in the Second Five Year Plan period, this handles iron-ore and coal along with some other dry cargo. Large quantity of iron ore is exported to Japan through this port. The imports through port are only half of its exports. The hinterland of Paradwip port is comparatively small and covers Odisha only.

10. Vishakhapatnam. It is the deepest land-locked and protected port built at the coast of Andhra Pradesh. It was thrown open to commecial shiping on 7th October, 1933. Since then, this port has been consistently upgrading its infrastructure in tune with advancing technology. An outer harbour has been developed to handle the export of iron-ore. Elaborate arrangements have been made to handle crude oil and other petroleum products. It also handles fertilizers. Vishakhapatnam has a capacity of handling 16.7 million tonnes of cargo traffic. It also has the ship-building and ship-repair industry. The primary export items are iron ore (especially from Bailadila mines to Japan), manganese ore, spices and wood. The imports comprise mainly of mineral oil, coal, luxury items and other industrial products.

The hinterland of Vishakhapatnam port commands an approximate area of 3.4 lakh sq km which is constituted by Andhra Pradesh, Telangana and the contiguous parts of Chhattisgarh, Madhya Pradesh, Maharashtra and Karnataka. This part of the country is very rich in mineral resources and agricultural produce.

11. Chennai. Chennai is the oldest artificial harbour on the East Coast of India established in 1875. It does not possess a natural harbour and an artificial harbour has been created in an area of 80 hectares near the coast. It mainly handles petroleum products, fertilizers, iron-ore and general cargo. The major items of exports are rice, textiles, leather and leather goods, tobacco, coffee, manganese ore, fish and fish products, coconut, copra etc. The imports consist of coal, crude oil, paper, cotton, vehicles, fertilizers, machinery, chemical products etc. It has a capacity to handle a traffic of 21.37 million tonnes and can accommodate as many as 21 vessels inside the harbour. Chennai is often hit by cyclones in October and November and shipping becomes difficult during these months. It is ill-suited for large ships because of the lesser depth of water near the coast.

The hinterland of the Chennai port encompasses the large part of Tamil Nadu, southern part of Andhra Pradesh and some parts of Karnataka. The port is gaining importance due to increased significance of its hinterland.

12. Ennore. This port has recently been developed to reduce pressure of traffic on Chennai port. Located slightly in the north of Chennai on the Tamil Nadu coast, this is the country's first corporate port. It envisages construction of two coal berths, one iron ore berth, one LNG berth, two POL/liquid chemicals berths and one crude oil berth for handling very large crude carriers. It has also a perspective plan to build three multi-purpose berths, five POL/liquid-chemicals berths and five container berths. The major items of traffic on the port are coal, iron ore, petroleum and its products, chemicals, etc. Its hinterland is a part of the hinterland of Chennai port.

13. Tuticorin. This port has also been recently developed at the Tamil Nadu coast about 8 km south-west of the old Tuticorin port. It has an artificial deep sea harbour which can accommodate vessels upto 8 metre draft in any season of the year. Two new berths are being developed. There is a plan to increase the depth of the port from the present 10.7 metres to 12.8 metres so that larger vessels could be accommodated. A long-term plan to build an outer harbour in four stages is also envisaged. The idea is to handle containers upto 6.3 million TEUs by 2021. The port handles the traffic of coal, salt, food grains, edible oils, sugar and petroleum products. Its main purpose is to carry on trade with Sri Lanka as it is very near to that country. Its hinterland is formed mainly by southern Tamil Nadu comprising districts of Madurai, Kanniyakumari, Ramnathpuram, Turunelveli and southern part of Tiruchchirappally. It is well connected by railways and roads.

Minor Ports. There are 200 minor ports, with a pronounced accent on the west coast. These ports are located in Gujarat, Maharashtra , Goa, Daman and Diu, Karnataka, Kerala, Lakshdweep, Tamil Nadu, Punducherry, Andhra Pradesh, Odisha, West Bengal and Andaman & Nicobar.

RAM SETU OR SETHUSAMUDRAM

Also known as Adam's Bridge, it is an ancient bridge which is made up of a 30 km long chain of shoals and sandbars between the southernmost island of Rameshwaram in Tamil Nadu State of India and Talaimannar of Sri Lanka. Two contradictory view points are being put forward regarding the origin and structure of this bridge. According to Hindu mythology, this bridge was built by Lord Rama to attack the Lankan king Ravana. Archaeological Survey of India (ASI) in its affidavit submitted to the Hon'ble Supreme Court of India said that the bridge is a natural formation made up of shoals and sand bars formed due to several millennia of wave action and sedimentation. Geological Survey of India (GSI) found that Ram Setu was not a man-made structure but represented a geological divide between the Palk Bay and the Gulf of Mannar. Several satellite images taken by NASA confirmed that Ram Setu was a 'tombolo' which is a narrow piece of land between an island or offshore rock and a mainland shore, or between two islands or offshore rocks. These are naturally occurring formations. Indian Space Research Organisation (ISRO) has opined that this is not a man-made structure, rather it has been formed by corals, sandbars and marine rocks.

The Plan. There is shallow sea between Dhanushkodi, the extreme end of Rameshwaram Island of India and Talaimannar of Sri Lanka with depth varying from 1 metre to 10 metres. Such a shallow stretch of sea is not suitable for shipping although ferry service was in operation till 1970s. The Government of India planned a sea water way 167 km long 300 metre wide and 62 metre deep by dredging a part of the sea level in this stretch of the shallow sea so as to provide a direct shipping route between Kanniyakumari and Tuticorin on one hand and other parts on the eastern coast of the country on the other hand. With the opening of this route, the ships don't have to move around Sri Lanka and save a lot of time and fuel. The original plan convisaged the movement of 3,055 ships by 2008 and 7,140 ships by 2025.

Historical Background. This plan was originally proposed by a British Commander A.D. Taylor of the Indian Marine in 1860. He felt that a navigation route could be created by dredging a part of Ram Setu. This route could be much shorter than the route around Sri Lanka and was able to serve the eastern coast of India in a much better way. In the year 1863, **Sir William Denison** selected a site about a mile (1.61 km) east from the one recognised by the Parliamentary Committee Report. However, the southern approach of the canal was left exposed to south-west monsoon and the proposal was declared unsuitable. In 1961, Townsend proposed the canal across Pamban Channel to enable passage of large vessels. However, the requirement of a curved channel subject to strong currents through Pamban Pass made it out of practical consideration. The Steering Committee Report of 1998 observed that on account of the declaration of the Gulf of Mannar as a biosphere reserve, a careful study would have be conducted with regard to implications of the project upon the said biosphere

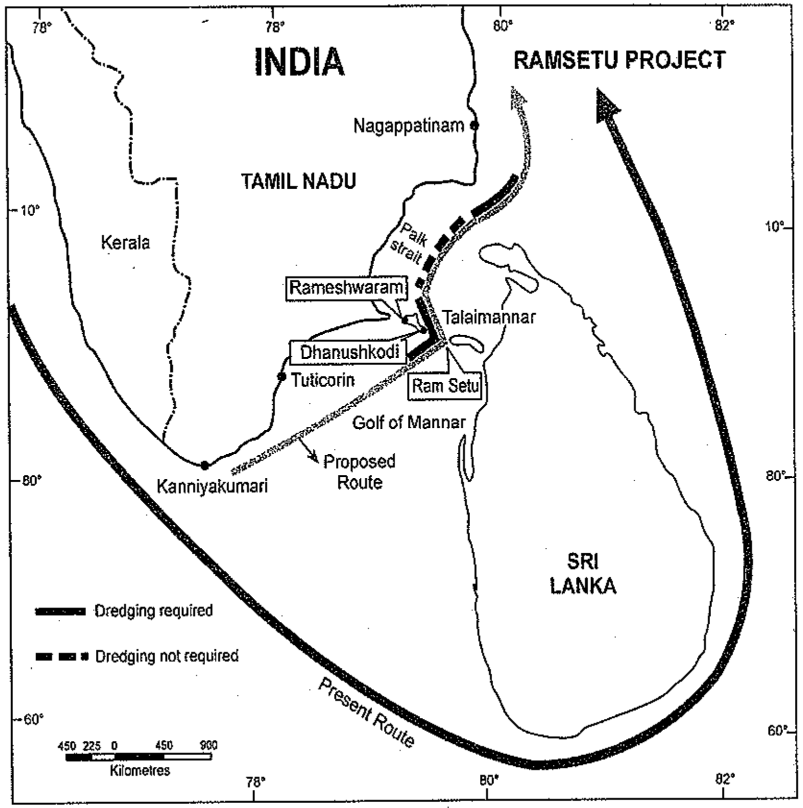

FIG. 26.10. The Ram Setu Project.

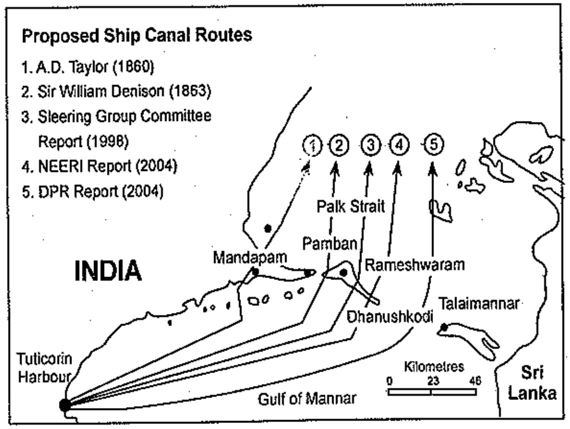

FIG. 26.11. Proposed Ship Canal Routes

reserve. It suggested another alignment of the canal, east of the island, can be thought afresh wherein land and could be avoided. The National Environmental Engineering Research Institute (NEERI), Nagpur, considered an Environmental Impact Assessment in 2004 and approved the alignment No. 6 as being environmentally viable route. In the same year DPR consultants validated NEERI's proposal with minor modifications in the entrance from the Gulf of Mannar after consideration of three different alternatives in the Ram Setu Bridge.

The Central Government under the leadership of the then Prime Minister Shri Atal Behari Vajpayee started this project in 1998 on the basis of the report of the Steering Committee and was formally inaugurated by Dr. Manmohan Singh in 2005. The dredging in the Adams Bridge region has been stopped in view of the Hon'ble Supreme Court Order dated 31st August, 2007 and 14th September, 2007. Pursuant to the orders of the Hon'ble Supreme Court, a Committee of Experts has been constituted under the Chairmanship of Dr. R.K. Pachauri, Director General, Energy and Resources Institute to consider the alternative alignment in respect of the Sethusamudram Ship Channel Project. Based on the recommendation of the Expert Committee, National Institute of Oceanography (NIO), Goa, has been assigned the task of undertaking Environment Impact Assessment (EIA) of the proposed alternative alignment. The NIO has submitted its report to the government for consideration. The future of this project will depend upon the reaction of the new BJP Government at the centre under the dynamic leadership of Shri Narendra Modi.

Controversies

This project has been surrounded by controversies since the day of its inception. There are strong arguments in favour of the project and still stronger arguments against it.

Arguments in favour of the project

1. If and when completed this project will help in saving a lot of time and fuel because the proposed route is much shorter than the existing route (**Table 26.19**).
2. Fifteen minor ports will be developed between Kanniyakumari and Chennai.
3. Increased ship traffic will lead to economic spin-offs, particularly in the backward districts of Ramnathapuram and Tuticorin.
4. Project touted as the catalyst for an economic boom in Tamil Nadu.

Arguments against the project

1. The project is expected to adversely affect 21 national marine parks and livelihood of lakhs of fisherman.
2. Dumping of sand in the Gulf of Mannar is said to be a long-term environmental hazard.
3. Strategically, experts feel that while Coast Guard and naval patrolling capability will go up, it may not necessarily translate into increased Indian dominance in the area.
4. High maintenance with round-the-year desilting expense, as the sea current through the Palk Stract and cyclones will constantly bring in huge loads of silt.
5. Some experts feel that Ram Setu offered an affective obstacle in the way of extremely devastating tsunami which occurred in the Indian Ocean on 26th December, 2004. This obstacle forced the tsunami take a course around the Sri Lankan Island and saved the Malabar coast of India from the fury of the tsunami. According to International Tsunami Society, the corals of this area acted as a protective shield for Kerala because most of energy of the tsunami was exhausted by the time it reached the Kerala coast.
6. Some prominent geologists opined that this area is the region of plate tectonics and is not suitable for navigation.
7. Ecologists believe that Ram Setu obstructs strong currents coming from the Bay of Bengal and protects the ecological balance.
8. Experts of navigation apprehend that Ram Setu Project can lead to any natural calamity. If a ship is entrapped in the area, there is no device to take it out and save it.

TABLE 26.19. Saving of distance through Sethusamundram Project (SSP) route in nautical miles

From	To	Mileage by present route	Mileage by SSP route	Distance saved
Kanniyakumari	Chennai	750	407	343
Kanniyakumari	Vishakapatnam	1,014	724	290
Kanniyakumari	Kolkata	1,357	1,103	254
Tuticorin	Chennai	769	345	424
Tuticorin	Vishakhapatnam	1,028	662	366
Tuticorin	Kolkata	1,371	1,041	330

COMPETITIVE AND COMPLEMENTARY CHARACTER OF MEANS OF TRANSPORTATION IN INDIA

In India, there are four major modes of transportation *viz.* road, rail, air and water transport. To this may be added pipeline transportation. Air transport is the fastest and the costliest whereas water transport is the slowest and the cheapest mode of transportation. They serve entirely different purposes and have practically no competition and complementarity. Pipeline transport is of recent origin and is restricted to specific corridors only. Moreover pipelines are useful for transporting liquids and gases only and have a unique character of their own. Thus the main issue of competitiveness and complementarity is with respect to road, railways and water transport system. The problem of competition arises in a situation when optimum utilization of one mode of transportation is discarded and some other mode of transportation is given priority. As against this a situation of complementarity arises when one mode of transportation helps the other mode in such a way that both are used to their maximum capacity. Roadways and railways are complementary at certain places and under certain conditions whereas they are competitive with each other at some other places and in some other conditions.

Complementary Role or Different Modes of Transport

Generally speaking, roadways are useful for short distances whereas railways are more suitable for long distances. Roadways play an important role in carrying agricultural produce from fields, minerals from mining areas and industrial products from factories to the railway yards. Usually, these items are carried by trucks from fields, mines, and factories to the railway yards over distances varying from 100 to 150 km. It is for the railways to carry these goods in the wagons over longer distances. After reaching the destination railway yard, the goods are again transferred from the rail wagons to the trucks which carry the goods to their ultimate destination. Thus road and railways play a complementary role for each other for short and long distances respectively.

Like freight, roads and railways play a complementary role for short and long distances with respect to passenger traffic also. Roadways are always given preference over railways for travelling over short distances. This is primarily due to flexibility possessed by the roadways. Vehicles can be stopped anywhere on the road-side. As against this, railways completely lack flexibility because railway trains stop at fixed stations only. India is par excellent, a country of villages and most villagers travel in buses to reach the nearest railway station and continue their journey to a distant railway station. After completing their rail journey they get down and board the buses to reach their ultimate destination.

It is because of the above mentioned complementary character of roadways and railways that the government has been laying more emphasis on construction of village roads. Pradhan Mantri Gram Sadak Yojna (PMGSY) was launched to provide single all-weater road connectivity to eligible unconnected habitations having a population of 500 persons and above in the plain areas and 250 persons and above in hill states, tribal areas, desert areas and Left-wing Extremist (LWE) affected districts. Under the programme, upto January 2012, about 4.41 lakh km roads to benefit 1, 14,433 habitations had been cleared.

Normally, road transport is prefer for journey extending upto 200-250 km and railways are preferred for journey more than this distance. Much of the long distances journey by rail is performed at night because railway coaches are equipped with sleeper and toilet facilities. But people living in areas surrounding the metropolitan cities prefer to travel by rail because railways offer monthly, quarterly and half-yearly passes at concesional rates to commuters. But these commuters use road transport to reach the railway station from their place of residence. Thus rail and road transport play a complimentary role with respect to commuters also.

Rail transport is almost completely absent in the Himalayan region (Jammu and Kashmir, Himachal Pradesh, Uttarakhand and north-eastern states). Under such a situation, the passengers travel long distances through the hilly areas to reach the rail head terminals at the foothills to continue their further journey by railway transport. Kalka, Hishiarpur, Dehra Dun and Shiliguri are such a railway terminals. People of the north-eastern states are almost completely deprived of the railway transport service. They have to travel long distances by road before they can reach any railway terminal from where they can reach their destinations situated at longer distances.

The Government of India has prepared an ambitious plan to improve inland waterways along major rivers of the country. The inland water transport system had been playing a vital role for transporting passengers and goods in early stage of development. But they lost much of their importance to road and rail transport because they could not compete with respect to speed. With growing pressure on road and rail transport and with crumbling infrastructure, inland water transport stand fair chances of reviving their old lost glory. The Government of India has already declared parts of five major river courses as national waterways. They are expected to play an important complementary role for both rail and road transport and relieve these modes of transport of much burden in the near future, particularly with respect to transportation of heavy and bulky commodities with low specific value. This is because water transport for heavy and bulky commodities is always much cheaper than roads and railways.

Roadway and railways play a major complimentary role to water ways with respect to international trade. The whole material for export is transported from the distant inner parts of the country to the ports by roads or railways to the ports from where it is exported to various countries by water transport. Similarly, imported goods imported through water transport are carried by roads and railways from the ports to different parts of the country. This is how ports develop their hinterlands. When the British rulers planned the development of rail routes in India, they paid due consideration to complimentary that existed between ocean routes and railway routes. This is the reason that all major railway lines were constructed to serve the major ports of India such as Mumbai, Kolkata and Chennai. The purpose was to carry raw materials from different parts of India to ports by roads and railways and then to Britain and finished industrial goods from Britain to ports and then to different parts of the country by roads and railways.

Competitive Role of Different Modes of Transport. The Government of India introduced scheme of grouping national permit to road transporters as a result of which trucks and buses started covering long distances across the inter-state borers. This initiated the period of competition between road and railways. Road transport is now more preferred upto a distance of 250 km and there is a tough competition between roads and railways within this limit of the distance covered. But railways are still preferred for distances exceeding 400-500 kilometres. Whereas railways offer more flexibility, over short distances, railways provide more comforts over long distances.

A casual look at the rail and road map of India reveals that in most parts of the country, railways and roadways run parallel to each other. This further adds to competition between these two modes of transportation as passengers and goods are divided between the two. Several surveys have indicated that railways are fast losing to roadways, particularly with respect to short distances upto about 250 km. For example most passengers from Delhi prefer to travel by road if they have to go to Chandigarh, Jaipur, Agra, Dehra Dun, Hardwar and *vice versa*. Similarly

traders prefer their goods to be carried by trucks between Delhi and these destinations because trucks can provide door to door service.

However, railways have an edge over roadways with respect to travel to some places of tourist interest. For example tourists prefer rail travel over road travel from Kalka to Shimla from Shiliguri to Darjeeling and from Pathankot to Kangra although buses and taxies take much less travel time between these stations. This is because of the fact that railway routes follow maundering path through the hilly areas and offer attractive spots of natural beauty which almost mesmerizes the tourists. A similar competition is found between railways and roadways for reaching Ooty in Tamil Nadu.

Even water transport offers tough competition to other modes of transportation in certain parts of India. **Figure 26.12** shows road transport is cheaper for short distances, railway transport is cheaper for long distances and water transport is cheaper for very long distances. Any mode of transportation aims at recovering the initial cost as well as moving or recurring cost from the passengers or goods transported by it. The road transport involves much less initial cost but the moving cost is very high. Therefore, road transport is the cheapest for short distance upto point A, beyond which rail transport is

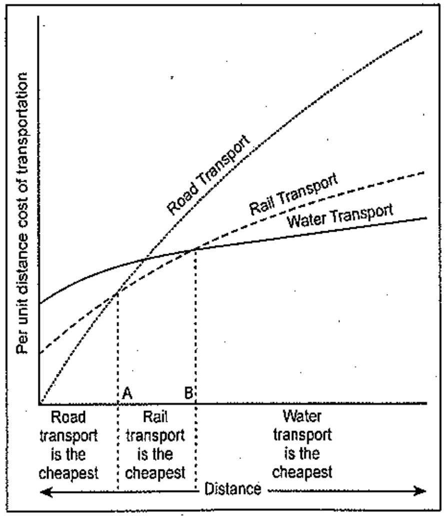

FIG. 26.12. Competition between road, rail and water transport

the cheapest upto point B. This is due to the fact that the initial cost in case is railways is much higher than that involved in railways, but moving cost for railways is much lower than for roadways. Initial cost in case of water transport is extremely high because huge amount of money is required for building ships, boats, steamers, ports and harbours. But moving cost is minimum in case of water transport because no expenditure is involved in maintaining water ways as against expenses for maintaining roads and railways tracks. Thus water transport is the cheapest for distances beyond point B.

Industries tend to be located in those areas where cost of transport is minimum. This is known as ***'Principle of Least Cost of Transport'***. This principle is not applicable to India because inland water transport is not properly developed here. However, some cases of competition between road and water transport can be found in some parts of the country. For example, there is tough competition between road and water transport in the Ganga-Brahmaputra delta region with respect to transportation of jute because most of the jute mills are located along the banks of the Hugli river. Similarly, lakes, lagoons and backwaters in the coastal region of Kerala have been joined with one another by canals which provide excellent facilities of inland water transport. These water ways offer stiff competition to road transport in this region.

COMMUNICATION

Communication is different from transport. Whereas transport involves the physical carriage of passengers and goods from one place to another, communication only involves transmission of word message and ideas. In early days the only way a message could be conveyed was by word of mouth. The use of words as a means of passing on messages relied on the proximity of the giver and receiver of the message, but in order to extend the range over which information could be transmitted, signal systems of various kinds were developed. The main signals through which messages were conveyed included drums, smoke signals or fly signals. The invention of writing helped in preserving the messages and communication became dependent upon transport. Written messages and letters could be carried by hand, by animals, by boat and later by rail or motor vehicles. In this way development of transportation had a deep impact on communications. But the technological advancements since the early nineteenth century helped in making communications independent of transport. Telecommunication (telegraph, telephone, radio, television, satellite, computer) are independent of transport network. But postal services still defend upon transport network.

Communication system contributes to the development of the economy, social relationships and also helps in promoting cultural unity. Internationally, it brings diverse people of the world close to one another.

In the event of any impending calamity, accident or emergency, instant means of communication flash the news across the globe so that relief can be rushed to the spot immediately.

Communication is of two types *viz.* 1. personal communication and 2. mass communication. Personal communication takes place between individuals and is made through postal network, telecom (telephone, telegraph, telex etc.) supported by computers. Mass communication, on the other hand, involves communication with the masses. Radio, television, cinema, press and print media and satellites are the main media of mass communication.

Personal Communication

Following are the chief modes of personal communication.

POSTAL SERVICES

It is the most commonly used mode of communication in India, the potal services play a vital role in the rural areas of the country.

The early postal system of India was solely used for official purposes and it was not until 1837 that the postal services were opened to the public. The first postage stamp was issued in Karachi in 1852, valid only in Sind province. In 1854, the Indian Post Office was reorganised as an institution, with a Director General-in-charge. 700 post offices were then already in existence. Since then, postal services have grown both in terms of the extent of the postal network and its scope and the variety of the services it offers. The statute governing the postal services in the country is the Indian Post Office Act, 1898. It vests the Government with the exclusive privilege of collecting, carrying and delivering letters within the country.

Indian Postal network is the largest postal network in the world. As on 31st March, 2011 country had 1,54,866 post offices, out of which, 1,39,040 were in rural areas and 15,826 were in urban areas. At the time of Independence there were 23,344 post offices throughout the country. Of these 19,184 post offices were in the rural areas and 4,160 offices in urban areas. The postal network has grown over six folds since then.

Expansion of postal network especially in the rural areas has been brought about by the system of extra departmental post offices. On an average, a post office serves an area of 21.23 sq km and a population of 7,817. Post offices in rural areas are opened subject to satisfaction of norms regarding population, income and distance laid down by the Department for the purpose. The element of subsidy involved in opening of post offices in hilly, desert and inaccessible areas is to the extent of 85 per cent of the cost, whereas the subsidy in opening of post office in normal rural areas, is to the extent $66\frac{2}{3}$ per cent of the cost.

The postal network consists of four categories of post office, *viz.*, head post offices, sub-post offices, extra-departmental sub-post offices and extra-departmental branch post offices. All categories of post offices offer similar postal services, delivery function being restricted to only earmarked offices. In terms of management control, accounts are consolidated progressively from branch post office to sub-post office and finally in head post office.

MAIL SYSTEM

First-class mail, *viz.*, post cards, inland letter cards and envelopes, are given air lift, without any surcharge, between stations connected by air. Second-class mail, *viz.*, book packets, registered newspapers and periodicals are carried by surface transport, *i.e.*, trains, buses and other means.

(*i*) (Postal Index Number) PIN has facilitated the prompt delivery of mail (*ii*) Speed post service has been introduced for fast and quick delivery of post (*iii*) Quick Mail Service (QMS) is another step in this direction.

MODERNISATION OF MAIL TRANSMISSION AND PROCESSING

Satellite Network

One hundred and fifty High Speed Very Small Aperture Terminals (VSAT) are being added to the existing 77 systems. With this the private network would consist of 227 VSAT stations and 1,350 Extended Stations. With the addition of 400 offices with capability to link to VSAT stations 1,977 post offices would be linked through this VSAT network to handle money orders and other related financial transactions.

Automatic Mail Processing Centres

Kolkata and Delhi have been put on the map of Automatic Mail Processing Centres with the induction of state-of-the-art letter-sorting machines. These two and the existing centres at Chennai and Mumbai would have additional equipment to cull, face and cancel the mail automatically.

Computerisation and Networking of Post Office

By the end of March 2007, the Department of Posts supplied computer and its peripherals like scanner, weighing scale, modems, etc. to all Head Post Offices and a large number of sub post offices.

Telecommunication

It is the modern device for the communication at individual and mass level. Telegraph, Telephone, Talex and Fax are the main means of telecommunication. The rise of telecommunication is directly linked with the advancement of electrical technology. Telecommunications brought about a revolution in communication system because of the high speed with which messages could be communicated. It became possible to send messages within a couple of minutes with the help of telegraphs which earlier took weaks together to reach their destinations. Further improvements made it possible to receive messages instaneously. People on opposite sides of the globe can speak to each other directly with the help of telephone, radio, television, Fax, internet etc. have facilitated the communication of messages within the time. Telecommunication services were introduced in India soon after invention of telegraphy and telephone.

1. Telegraph. The first development in telecommunications was the invention of the telegraph by Samuel Morse in 1844. Messages could be transmitted by wires as a series of electrical impulses. These signals formed the *Morse Code*, which could be readily interpretted. Telegraph wires soon linked most places and undersea cables were laid across seas and oceans and most places of the world were provided with telegraph links within a few decades.

First Telegraph line between Kolkata and Diamond Harbour was opened for traffic in 1851 just after seven years of invention. By March 1884, telegraph messages could be sent from Agra to Kolkata. By 1900, telegraph had started serving Indian Railways. Telegraph has now become outdated with the development of telephones, internet, e-mail etc. In fact it is completely closed down in India now.

2. Telephone. Telephone was invented by Alexander Graham Bell in 1875. The invention of telephone made possible direct and instantaneous links from one part of the world to another. A close network of telephone wires and undersea cables was laid to provide facility of telephonic links in different parts of the world.

As in the case of telegraph, telephone service was also introduced in Kolkata in 1881-82, barely six years after invention of telephone. First automatic exchange was commissioned at Shimla in 1913-14 with a capacity of 700 lines.

The Department of Telecommunication (DoT) has improved significantly since independence both in quality and quantity. Initially, the exchanges were of manual type, which subsequently were upgraded into automatic electro-mechanical type. In the last two decades, a significant qualitative improvement has been brought about by inducting Digital Electronic Exchanges in the network on a large scale. Today 100 per cent telphone exchanges in the country are of electronic type.

In the field of international communications, tremendous progress was made by the use of Satellite Communication and Submarine links. The voice and non-voice telecom services, which include data transmission, facsimile, mobile radio paging and leased line services, cater to a variety of needs of both residential and business customers. ISDN facility is available in a number of cities. A dedicated Packet Switched Public Data Newtwork with international access for computer communication services is also made available.

The telecom sector has been one of the fastest growing sectors in recent years. It is now the second largest telephone network in the world, after only China. A series of reform measures by the government, wireless technology, and active participation by the private sector played an important role in the exponential growth of the telecom sector in the country. Tele-density, which shows the number of telephones per 100 persons, was 75.23 per cent in 2014. With the growth of mobile telephony due to easy access and affordability, the number of landline telephones has declined from 36.96 million in 2010 to 32.17 in million as on 31st October 2012. Wireless telephones now account for 96.7 per cent of all telephones. The share of the private sector, in terms of number of subscribers, has increased from 86.3 per cent to 86.6 per cent during the period from April to June 2012 and is currently placed at 86.1 per cent (end- October 2012).

Since the announcement of the Broadband Policy in 2004, several measures have been taken to promote broadband penetration in the country. As a result, there were 22.86 million internet subscribers including 13.79 million broadband subscribers at the end of March 2012. Broadband subscribers increased to 14.81 million by the end of October 2012. Special efforts are being made to increase the penetration of broadband, especially in rural and remote areas. The government has approved a project at a cost of ₹ 20,000 crore for creating a National Optical Fiber Network (NOFN) which will provide broadband connectivity to 2 5 lakh gram panchayats for various applications like e-health, e-education, and e-governance. The project is being funded under the Universal Service Obligation Fund (USOF).

Mass Communication

In a country of vest dimensions like India, mass communication plays a vital role in creating awareness among the masses, providing information and education as well as healthy entertainment. Electronic media (radio and television) and print media (newspapers and periodicals) are the main components of mass communication.

TABLE 26.20. Telephone Connections & Tele-density

	At the end of March (in million)				
	2010	**2011**	**2012**	**2013**	**2014**
Total telephones	621.28	846.33	951.35	898.02	933.02
Landline telephones	36.96	34.73	32.17	—	—
Wireless telephones	584.32	811.60	919.17	—	—
Rural telephones	200.77	282.29	330.83	—	—
Urban telephones	420.51	564.04	620.52	—	—
Telephones of Private Sector (% share)	515.41	720.32	821.08	—	—
	(82.96%)	**(85.11%)**	**(86.31%)**	—	—
Telephones of Public Sector (% share)	105.87	126.01	130.27	—	—
	(17.04%)	(14.89%)	(13.69%)	—	—
Rural tele-density in %	24.31	33.83	39.26	41.05	44.01
Urban tele-density in %	119.45	156.93	169.17	146.64	145.46
Overall tele-density in %	52.74	70.89	78.66	73.32	175.23

Source : Department of Telecom (DOT). Quoted in Economic Survey 2012-13, p. 246 and Economic Survey 2013-14, p. 204.

NATIONAL TELECOME POLICY (2012)

The Government approved National Telecom Policy (NTP) 2012, which addresses the vision, strategic direction, and the various medium- and long-term issues related to the telecom sector, on 31 May 2012. NTP-2012 is aimed at maximizing public good by making affordable, reliable, and secure telecommunication and broadband services available across the country. The objectives of NTP-2012 include the following :

- Provide secure, affordable, and high-quality telecommunication services to all citizens.
- Strive to create One Nation-One Licence across services and service areas.
- Achieve One Nation-Full Mobile Number Portability and work towards One Nation-Free Roaming.
- Increase rural tele-density from the current level of around 39 to 70 by the year 2017 and 100 by the year 2020.
- Recognize telecom, including broadband connectivity, as a basic necessity like education and health and work towards 'Right to Broadband'.
- Provide affordable and reliable broadband-on-demand by the year 2015 and to achieve 175 million broadband connections by the year 2017 and 600 million by the year 2020 at minimum 2 Mbps download speed and make available higher speeds of at least 100 Mbps on demand.
- Provide high-speed and high-quality broadband access to all village panchayats through a combination of technologies by the year 2014 and progressively to all villages and habitations by 2020.
- Recognize telecom as an infrastructure sector to realize the true potential of information communication technology (ICT) for development
- Address right-of-way (RoW) issues in setting up of telecom infrastructure.
- Mandate an ecosystem for ensuring setting up of a common platform for interconnection of various networks for providing non-exclusive and non-discriminatory access.
- Strive for enhanced and continued adoption of green policy in telecom and incentivize use of renewable resources for sustainability.
- Achieve substantial transition to the new Internet Protocol (IPv 6) in the country in a phased and time-bound manner by 2020 and encourage an ecosystem for provision of a significantly large bouquet of services on the IP platform.

Prasar Bharati

Prasar Bharati is the public service broadcaster in the country, with All India Radio and Doordarshan as its two constituents. It was constituted on 23 November, 1997. The major objectives of the Prashar Bharati are :

(*i*) Upholding the unity and integrity of the country and the values enshrined in the constitution.

(*ii*) Promoting national integration.

(*iii*) Safeguarding citizen's rights to be informed on all matters of public interest and presenting a fair and balanced flow of information.

(*iv*) Paying special attention to the fields of education and spread of literacy, agriculture, rural development, health and family welfare and science and technology.

(*v*) Creating awareness about women's issues and other vulnerable sections of the society.

(*vi*) Providing adequate coverage to the diverse cultures, sports and games and youth affairs.

(*vii*) Promoting social justice, safeguarding rights of working classes, minorities and tribal communities.

(*viii*) Expanding broadcasting facilities and promoting research and development in broadcast technology.

Radio

Radio is a powerful medium which provides all sorts of useful information, news and variety of entertainment. Radio broadcasting began in India in early 1920's. The first programme was broadcast in 1923 by Radio Club of Bombay. This was followed by setting up of a Broadcasting Service in 1927 on experimental basis in Bombay (Mumbai) and Calcutta (Kolkata). The Government took over the transmitters and began operating them under the name Indian Broadcasting Service. It was changed to All India Radio (AIR) in 1936.

At the time of independence *i.e.* in 1947. AIR had a small network of six stations and 18 transmitters. The coverage was 2.5 per cent of the area and 11 per cent of the population. Today AIR has a network of 225 broadcasting centres covering 91.42 per cent of the area almost reaching the entire population. Operating in a linguestically diverse country like India, AIR broadcasts in 24 languages and 146 dialects.

AIR operates its services through five channels namely : (*i*) Primary Channel, (*ii*) National Channel, (*iii*) Commercial Broadcasting Service (Vividh Bharti), (*iv*) FM Channels and (*v*) External Services Channels.

There has been a phenomenal progress in the news broadcasting by AIR. From 27 news bulletins in 1939-40. AIR now puts out 346 bulletins daily. News Headlines for every hour are broadcast on AIR FM, Delhi, AIR News on Phone was introduced in 1998.

Doordarshan

Doordarshan (DD), the national television service of India is one of the largest terrestrial networks in the world. Television broadcasting assumes tremendous importance in a developing country like India, which has low literacy rate and has varied cultures and multiple languages. Today, television is the most efficient and effective way to disseminate information and educate the masses. The country today has both terrestrial and satellite broadcasting services.

The first telecast in India orginated from a makeshift studio in the Akaswani Bhawan, New Delhi on 15 September, 1959. The regular service with a news bulletin became operational in 1965. After seven years, the second television commenced service in Mumbai, By 1975, TV service was available in Kolkata, Chennai, Srinagar, Amritsar and Lucknow.

The first experiment with satellite technology in India was conducted in 1975-76 under the programme Satellite Instructional Television Experiment (SITE). This was incidently, the first attempt in the world to use satellite broadcasting for social education. Colour transmission was introduced during the Asian Games held in New Delhi in 1982. The year 1982 also witnessed the introduction of a regular satellite link between Delhi and other transmitters, heralding the arrival of the National Network. Metro Channel was introduced in 1984.

Doordarshan presently operates 30 channels. It has three-tier programme service—National, Regional and Local. The National programmes are concerned with events and issues of the entire nation. The regional programmes cater to the interests of a particular state or region. The local programmes are area specific and cover local issues featuring local people. A new entertainment channel of Doordarshan, DD Bharati was launched on 26 January, 2002.

The programmes telecast by Doordarshan include news, current affairs, science, cultural magazines, documentaries, music dance, drama, serials and feature films. Government policies, development programmes and current affairs are regularly telecast. It also transmits educational programmes for schools and universities. There are different channels for different types of programmes.

Several channels on television have been made available to provide entrepreneurs. This has promoted a keen and healthy competition to improve the quality of programmes. At present programmes of all types can be viewed at all the twenty-four hours of the day.

Cinema

Cinema is yet another power means of mass communication. It entertains millions of people everyday throughout the country. Feature films are being produced in India since 1912-13. The initial productions consisted of silent films. The era of silent films was overtaken by the talkie era in 1931 when Ardeshir Irani (1886-1969) produced *Alam Ara*. India now leads the world in the annual output of feature films. Before the advent of the TV era, cinema was the main source of entertainment for the masses but lost much of its viewership to TV. However, it has once again captured its viewers and regained the lost glory. In India, films can be publically exhibited only after they have been certified by the Central Board of Film Certification (CBFC).

Press and Print Media

Newspapers, periodicals and journals fall in the category of print media. According to the report of the Press Registrar, the total number of newspapers and periodicals being published in India was 65,032 in 2007. There were 7,131 dailies, 374 tri/triweeklies, 22,116 weeklies, 8,547 fortnighlies, 19,456 monthlies, 4,470 Quarterlies, 605 Annuals and 2,333 other periodicilies. Newspapers were published in as many as 123 languages and dialects during 2007. The largest number of newspapers (20,589) were published in Hindi followed by English (7,596) and Marathi (2,943). Daily newspapers were brought out in all the principal languages except Kashmiri.

Newspapers were published from all states and union territories. During 2007, the largest number of newspapers were published from Uttar Pradesh (8,397) followed by Delhi (6,926), Maharashtra (6,018) and Madhya Pradesh (3,555). Uttar pradesh continued to have the largest number of daily newspapers (841), followed by Maharashtra (573), and Karnataka (479). Bombay Samachar, a Gujarati daily published from Mumbai since 1822 is the oldest existing newspaper.

Computers

"Computer is an electronic device which is used for electronic data processing. It accepts the data, processes the data and converts the data into meaningful information. It is also used to perform mathematical and logical operations." This simple definition of computer amply proves that computers have a wide range of uses and play a dominant role in the sphere of communication system. Basically, a computer performs the following four functions :

(*i*) It accepts data as input.

(*ii*) It stores data, keeps it in its memory, and recalls the same as and when required.

(*iii*) It processes data as per instructions given to get required information.

(*iv*) It communicates the information as output.

The versatile use of computers in so many different fields is the outcome of its special capabilities in terms of speed, accuracy, consistency, storage capacity and automation. It plays an important role in the fields of education and transfer of knowledge by dint of its aforesaid qualities.

INDIAN SPACE PROGRAMME

India's space ventures date back to the ancient times when fireworks based on Chinese technology were first used in the country. Use of rockets by the Indians during the Mysore war against the British rulers inspired William Congreve to come out with Congreve rocket in 1804. Indian scientists and politicians recognised the significance of rocket technology and steps were taken immediately after Independence to develop this branch of science for defence, and for research and development in other fields. A young Indian British Veteran Sarabai (1919-1971) founded a research laboratory for the study of cosmic rays. Another distinguished scientist, Homi Bhabha (1909-1966), also studied cosmic rays in 1940s. He realised the potential of satellite and Indian National Committee for Space Research was formed in 1962. The purpose of this committee was to identify the country's goals and priorities in the field of space research. Thumba near Thiruvananthapuram was chosen as an international facility for launching sound rockets and it became operational in 1963 for launching foreign rockets to study atmosphere. The main reason for selecting Thumba was its proximity to the magnetic equator of the earth.

The Indian Space Research Organisation (ISRO) prepared a programme to make sounding rockets and their propellants at Thumba. A Space Science and Technology Centre was also set-up at Thumba. Thumba Complex was renamed as Vikram Sarabai Space Centre in honour of Sarabhai who made an outstanding contribution to the development of space science and technology in India.

The island of Sriharikota in Andhra Pradesh about 80 km north of Chennai, was chosen as a launch centre and it became operational in 1971 when Rohini-125, a sounding rocket was launched from here. Sriharikota has been renamed as Satish Dhawan Space Centre in honour of the late Prof. Dhawan who played a key role in realising the dream of Sarabhai. This centre has several tracking radars, including a Doppler Weather Radar (DWR) for detecting wind velocity in real time and for understanding severe weather conditions. Meanwhile, a space centre as set-up at Ahmedabad in 1967 to provide the necessary thrust for application of space technology in different fields of development. A satellite project as also established at Bengaluru in 1972 which was developed as ISRO Satellite Centre later on. This centre has the provision for design, development and launching of all spacecraft. Centres have also been established at Balasore in Odisha, Lucknow in U.P., Car Nicobar in Andaman and Nicobar Islands, Kavalur in Tamil Nadu.

Rohini-75. Rohini-75 (the number indicating the diameter of the rocket in millimetres) was the first successful rocket launched from Thumba in 1967. This was followed by Rohini-100; 125, 300 and 560. The main purpose of these rockets was to study the atmosphere and conduct tests for sub-systems for bigger launch vehicles. The success in sounding rockets led to the design and development of a Satellite Launch Vehicle (SLV). Till now over 1,000 sounding rockets have been launched. To begin with, only a single stage rocket weighing 100 kg. was launched and later on a stage of four stage rockets weighing 17,000 was reached.

Satellite Launch Vehicle (SLV) and Augmented Satellite Launch Vehicle (ASLV). The first SLV-3 was launched from Sriharikota in August 1979 which infinitely proved a failure. The second attempt was made by launching is 35 kg Rohini satellite in July, 1980 which was orbited by SLV3. This attempt was a successful after which many successful attempts were made from 1981 to 1983.

ISRO started working on an ASLV which was designed to put a 150 kg satellite into near earth orbit. The attempts made in this regard in 1987 and 1988. could not meet much success. ASLV-D2 was launched in July 1988. In spite of many improvements, this attempt failed. Further improvements were made in ASLV-D3 and its launch in May, 1992 was successful. The object of this mission was to operationalise the ASLV's capability of placing a 150 kg satellite—as a part of ISRO's Stretched Rohini. Satellite Series (SROSS)—into a 400 km near circular orbit. This could achieve only partial success.

Geosynchronous Satellite Launch Vehicle (GSLV) is a three-stage vehicle for the launch of which attempt was made in March 2001. It developed some technical problems which were removed at a later stage. The successful launch took place on 19 April, 2001. The second development flight of GSLV with GSAT-2 onboard weighing 1,825 kg was launched successfully in 2003. The rocket placed the geosynchronous satellite, EDUSAT, in correct orbit in September, 2004. The launch of GSLV-FO2 in July, 2006 was a complete failure as it crashed in the Bay of Bengal about 60 seconds after the take off.

APPLE (Ariane Passenger Payload Experiment) was launched from Kourou in French Guyana on 19 June, 1981. Its life was designed for two years but it worked for 27 months. It helped in conducting a number of experiments including those concerned with communication, TV, computer, etc.

INSAT (Indian National Satellite System) series. In 1980, the Government of India decided to purchase typical type of satellites which could help simultaneously in the fields of communication, TV and meteorology. The first in this series was INSAT-1 which had a capacity to provide 4,300 two-way telephone circuits through 12 transponders for national coverage. Transponders are devices which receive radio signals from the ground and transmit them. INSAT-1A launched on 10 April, 1982 from Cape Canaveral could not meet the desired goal due to a number of technical problems. INSAT-1B was an improved version and was launched from a US space shuttle in September 1983. It functioned well for over seven years, a duration which was longer than its designed life. INSAT-1C was launched in July, 1988 by an Ariane rocket. It met with only half success because it helped in operating only half the communication and television channels but the meteorological package worked fully. On 22 November, 1989, the spacecraft lost its contact with the earth. INSAT-1D was launched in June, 1990. All services of INSAT-1B were transferred to INSAT-1D.

Although India depended heavily on the imports for the first generation of INSATs, the second generation of this series was indigenously developed and fabricated, INSAT-2A was launched on 2 July, 1992. This was followed by launch of INSAT-2B on 22 July, 1993. These two missions were successful to a great extent and provided increased capacity for telecommunications and broadcasting, better resolution for weather forecasting, etc.

INSAT-2C and INSAT-2D were designed without monitoring payload because there was sufficient facility for this purpose in the satellites which were working in 1995. These two satellites could not live their full life due to short circuit. INSAT-2E was an improved version of the earlier satellites. It was launched from Kourou in April, 1999. Its transponders were able to cover vast parts of South-east Asia, China, Europe and Australia. It was supposed to work for 12 years. The commissioning of INTELSAT-2E has strengthened the telecom services, TV broadcasting and it also carries an advanced meteorological payload.

The third generation of INSAT series started with the launch of INSAT-3B in March, 2000 from Kourou. It was a communication satellite launched ahead on INSAT-3A following the failure of INSAT-2D. This was followed by INSAT-2C in 2002 and INSAT-3A and 2003.

INSAT-4 series was started in December 2005 from Kourou. It has been used for direct to home television within the country and for communication within India as well as in countries located in south-east and north-west of India.

EDUSAT. Satellite links have become a strong tool in the field of education keeping in view the acute shortage of competent teachers at the school, college and university level as well as in the professional institutions. EDUSAT was launched by ISRO in 2004 to provide easy access to quality education. In addition to providing support to formal education, it is used for propagating information regarding health, hygiene etc. among the rural masses and in remote areas. *Telemedicine through INSAT* has also become a reality and lakhs of people are benefited by this project.

Remote Sensing Satellites

Keeping in view the growing importance of Remote Sensing in everyday life, ISRO prepared a programme to launch remote sensing satellites in 1979 and consequently Bhaskara-I and Bhaskara-II were launched. Bhaskara-I was used to study agricultural land, dry deciduous forests within the tropics, dry temperate forests of the Himalayas and ice cover in the Himalayan region. Bhaskara-II was used to study, land, ice cover, drought prone areas, geological structure and forest resources. Maps concerning land cover and land use were prepared for West Bengal and Bihar. Images of sedimentary cover over the Ganga plain were obtained. Maps of forest cover for Karnataka, West Bengal, Odisha and Kachchh were prepared. Besides, ice cover over parts of the Himalayas were also studied. Satellite Launch Vehicle (SLV)-3 was launched in April 1983 which helped in studying water and forest resources cloud and ice cover.

September 9, 2012 was the historic day with ISRO when it launched 100th mission Polar Satellite Launch Vehicle (PSLV-C21) from Sriharikota.

In the year 1972, National Remote Sensing Agency (NRSA) was set-up at Balanagar near Hyderabad. First remote sensing satellite known as Indian Remote Sensing Satellite (IRS-IA) was launched on 17th March, 1988. It was equipped with Linear Imaging Self Scanning Sensors (LISS) which help in giving better results.

The second generation **IRS-1C** remote sensing satellite was launched in 1995 which completed its ten year tenure in 2005. During those ten years it took over 6 lakh images while revolving around the earth for 60,000 times. **IRS-P3** was launched in 1995 for studying ice, clouds, moisture in crops and damages caused by floods. **IRS-1D** was launched in 1997 which took images of U.S.A., Germany, Japan, Dubai, Korea and Thailand in addition to those of India.

Oceansat was India's first satellite which aimed at studying fish resources, change in sea level, speed of sedimentation, sea pollution, sea water temperature, air moisture over the sea surface and coral reefs. It was launched in 1999.

Technology Experiment Satellite (TES) was launched in 2001. It aimed at possibilities of introducing new technology in cartography.

Resource Set-I was an improved version of IRS-1C and IRS-1D and was meant to estimate the natural resources in the country. It was launched in 2003.

Cartosat-1 and Cartosat-2 were launched in 2005 and 2007 respectively. They are designed to up date topographical maps and prepare maps on large scale of 1 : 50,000. Maps prepared in this way are in great demand all over the world due to their accuracy and high quality. Normally, these satellites prepare maps for about 30 km in one day and complete map of the whole country within 100 days. At this speed, they can prepare a map for the whole world within one year.

Polar Satellite Launch Vehicle (PSLV) uses both gas and liquid fuel. **PSLV-D1 mission** was launched on 20 December 1993 from Sriharikota. It could not succeed much due to fault in its software. PSLV-D2 mission was launched on 15 October, 1994 again from Sriharikota. Third launch of PSLV was conducted in 1996. In the year 1997, PSLV-C1 launched IRS-1D. In the year 1999, PSLV-C2 or Oceansat was launched.

Chandrayan-1 Mission

Chandrayan which in Sanskrit means 'Moon Vehicle was the most ambitious and most talked about space project which thundered off into the space on 22 October, 2008 from Satish Dhawan Space Centre located in Sriharikota by means of the four stage space workhorse PSLV (Polar Satellite Launch Vehicle) featuring alternate liquid and solid fuel stages. It started revolving around the earth on an elliptical path being 240 km away in **parigee** and 24,000 km away in **apogee**. It started moving towards the moon after making a number of revolutions

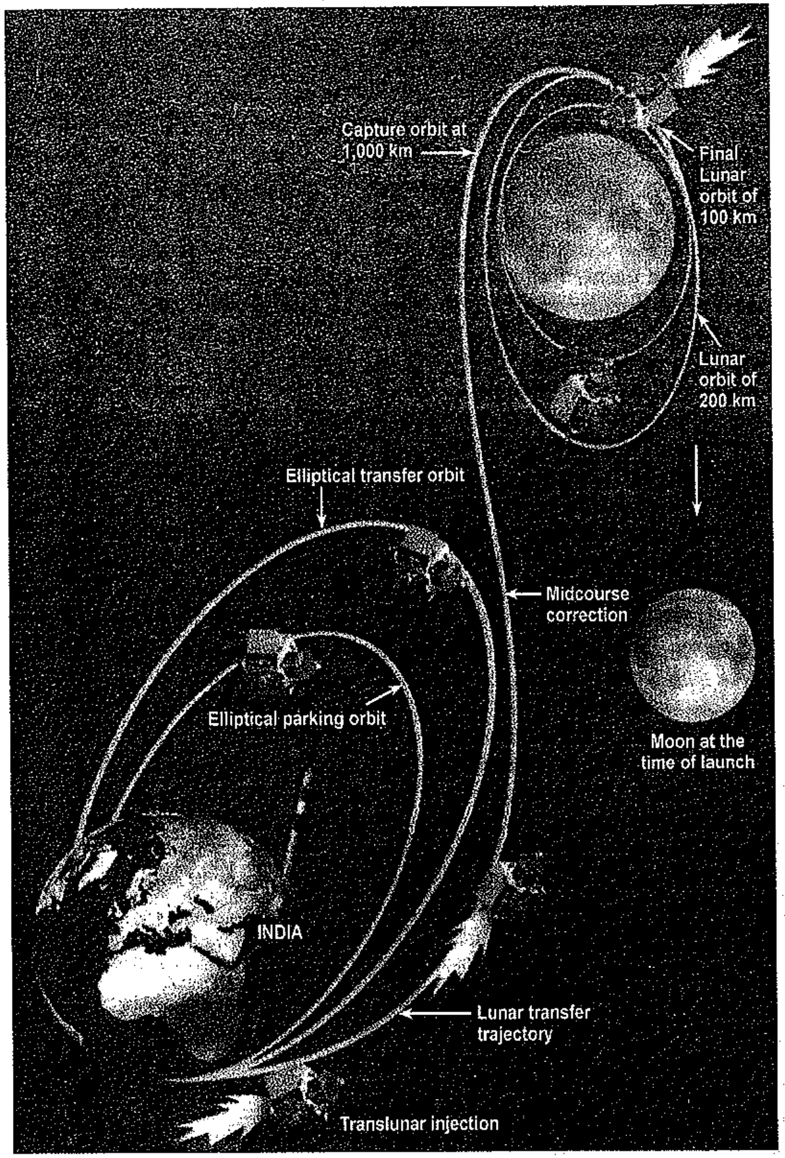

FIG. 26.13. Chandrayan

around the earth. The Chandrayan had a flawless take off and it was to ignited in four stages. Soon after its separation from the fourth stage. Chandrayan was initially placed in an orbital with its farthest point from the earth being 22,860 km. On October 28, 2008 it was raised to 4,77,515 km and on October 26, 2008, it became the first Indian spacecraft to enter deep space crossing the 1,50,000 km mark. On October 29, 2008, it went up to 2,67,000 km and its terrain mapping camera was switched on. On 4 November, 2008, the lunar orbitor flow into lunar transfer trajectory which meant that the Chandrayan had successfully entered the main highway to the Moon.

November 8, 2008 was the day of nerve-wracking and mail-biting because lunar orbit insertion (LOI) was being eagerly awaited. This is the most critical exercise because nearly 30 per cent of the unmanned lunar satellites by the U.S.A. and the erstwhile U.S.S.R. had failed at this point. This is due to the fact that the gravity of the earth and the moon cancel each other at this point. Fortunately, this hurdle was crossed and the speed of the spacecraft was reduced to 366 metres per second so that the craft could enter the moon's gravitational field. Its farthest point from the moon at this stage was 75.02 km which was gradually reduced and on 12 November, 2008, it reached the operational orbit of 100 km by 100 km. Still one major milestone to be crossed was crash landing of 29 kg indigenous Moon Improved Probe (MIP) about 32 km away from the Shackleton Crater in the Moon's South Pole. On 15 November, 2008, MIP slammed into the Moon's surface and India became the fifth country to show its presence on the Moon after the U.S., U.S.S.R., European Space Agency (17 countries) and Japan. The most outstanding feature of the Chandrayan was that its cost was only ₹ 386 crore which has been termed on the lowest expenditure according to international standards.

Immediately after landing on the moon's surface the Chandrayan started sending signals to ISRO Telemetry Tracking and Command Network (ISTRAC) at Bengaluru. The whole life of the Chandran was fixed for two years. But unfortunately on August 30, 2009, ISRO failed to restore the snapped communication link and the contact with the spacecraft was permanently lost. Consequently the mission was terminated. Still the ISRO believed that it was a great success as the Chandrayan completed about 95 per cent of the mission. Its major achievement among others, was the discovery of the widespread presence of water molecules in the linear soil.

Chandrayan-II. Indian space scientists were not much discouraged by partial failure of Chandrayan-I and they moved ahead with their plan to launch Chandrayan-II for gathering more information about the moon. Whereas Chandrayan-I was launched by Polar Satellite Launch Vehicle (PSLV), Chandrayan-II will be launched by Geosynchronous Satellite Launch Vehicle (GSLV) with a lift mass of 2560 kg. It will be a combo of three discrete spacecrafts—an Orbiter Craft module (OC), a Lander Craft module (LC) and a Rover that piggy backs the lunar surface on the lander and then drives off to explore the lunar surface surrounding the landing site. If all goes well Chandrayan-II will be launched by the end of 2016 or in the beginning of 2017.

Mangalyan

Mangalyan which is Sanskrit means Mars craft is Indias Mars Orbiter Mission (MOM). It was launched from Satish Dhawan Space Centre, at Sriharikota, using a Polar Satellite Launch Vehicle (PSLV) on 5 November, 2013. The MOM probe spent about a month in the earth orbit, where it made a series of seven altitude-raising orbital maneuvers before trans-Mars infection on 30 November, 2013. It crossed half way to Mars on 9 April, 2014. Currently it is being monitored from the Spacecraft Control Centre at ISRO Telemetry Tracking and Command Network (ISTRAC) in Bengaluru with support from Indian Deep Space Network (IDSN). Three stages of MOM are depicted in **Fig. 26.14**.

Major Milestones in India's Space Programme

1962 : Department of Atomic Energy forms the Indian National Committee for Space Research Work on Establishing Thumba Equatorial. Rocket Launching Station (TERLS).

November 21, 1963 : India launches first sounding rocket from TERLS.

1965 : Space Science and Technology Centre established in Thumba.

1967 : Satellite Telecommunication Earth Station set-up at Ahmedabad.

August 15, 1969 : Indian Space Research Organisation (ISRO) formed under Department of Atomic Energy.

June 1, 1972 : Space Commission and Department of Space (DOS) set-up. ISRO brought under DOS.

April 19, 1975 : ISRO launches first Indian satellite Aryabhatta.

August 10, 1979 : First experimental launch of SLV-3 with Rohini Technology Payload on board. Satellite can't be placed in orbit.

June 7, 1979 : An experimental satellite for earth observations, Bhaskara-1, launched.

July 18, 1980 : Second experimental launch of SLV-3, Rohini satellite successfully placed in orbit.

1981 : First developmental launch of SLV-3, Bhasakara-II launched, Apple, an experimental geo-stationary communication satellite launched.

1982 : INSAT-1A launched on April 10, deactivated on September 6.

1983 : INAT-1B launched.

1984 : Indo-Soviet manned space mission.

1988 : Launch of first operational Indian Remote Sensing Satellite, IRS-1A.

1992 : First satellite of the indigenously-built second generation INSAT series, INSAT-2A launched.

1993 : First developmental launch of PSLV. Satellite couldn't be placed in orbit.

1994 : Second developmental launch of PSLV. Satellite successfully placed in orbit.

1999 : India launches two foreign satellites, one from Germany and one from Korea, for first time as co-passenger satellites.

2001 : First developmental launch of GSLV-D1.

2003 : Second developmental launch of GSLV-D2.

2008 : PSLV-C11 successfully launches CHANDRAYAAN 1.

2013 : PSLV-C25 successfully launches Mars Orbiter Mission spacecraft.

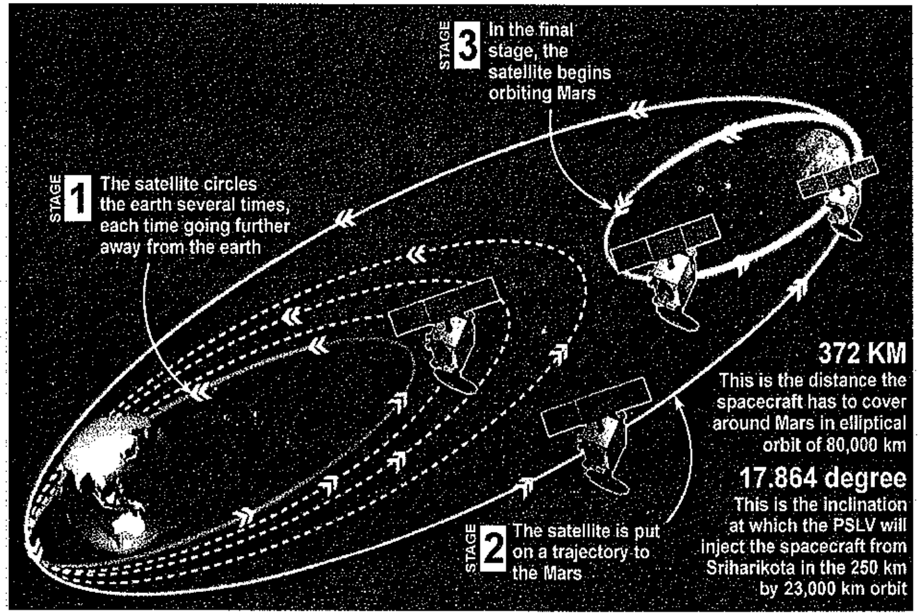

FIG. 26.14. Mangalyan's journey to Mars

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Foreign Trade

The exchange of goods or merchandise or their sale-purchase is known as trade. Trade is of three types (*i*) Local trade (*ii*) Regional trade and (*iii*) Foreign or International or Overseas trade. When one country exchanges goods or merchandise with another country, it is known as overseas trade or foreign trade. Advancement of international trade of a country leads to its economic prosperity. It is important both as a source of imports and as an outlet for exports. "International Trade of a country is rightly known as its *Economic Barometer*".

India has been maintaining trade links with China, Myanmar, Indonesia, Malaysia, Thailand, Iran, Iraq, Afghanistan, Saudi Arabia, Egypt, Greece, etc. since ancient times. With the establishment of British rule in India, our trade ties became stronger with Britain. India used to export raw materials such as cotton, tea, iron-ore, etc. to Britain and import manufactured goods, machinery, medicines, etc. from that country.

TRENDS IN INDIA'S FOREIGN TRADE

Table 27.1 shows the trends of foreign trade of India. There has been a rapid increase in the imports between 1950-51 and 1960-61. India had to import machinery and other items for industrial progress during that period. The value of exports increased considerably between 1960-61 and 1970-71 reducing the trade deficit from ₹ 480 crore in 1960-61 to a mere ₹ 99 crore in 1970-71. After that, both imports and exports have been increasing but imports have always been outpacing the exports. The rapid increase in India's overseas trade has been largely due to growth and diversification of Indian economy in the post-Independence era. However, inflationary trends and devaluation of the Indian currency have also contributed to increase in the volume of India's international trade :

Balance of Trade. All the countries of the world are importers as well as exporters of certain goods or services. *The difference between the value of a nation's exports and imports of all goods and services over a given period of time is called **balance of trade**.* If the value of the total export is more than the value of the total import in a country, it has a ***positive balance*** of trade. A country with positive balance of trade is known as ***trade creditor nation***. If the value of the exports is lower than the value of imports, the country has a ***negative balance*** of trade. A country with negative balance of trade is known as a ***trade debtor nation***.

TABLE 27.1. India's Foreign Trade (in ₹ crore)

Year	Imports	Exports	Total value of trade	Balance of trade
1950-51	608	606	1,214	–2
1960-61	1,122	642	1,764	–480
1970-71	1,634	1,535	3,169	–99
1980-81	12,549	6,710	19,259	–5,839
1990-91	43,193	32,558	75,751	–10,635
2000-01	2,30,873	2,03,571	4,34,444	–27,302
2005-06	6,60,409	4,56,418	11,156,827	–2,63,991
2006-07	8,40,506	5,71,779	14,12,285	–2,68,727
2007-08	11,02,312	6,55,864	16,63,576	–3,56,448
2008-09	13,74,436	8,40,755	22,15,191	–5,33,680
2009-10	13,63,736	8,45,534	23,09,270	–5,18,202
2010-11	16,83,467	11,42,922	28,26,389	–5,40,545
2011-12	23,45,463	14,65,959	38,11,422	–8,79,540
2012-13	26,69,162	16,34,319	4,30,3481	1034843
2013-14	27,14,182	18,94,182	46,08,364	–82,000

Source : (*i*) Directorate General of Commercial Intelligence and Statistics (DGCI&S), Kolkata.
(*ii*) India, 2014 Reference Annual, p. 140.
(*iii*) Economic Survey 2013-14, Statistical Appendix, p. 69.

Table 27.1 shows that India's balance of trade has been invariably unfavourable. This is because of our increasing demands and growing economy.

In spite of the phenomenal growth of our foreign trade, India stands nowhere in the international market. As a matter of fact, India's share in the international trade has decreased with the passage of time. India's share in the international trade was 2.2 per cent in 1948-49 which declined to 1 per cent in 1963-64 and 0.4 per cent in 1995-96. Many other developing countries have excelled India in the overseas trade. India ranked 16th in 1953, 20th in 1963, 41st in 1983 and 50th in 1996 in the hierarchy of world nations doing overseas trade. However, India's foreign trade has recovered to a great extent since 2000-01. Improved global growth and recovery in world trade aided the strengthening of Indian exports. On the other hand, firming up of domestic economic activity, especially in the manufacturing sector, provided a strong support base for exports. Recent recovery in international commodity prices and various policy initiatives for export promotion and market diversification have also contributed to improve export performance. Consequently India's exports in recent past have continued to grow at a higher rate

As per press release of the World Trade Organisation (WTO) in April, 2013, India is the 19th largest exporter in the world with a share of 1.6 per cent and 10th largest importer with a share of 2.6 per cent in 2013. In commercial services, India is the 6th largest exporter with a share of 3.4 per cent and 7th largest importer with a share of 7.3 per cent.

Basis of Overseas Trade

Overseas trade depends upon several factors. Some important factors are discussed as under :

1. Difference in Natural Resources. The fundamental base of international trade is the difference in natural resources of different countries. There are variations in relief, structure, geology, climate and soil from one country to the other. These variations lead to variations in natural resources. Some countries produce certain things more than their requirement and export them while some other countries may be lacking them and import those commodities.

2. Marketable Surplus. Some countries are capable of producing certain things more than their internal consumption. In other words, these countries have marketable surplus which they trade with those countries having demand for such products. For example, tea from India, coffee from Brazil, jute from Bangladesh, paper and pulp from Norway and Sweden, wood from Australia and petroleum from the middle East are available for export. Advanced countries like the United States of America, United Kingdom, Russia, Germany and Japan export finished goods.

3. Scarcity of Goods. There is not even a single country in the world which does not have scarcity of one commodity or the other. Japan and Britain do not have raw materials. Hence, these countries have to import raw materials from a large number of countries. Thus, scarcity of goods also encourages international trade. Japan depends heavily on iron ore supplies from India.

4. Transport and Communication. Trade involves exchange of goods which requires proper arrangement for transportation and communication. Land, water and air transport have helped international trade to a great extent. Heavy commodities like coal and iron ore as well as light and perishable commodities like milk and milk products, meat, fruits and vegetables etc. can be sent to all parts of the world by efficient means of transport and refrigeration. Countries with poor transport system have not been able to develop international trade. Realising the significant role played by transport system for promoting trade, India has launched an ambitious programme to improve surface transport. In addition, certain ports like Jawaharlal Nehru, Kandla, Tuticorin, Ennore, Paradwip, Haldia, etc. have either been developed or improved.

5. Disparities in Economic Growth. There are disparities in the economic growth in different parts of the world. Some countries are still engaged in primary activities such as agriculture, mining, etc. These countries mainly export minerals and agricultural raw materials. India's export consisted of raw materials for a pretty long time even after Independence. It is only recently that India has been able to diversify its exports as a result of diversification of her economic activities.

6. Trade Policy. Free trade policy encourages international trade whereas restrictions on the trade discourage it. For example, India has restricted the export of oil-seeds to meet the domestic demand. Similarly, India has imposed heavy import duty on certain finished goods to encourage industries at home.

7. War and Peace. Peace is the most important condition for the development of international trade. International trade gets disrupted during the time of war.

8. Political Relations. Countries having cordial political relations have better exchange of goods which encourages international trade. For example, India and Russia have good political relations and trade between these two countries has increased. On the other hand, the U.S.A. and Russia have strained political relations and trade between these two big countries is at low level. India's trade with the neighbouring Pakistan remained at low level ever since that country came into being in 1947 primarily due to strained political relations between the two countries. However, improved political relations between the two countries in the recent past have shown positive results. Exports to Pakistan had surged by almost three and half times since April-October, 2004.

COMPOSITION OF EXPORT TRADE OF INDIA

India has been a traditional exporter of raw materials since time immemorial. But the complexion of India's export trade has undergone a world of change since Independence. At present, Indian exports cover a wide range of items of agricultural, industrial, handicrafts, handloom and cottage sectors. Exports of electronic, hardware and software goods have increased considerably since the beginning of 1990s, and more significantly, these items are mainly destined to the advanced countries. The export growth

is gradually becoming broad based notwithstanding some deceleration in export growth of primary commodities. The major contributor to this increase has been the manufacturing sector in general, and engineering goods, chemicals and related products, leather and manufactures and gems and jewellery in particular.

1. Tea. India is a traditional exporter of tea in the world market. India has maintained its supremacy as an outstanding exporter of tea inspite of tough competition from the other tea producing countries. However, our percentage of tea and *mate* export in the world market has decreased considerably primarily, due to increased exports from other countries like Sri Lanka, China and Japan. In 2013-14 India exported 247.6 thousand tonnes of tea valued at about ₹ 4,832 crore. Britain has been the traditional buyer of our tea. Other important buyers are Russia, Poland, Iran, Egypt, Germany, Afghanistan, Netherlands, Australia and the USA.

2. Leather and Leather Goods. India has the largest population of livestock in the world which provide large quantity of leather in the shape of hides and skins. Previously, India used to export leather in its raw form but now the main export is that of leather goods. India exported leather and leather manufactures including leather footwear, leather travel goods and leather garments worth ₹ 28 crore in 1960-61 which rose to ₹ 298 crore in 1990-91 and to ₹ 34,517 crore in 2013-14. Footwear constitutes the most important item of leather exports. The USA, Russia, Germany, Britain, Yugoslavia, Italy, France and Japan are the main importers of our leather and leather goods. Recently, competition from China has grown considerably with respect to exports of leather and leather goods.

3. Ores and Minerals. India exports a large variety of ores and minerals which account for about one-fourth of our total exports. Higher international prices provided impetus to exports of metals and mineral ores.

(*a*) ***Precious stones, gems and jewellery*** have become the most important items of export from India in the recent past. They account for nearly 13.1 per cent of our total exports. This is the highest percentage accounted for by any single item of export. India imports gems and precious stones in their raw form and exports them after proper cutting and polishing. India was an insignificant exporter of gems and jewellery and the exports were worth ₹ 7 crore only in 1960-61 which increased to ₹ 2,48,465 crore in 2013-14. This speaks volumes of increase in our gem and jewellery exports. The USA, Switzerland, Japan, Belgium, Netherlands, France, Hong Kong, Singapore and countries of the Middle East are our main buyers. Improvement in off-take and recovery in major markets like the USA and Europe aided a pick up in exports of gems and jewellery. Israel and Belgium have emerged as our main competitors in the recent years.

(*b*) ***Iron ore*** is the single largest metal exported by India. High quality magnetite and hamatite ores are found in large quantities which are in great demand in the industrial countries. Japan is the largest buyer of our iron ore, purchasing more than two-thirds of our exports. The other customers are Korea, Romania, Russia, Malaysia, and Germany. India exported iron ore worth ₹ 956 crore in 2013-14. The recent trend has been to curtail the exports of iron ore and use it within the country to provide a solid base to iron and steel industry.

(*c*) ***Mica.*** India holds monopoly in the production of mica and is the largest exporter of mica in the world. In 2013-14, India exported mica valued at ₹ 304 crore.

(*d*) ***Chemicals and allied products*** account for about 13.2 per cent of our exports. The main buyers are Russia, the USA, Britain, the Netherlands, France, Saudi Arabia, Bangladesh, UAE, Indonesia, Thailand, Hongkong and Kuwait. The value of chemicals and allied products was ₹ 2,50,325 crore in 2013-14.

4. Engineering Goods. As a result of industrial progress, India is in a position to export engineering goods even to some of the advanced countries. In 1950-51, the Indian engineering goods exports were just ₹ 3 crore which jumped to ₹ 3,08,682.03 crore in 2012-13. Saudi Arabia, Japan, Iran, Sri Lanka, Uganda, etc. are the main purchasers of Indian engineering goods. Besides, electronic goods worth ₹ 7,992.39 crore were exported to advanced countries like the USA and Japan in 2003-04. Exports of engineering goods grew on the back of rising demand from countries in South-east Asia and China.

5. Cotton Textiles and Yarn. India now exports both inferior and superior quality cloth and yarn to different countries including the USA, Russia, Australia, New Zealand, the Netherlands, Britain, Germany, etc. While exports of manmade yarn, fabrics and made up increased, those of cotton yarn and fabrics were stagnant. In the year 2013-14, India exported cotton yarn, fabrics made ups, etc. worth ₹ 53,914 crore.

6. Readymade Garments. Readymade garments have become a very important item of export during the last few years. Indian readymade garments have become very popular even in some of the advanced countries due to their attractive designs, new fashion and colour combinations. They are competitively cheap in the foreign markets because labour is quite cheap in India. The total earnings from the export of readymade garments were ₹ 1,067 crore in 1985-86 which increased to ₹ 90,402 crore in 2013-14. In 2013-14, readymade garments accounted for about 4.8 per cent of the total exports of India which was next only to that of gems and jewellery.

7. Jute Manufactures. India was the largest producer and exporter of jute manufactures before partition in 1947. The partition of the country, introduction of substitutes and competition from other countries led to problems in the export of jute manufactures. In spite of these adversities, India has been doing well in the export of jute manufactures. India exported jute manufactures including twist and yarn valued at ₹ 2,296 crore in 2013-14. Eight countries purchase about two-third of our jute exports. These include the USA, Australia, Canada and European countries.

8. Marine Products. India is comparatively a new entrant in the export of marine products. The real progress in this field started after 1975. The total value of the exports of sea products was ₹132.15 crore in 1975 which rose to ₹ 18,833.06 crore in 2012-13. The main items of marine exports are fish, dried prawn and shrimps. India exports these products to over 80 countries. Japan and the USA purchase about 90 per cent of our exports. Other important customers are the Netherlands, Kuwait and France.

9. Coffee. India exports coffee to the USA, Russia and some European countries. In 2013-14, 278.9 thousand tonnes of coffee worth ₹ 4,797 crore was exported.

10. Spices. India has been a traditional exporter of spices. It was a major item of export of India during the British period. But its relative importance was reduced after Independence as a result of increase in other exports. The total quantity of spices exported in 2013-14 was 1,029.3 thousand tonnes and the total earnings from the export of spices in that year was ₹ 15,981 crore.

COMPOSITION OF IMPORT TRADE OF INDIA

Like exports, Indian imports have also increased manifold. India used to import mainly the manufactured goods before Independence. At the time of Independence, roughly 70 per cent of imports into India consisted of either manufactured consumer goods or inputs for manufacturing industries. But after that, the import of manufactured goods decreased gradually and our imports saw a large variety of goods. The demand for petroleum and petroleum products increased tremendously which made it necessary for us to import large quantities of these items. The other major items of import are machinery, tools, cereals, fertilizers, edible oils, iron and steel, pearls and precious stones, superior quality cotton and paper, etc. Like exports, India's imports are also tending to become broad based. The growth in imports has been contributed by robust increase in imports of food and allied products (mainly edible oils), capital goods, raw materials and manufactured intermediate and consumer goods.

1. Petroleum and Petroleum Products. This is the largest single item of import by India these days. There is great demand for petroleum and petroleum products and this demand is increasing at an accelerated rate. Transport and industry are two major sectors of consumption. In 2013-14, petroleum, oil and lubricants worth ₹ 10,00,064 crore were imported which accounted for 36.8 per cent of our total imports. In mid 1970s when the world was facing oil crisis due to Arab-Israel war, oil accounted for about 75 per cent of our import bill. Gulf war and disintegration of the former USSR in early 1990s had very adversely affected our oil supplies. Efforts are being made to increase the home production of oil so as to reduce dependence on the imports. Iran, Saudi Arabia, UAE, Iraq, Kuwait, Venezuela, Indonesia and Malaysia are the main sources of oil supply to India.

2. Machines. Special emphasis was laid on the industrial growth immediately after Independence which made it necessary to import machinery on a large scale. Now, most of the machines are manufactured in the country itself and only the machines involving high technology are imported. Textile machinery, electrical machines, farm implements and mining machines are the main items of import. These machines are mainly imported from the USA, Britain, Germany, Russia, France, Japan, Belgium, Poland, Italy, The Netherlands, Canada, Australia, etc.

3. Iron and Steel. Although there has been a considerable increase in the production of iron and steel in India, yet our production always falls short of our demand. This increase in demand has been largely due to the industrial growth in the country. India imported 7,406.3 thousand tonnes of iron and steel worth ₹ 47,912 crore in 2013-14 which was about 1.8 per cent of our total imports. Our main suppliers are Japan, Germany, Belgium, Britain and Korea. Japan supplies about 20 per cent of our total imports.

4. Minerals. Apart from iron and steel, India imports a large variety of minerals including copper, lead, tin, zinc, aluminium, etc. These minerals are imported from the USA, Britain, Japan, Germany, Switzerland, Australia, Myanmar and Malaysia, etc.

5. Fertilizers. The increasing demand for fertilizers for agricultural growth has to be met by imports. India imported 22,154.2 thousand tonnes of fertilizers worth ₹ 38,231 crore in 2013-14. The USA, Germany and Japan are the main sources of fertilizers.

6. Pearls and Precious Stones. India imports a large quantity of pearls and precious stones in their raw form and exports them after cutting and polishing. The real increase in their imports has been seen after 1970. The import bill of pearls, precious and semi-precious stones, both worked and unworked was a meagre ₹ 1 crore in 1960-61 which shot up to ₹ 25 crore in 1970-71, ₹ 3,738 crore in 1990-91 and ₹ 1,44,557 crore in 2013-14.

7. Gold and Silver. Gold and silver have also become very important items of import. After a decline of 6.4 per cent in 2002-03, the gold and silver imports (excluding imports through passenger baggage), picked up sharply by 59.9 per cent in 2003-04, notwithstanding a rise in international bullion market. These imports seem to have been buoyed up by recovery in domestic demand, on the back of agricultural rebound and strengthening of rupee against the US dollar. The duty reduction on imported gold from ₹ 250 to ₹ 100 per 10 gram, and liberalization of such imports as per trade facilitation measures announced in January 2004 may have also provided a demand fillip. However, fall of Indian currency against $ US in early 2010s put some restriction on imports of gold and silver but it has bounced back. Value of imports of gold and silver increased to ₹ 3,02,921.96 in 2012-13 as against ₹ 2,94,255.18 in 2011-12.

8. Edible Oils. The production of edible oils has always been falling short of our demand which is met by imports. In 2013-14 about 10,434.2 thousand tonnes of edible oils costing ₹ 56,489 crore were imported. The corresponding figures for 1995-96 were 1,062 thousand tonnes and ₹ 2,260 crore. The USA, Brazil and Malaysia are the main sources of edible oils for India. These three countries supply about three-fourths of our edible oils.

9. Chemicals. India imports a large variety of chemicals including ammonia, sulphate, super phosphate, nitric acid, soda ash, bleaching powder and potash. India imported chemical elements and components worth ₹ 22,498 crore in 2013-14. The main sources of our chemicals are the USA, Japan, Germany, the Netherlands, Belgium, France, Britain, Italy, Kuwait and Korea.

10. Medicines. Large quantities of medicines are required to provide increasing medical treatment to the fast-growing population of India. A part of this requirement is met by importing medicines especially costly and life-saving drugs. India spent ₹ 17,944 crore in 2013-14 to import medicinal and pharmaceutical products. About half the imports are from Germany, Italy, China, Switzerland, Spain, Belgium and Poland.

11. Paper. With the increase in literacy and publication, India is finding it hard to meet her requirements from the indigenous production and has to import paper. The shortage of newsprint is badly felt. Pulp and scrap paper are also imported to manufacture paper. India imported 3,648.8 thousand tonnes of pulp and waste paper worth ₹ 8,378 crore and 2,761.3 thousand tonnes of paper, paper board and manufactures thereof worth ₹ 15,067 crore in 2013-14. Russia, Sweden, Germany, Bangladesh, Brazil, China, Czech Republic, Slovakia and Korea are the main suppliers of these items.

12. Fibres. Although India is a major producer of fibres, she has to import different varieties of fibres to feed her textile industries which are growing at a fast speed. The main fibres imported are raw cotton, raw wool, raw jute and synthetic fibres.

(a) Raw Cotton. Although India is a big exporter of inferior quality cotton, she has to import superior quality cotton. Egypt, Uganda, the USA, Tanzania, Sudan and Peru are important suppliers. India imported 177.7 thousand tonnes of raw cotton worth ₹ 2,371 crore in 2013-14.

(b) Raw Wool. Large proportion of wool produced in India is of inferior quality and large quantity of superior wool is imported mainly from Australia. India had to spend ₹ 1,962 crore on the import of 89.6 thousand tonnes of raw wool in 2013-14.

(c) Raw Jute. India's jute supplies were drastically cut as a result of partition of the country in 1947, because most of the jute producing areas went to present Bangladesh. Strenuous efforts have been made to increase area and production of jute within the country, but demand of raw jute by jute textile industry far outstrips the supply. Therefore, India has to import raw jute primarily from Bangladesh. In 2013-14, India imported 52.7 thousand tonnes of raw jute at the cost of ₹ 146 crore.

(d) Synthetic Fibres. With the diversification of the textile industry and with trend in favour of synthetic fibres, the demand for these fibres is increasing rapidly; a large part of which has to be met by imports. India spent ₹ 502 crore to import 73.3 thousand tonnes of synthetic fibres in 1995-96. However, the corresponding figures were ₹ 1,889 crore and 119.3 thousand tonnes respectively in 2013-14.

DIRECTION OF INDIA'S FOREIGN TRADE

Direction of foreign trade means those regions and countries with which India has trade relations. Although we have trade contacts with almost all the countries of the world, yet there are certain countries which are more important than the others.

Britain was our most important trade partner before Independence. This was the result of the policy of exploitation of India by the British rulers. They exploited the natural resources of India to get the raw materials and created a vast market here for their manufactured goods. But the situation has drastically changed since Independence. Direction of India's exports and imports from different regions/sub-regions is outlined in **Table 27.2**.

TABLE 27.2. Direction of India's Foreign Trade (2012-13)

Region	Percentage Share
1. Europe	18.6
1.1. European Union Countries	16.75
1.2. European Free Trade Association (EFTA)	0.46
1.3. Other European Countries	1.4
2. Africa	9.7
3. America	17.75
3.1. North America	13.24
3.2. Latin America	4.51
4. Asia	50.76
4.1 East Asia (Oceanic)	0.91
4.2 ASEAN	10.96
4.3. West Asia	20.76
4.4. N.E. Asia	13.21
4.5. South Asia	4.91
5. CIS and Baltics	1.24
6. Unspecified Region	1.95
Total	100.00

Source : India 2014, A Reference Annual, pp.142-43.

SALIENT FEATURES OF FOREIGN TRADE OF INDIA

1. Negative or Unfavourable Trade. India had to import various items like heavy machinery, agricultural implements, mineral oil and metals on a large scale after Independence for economic growth. But our exports could not keep pace with our imports

which left us with negative or unfavourable trade. This situation still persists and is clear from **Table 27.1**.

2. Diversity in Exports. Previously, India used to export its traditional commodities only which included tea, jute, cotton textiles, leather, etc. But great diversity has been observed in India's export commodities during the last few years. India now exports over 7,500 commodities. Since 1991, India has emerged as a major exporter of computer software and that too to some of the advanced countries like the USA and Japan.

3. Worldwide Trade. India had trade links with Britain and a few selected countries only before Independence. But now India has trade links with almost all the regions of the world. India exports its goods to as many as 190 countries and imports from 140 countries.

4. Change in Imports. Earlier we used to import foodgrains and manufactured goods only. But now oil is the largest single commodity imported by India. Both the imports as well as exports of pearls and precious stones has increased considerably during the last few years. Our other important commodities of import are iron and steel, fertilizers, edible oils and paper.

5. Maritime Trade. About 95 per cent of our foreign trade is done through sea routes. Trade through land routes is possible with neighbouring countries only. But unfortunately, all our neighbouring countries including China, Nepal, Myanmar are cut off from India by lofty mountain ranges which makes trade by land routes rather difficult. We can have easy access through land routes with Pakistan only but the trade suffered heavily due to political differences between the two countries.

6. Trade through a few Selected Ports Only. We have only 13 major ports along the coast of India which handle the major part of overseas trade of India. Very small amount of foreign trade is handled by the remaining medium and small ports.

7. Insignificant Place of India in the World Overseas Trade. Although India has over 17 per cent of the world's population, her share in the world overseas trade is less than one per cent. This shows the insignificant place of India in the world's overseas trade. This is, however, partly due to very large internal trade, vast dimensions of the country provide a solid base for inter-state trade within the country. Europe is divided into a large number of smaller countries and the international trade is quite high (trade counted twice, first time as exports and second times as imports).

8. State Trading. Most of India's overseas trade is done in public sector by state agencies and very little trade is done by individuals.

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CHAPTER 28

Tourism

INTRODUCTION AND DEFINITION

Tourism has different meanings in different languages and different regions and can be defined in different ways. The present day tourism is not the same as travels of the early periods of human history. In the language of Jew, the word '*Torah*' mean study or search and 'tour' seems to have been derived from it. In Latin the original word '*Tornos*' stands close to it. 'Tornos' was a kind of round wheel-like tool hinting at the idea of a travel circuit or a package tour. In Sanskrit, '*Paryatan*' means leaving one's residence to travel for the sake of rest and for seeking knowledge. '*Deshatan*' is another word which means travelling for economic benefits. '*Tirthatan*' is the third equivalent which means travelling for religious purposes. All the three words convey the meaning and concept of tourism much more appropriately, as well as comprehensively.

Tourism as a modern term is applicable to both international and domestic tourists. It is the *temporary movement of people to destinations outside their normal place of work and residence*. Such a pleasure-seeking tourist is a traveller moving from place to place or visiting the same place time and again. Tourism includes all economic activities which are organised to fulfill the needs of such travellers. Any travel for holidaying, business or professional trips becomes a part of tourism if it is temporary, is undertaken voluntarily and does not aim at earning any livelihood.

According to **Ziffer** (1989), *"Tourism involves travelling to relatively undisturbed or uncontaminated natural areas with the specific object of studying, admiring and enjoying the scenery and its wild plants and animals, as well as any existing cultural aspects (both past and present) found in these areas"*. Tourism for some provides entertainment, for others it serves as a holiday and for yet others it is a means of understanding other peoples' ways of life, cultures and traditions. According to a Chinese proverb, "*Travelling a mile imparts more knowledge than reading a mile of written words.*" In today's world, tourism is an important socio-economic activity. Tourism is now recognised as an industry generating a number of social and economic benefits. It promotes national integration and international understanding, helps in improving infrastructure, creates employment opportunities and augments foreign exchange earnings. Tourism is as much a part of socio-

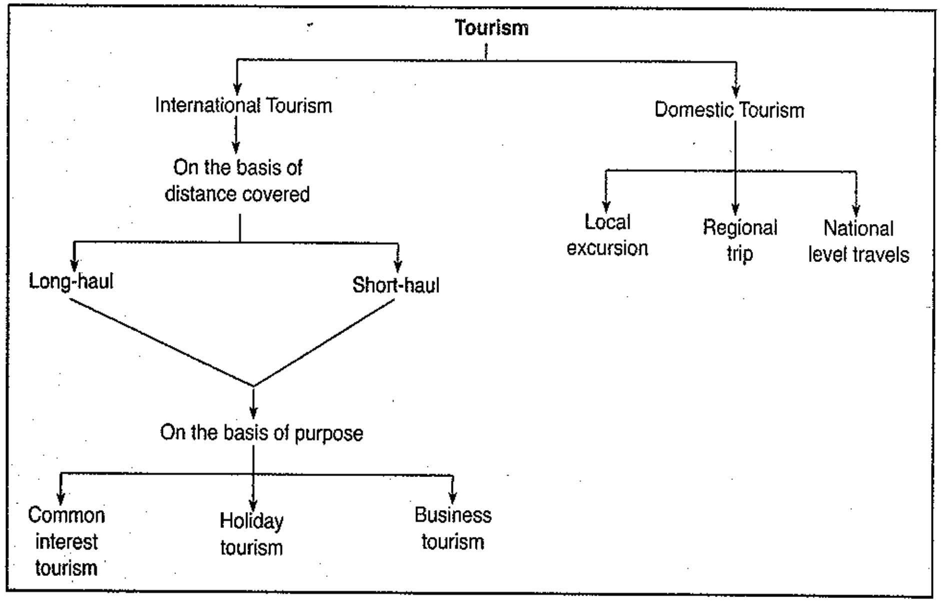

FIG. 28.1. Types of Tourism

economic development as any other related acitvity. The advanced economies of the west and the emerging economies of south-east Asia underline the linkage between tourism and growth. In any area where a place of tourist attraction is located, there exists a tourist economy besides the domestic area economy. It also lends a helping hand to local handicrafts and cultural activities.

Types of Tourism

Different types of tourism can be recognised depending on length of stay, mode of transport used, distance travelled, purpose of trip and price paid by tourists. Broadly speaking, there are four major types of tourism namely : (*i*) international tourism, (*ii*) domestic tourism, (*iii*) long distance tourism, and (*v*) short distance tourism.

(*i*) **International Tourism.** An international tourist crosses the boundaries of one or more countries, uses different currencies, faces different languages and meets different types of people. Usually international tourism involves longer distances although crossing small countries or travelling in the neighbourhood of international borders may involve short distances.

(*ii*) **Domestic Tourism.** It is concerned with travelling within the country. It does not need a passport and visa or conversion of one currency into another. Domestic tourism has greater scope in countries of large dimensions such as India as compared to smaller countries. From a geographical viewpoint, domestic tourism may range from local excursion, regional trips to national level travels.

On the basis of purpose of tour or the motives of tourists, tourism is of three types, *viz.*, (*a*) common interest tourism, (*b*) holiday tourism and (*c*) business tourism. In case of *common interest tourism*, the purpose of visiting and the visited persons in common. Visiting friends and relatives in this type puts very low pressure on the provision of tourist facilities at the destination. *Holiday tourism* is the most popular type. A fine weather favourable for sightseeing, touring, recreation and going round different cultural sites are sought after by incoming tourists of this category. *Business tourists* travel to boost their business, attend trade fairs and conferences pertaining to commerce or professions. They combine business with recreation using same facilities as provided for holiday tourists.

Nature's Gift for Tourism

Nature is bountiful and provides vast opportunities in form of gifts to enhance tourism.

1. Weather and Climate Resources. India is vast country and its different parts experience different types of climate. This extraordinary asset in the form of varied climates can be encashed to promote tourism in the country by attracting tourists from far and near. Regional variations in the climate of India are caused by five main factors, *viz.*, (*i*) the vast size of the country, (*ii*) tapering of the peninsular India towards the south, (*iii*) the latitudinal extent astride the Tropic of Cancer, (*iv*) situation at the head of the Indian Ocean, and (*v*) role played by the Himalayas as a climatic barrier between India and central Asia, protecting the country from cold and dry winds from central Asia during winters. A tourist will find different types of climate in the Great Plain of North India, the snow covered Himalayas, in the peninsular plateau area and in the coastal regions. There are climatic variations from one state to another and even from one district to another. These climatic variations are of great advantage to engage tourists in a variety of activities during their stay in the country. However, strong influence of the monsoons along with their typical rhythm provides underlying unity to India's climatic diversity. This unity in diversity of the Indian climate is a potent factor which works to attract tourists. The visiting tourist can choose to stay in any type of climate and enjoy the changing status of weather while moving from one place to another. Temporal changes in weather are no less pronounced than the spatial changes. India is one of the few countries where there is change in weather after every two months. The spatial and temporal changes in India's climate and weather act as a great magnet to attract tourists and enable them to enjoy the gift of nature. Larger the diversity, greater is the potential of climate resources to develop tourism.

2. Landscape Resources. Geology and physiography are two major bases of landscape resources. These two aspects influence the landscape and determine the rocky peaks for climbing, cliffs or scarps for hand gliding, steep snowy slopes for skiing and caves for exploiting them for sightseeing. Rock formations exposed in areas like Deccan plateau or Ladakh attract tourists interested in trekking. There is ample scope for rural tourism also. Water bodies and waterpoints like riversides, gorges, waterfalls, springs, etc. provide spectacular views to the tourists. Sunbathing and adventurous raffling and rowing are associated with water tourism.

Although all sorts of landscape resources attract tourists, yet the degree to which different types of landscapes act as tourists attraction varies greatly. According a research report by A. Gilg of Exter University in U.K., mountains comprise the greatest attraction for the tourist. The other features, in descending order are bold hills, hilly country, plateau uplands and lowlands.

Forest landscape is found to be equally attractive, irrespective of topography. It is for this reason that National Parks, Sanctuaries as well as Biosphere Reserves are used as tourist spots. Seeing wildlife in its natural habitat rather than in a zoo or a safari-park is termed as Nature Tourism these days. Vegetation in wilderness and wildlife which depends on it constitute a very important element of tourist landscape.

3. Seascape Tourist Resources. Coastal waters of the mainland of India and that of the groups of islands (Andaman & Nicobar Islands in Bay of Bengal and Lakshadweep in Arabian Sea) comprise another major source of tourist attraction. Sandy beaches, coves, spits and lagoons, reefs and seaside cliffs are tourist hot spots. These are visited for sunbathing, swimming, boating and surfing. This type of tourism flourishes only in those areas where waves are gentle and tidal currents are not dangerous.

4. Historical and Cultural Resources. These are manmade features and are found in almost all parts of the country. Such resources are associated with historical, religious or cultural events. A rich historical and cultural heritage has developed during long course of history of India. These include statues, shrines, tombs, minarets, forts, palaces, ancient monuments as well as recent buildings and are famous for their architectural designs and structural beauty.

Classification of Tourist Resorts

There are several types of tourist resorts depending on their location in different geographic regions, diverse characteristics of their sites, and scope for a variety of tourists activities. A brief classification of tourist resorts is given as under :

1. Mountain and Hill Resorts. Almost all mountainous and hilly areas of India are dotted with places of tourist interest. In the north are the Himalayan ranges; blessed with scenic beauty which is beyond description. Besides, there are high hills in the northeast and in and around the Nilgiris in the south. There are hill ranges of medium to low heights in the Western Ghats, Vindhyas, Satpuras and the Aravalis in addition to isolated hillocks elsewhere. Hill resorts are divided into following three categories according to their altitude.

(*a*) Resorts at great heights (between 2,100—3,500 metres above mean sea level).

(*b*) Hill resorts at medium altitudes (between 1,200 and 2,100 metres above mean sea level).

(*c*) Hill resorts at low altitudes (between 800 and 1,200 metres above mean sea level).

Map in **Figure 28.2** shows that the maximum number of hill resorts are at medium heights followed by those located at low heights. Very few tourist resorts are at very great heights.

2. Beach Resorts. The long coastline of India has several beaches which offer ample scope for promotion of beach tourism. A number of beautiful beaches of Goa and that of Kovalam in Kerala are quite popular with the tourists. There are vast stretches of shining golden sands of beaches at Chorwad and Ahmedpur-Mandvi. The Maharashtra coast has eight small beaches from Mumbai's famous Juhu to Murud at a distance of 220 km. Goa's 105 km long coastline has as many as 40 beaches, out of which 12 are very popular with the tourists. Karnataka's beaches are at Mangalore and Karwar. The sun-swept Marina beach in Chennai (Tamil Nadu) is the world's second longest beach. It runs for a distance of 12 km from Chennai harbour in the north to Santhome (St. Thomas) Church in the south. Two beaches of Andhra Pradesh, namely Ramakrishna Mission and Rishi Konda are located in the close proximity of Vishakhapatnam. Odisha's Gopalpur beach is surrounded by sand dunes. Besides Puri and Konark, Chandipur near Balasore is known for its 55 km recession of the tides each day at its head. Digha beach of West Bengal is very close to the Ganga's mouth. With a total length of 6 km it is one of the widest in the world amidst gently rolling sea and thick casuarina forest on its two sides.

3. Cultural Centres (Heritage Tourism). India is proud of being very rich in heritage tourism. Her cultural centres are of varied types, the outstanding centres being temples or pilgrim centres (of all faiths), ancient ruins, forts, memorials, palaces, places of historical importance and gardens. These cultural centres are distributed all over the length and breadth of India.

4. Adventure Tourism (Off-beat Resorts). Adventure tourism includes a large variety of activities such as trekking, skiing, river rafting, water games, mountaineering, rock climbing, hang gliding, para gliding, hiking and camping in habitats of wild life. This type of tourism is not very popular as only about 7 per cent of the total tourists traffic opt for adventure tourism. However, there is great scope of making it popular if young people particularly in the age-group of 25-35 years are motivated for adventure tourism.

(*i*) ***Trekking***. Trekking involves walking or hiking over long distance for fun and recreation. The real thrill of trekking comes by walking over rugged and remote terrain lacking in good means of transport, going up and down the hills, crossing passes and coping with extremes of variable weather in high altitudes. Some of the well defined trekking routes are marked in Ladakh, Uttarakhand, Sikkim, Arunachal Pradesh, etc.

(*ii*) ***Mountaineering***. Lofty peaks in the Himalayan region have attracted mountaineers from all over the world. Mountaineering became very popular with the adventure lovers after the conquest of Mount Everest in 1953. The Himalayan region has the largest number of high peaks in the world. Most of the high peaks are under permanent snow and throw great challenge to mountaineers. In Jammu and Kashmir, there are a series of mountain peaks in Pir Panjal, Great Himalaya, Zaskar, Ladakh and Karakoram ranges. These are between 5,000 and 7,000 metres above sea level. High Himalayan ranges in Himachal Pradesh have about 150 peaks located at altitudes of over 5,400 metre. On an average, there is one high peak after every 20 km. In Uttarakhand, the source of the holy Ganga, a few kilometres above Gau Mukh ice cave, lies one of the best mountaineering areas of the world. Towards the east, Sikkim offers great opportunities to climbers. The Indian Mountaineering Institutes at Manali, Darjeeling and Uttar Kashi and the Indian Mountaineering Foundation at Delhi render valuable help and guidance in organising and sponsoring the mountaineering expeditions.

(iii) Winter Sports Resorts. Winter sports have become very popular with tourists (both Indian and foreign) in the recent past. Skiing is one of the most popular winter sports on the snowy slopes of

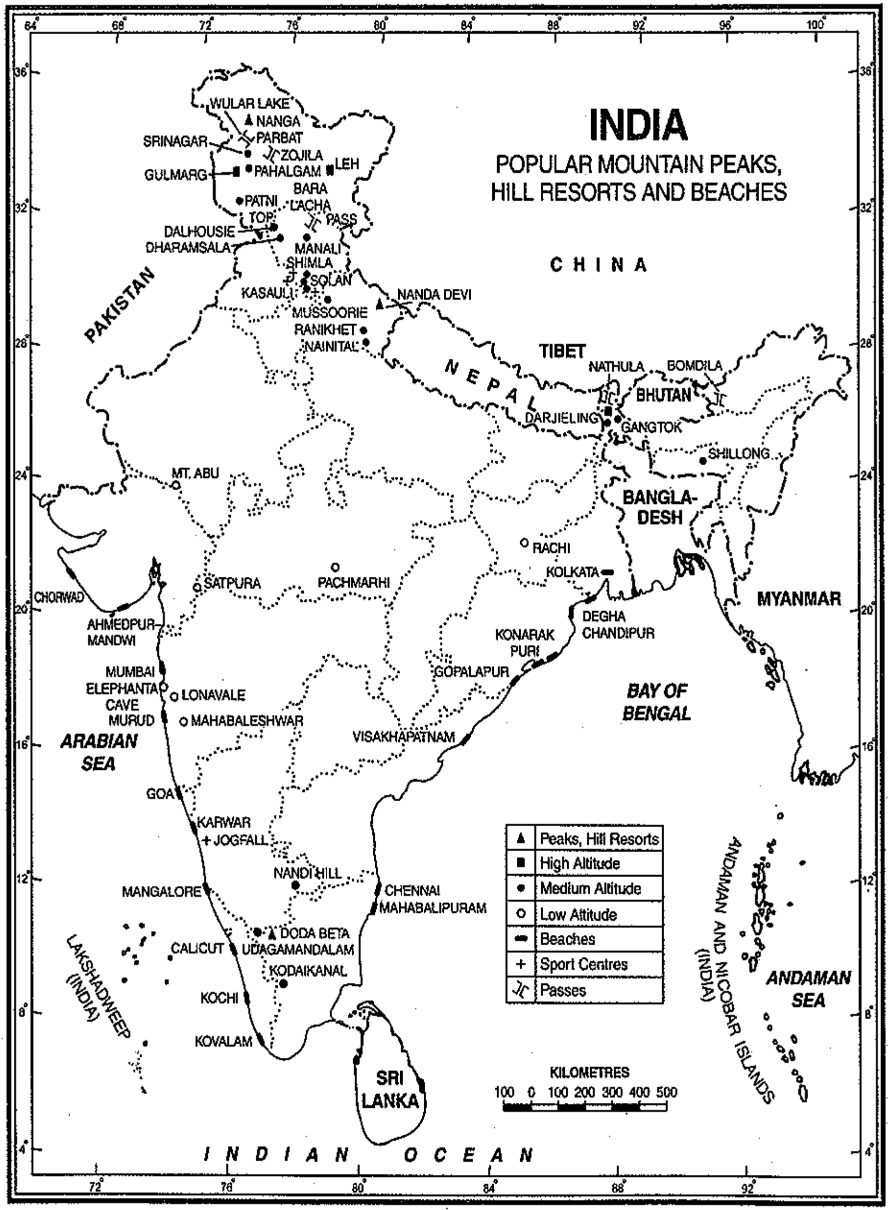

FIG. 28.2. Popular Mountains Peaks, Hill Resorts and Beaches

Himalayas, Gulmarg (2,730 m) in Jammu & Kashmir, Narmada (2,700 m), Kufri near Shimla as well as slopes along Solang Nala close to Manali in Himachal Pradesh and Auli near Joshimath in Uttarakhand offer excellent opportunities for winter sports.

(iv) Hand gliding and Paragliding. These two sports are full of thrill as they give the joy of soaring high in the sky. Facilities for this sport are available in the valleys of Bilaspur, Manali and Bir (Kangra) in Himachal Pradesh and at Udagamandalam in Tamil Nadu.

(v) Water Sports Tourism. Rafting is the most important of all the water sports in India. It has become quite popular in the recent past and has tremendous scope for promotion in the near future. Facilities for rafting exist in Ganga near Rishikesh, Beas near Manali and Indus in Ladakh. However, Tista in Sikkim, Brahmaputra in Assam, Chandra in Lahul (Himachal Pradesh) and Bharati in Arunachal Pradesh hold great potential with regard to rafting.

India's numerous natural and man-made lakes offer large scope for developing aquatic games like sailing, angling of trout fish and wind surfing. Rivers and canals criss crossing Goa have been developed as water bodies for water sports.

Clear sea water surrounding Andaman and Nicobar Islands in Bay of Bengal and Lakshadweep in Arabian Sea provide ideal sites for developing diving sports.

(vi) Cave Tourism. India has a large number of caves and rock-cut temples some of which still await development as tourist designations. There are about 30 caves around Aurangabad, of which Ajanta is the most popular. Around 500 caves are found around Pachmarhi in Madhya Pradesh. Some of them have paintings of early man. The twin hills of Khandagiri and Uraygiri near Bhubaneshwar have caves showing rock sculpture. Cherrapunji in the Garo hills of Meghalaya has a beautiful cave in limestone area. The cave has well developed stalactite and stalagmite formations. A recent discovery of Asia's longest 19.2 km cave besides 200 other caves in the Jaintia hills of Meghalaya has given a big boost to cave tourism in this state. Cave tourism has a large number of attractions varying from their sites, geological formations to rock paintings, sculpture myths and legends.

(vii) Wilderness Tourism. With her rich and diverse biological heritage in the form of varied flora and fauna, India offers vast scope for wilderness tourism. Wilderness tourism develops on National parks, sanctuaries and wetlands. National parks and sanctuaries have already been discussed in chapter on *Natural Vegetation* and need not be repeated here.

Growth of Tourism in India

Tourism in India has a strong relevance to economic development, cultural growth and national integration. As mentioned earlier, India is a vast country of great beauty and diversity and her tourist potential is equally vast. With her rich cultural heritage as superbly manifest in many of the architectural wonders (palaces, temples, mosques, forts, etc). caves and prehistoric wall paintings, her widely varied topography ranging from the monotonous plains to the loftiest mountains of the world, her large climatic variations ranging from some of the wettest and the driest as well as from the hottest and the coldest parts of the world, beautiful long beaches on the sea coast, vast stretches of sands, gregarious tropical forests and above all, the great variety of the life-style, India offers an unending choice for the tourist.

The roots of tourism in India can be traced to pilgrimage. Places of pilgrimage provided a firm ground to tourism in the beginning and still continues to be one of the most effective factors of promoting tourism in India. It is interesting to note that in the early stages, pilgrimage based tourism was only of domestic nature but during recent years, an increasingly large number of foreign tourists have also started visiting places of pilgrimage. With other attractions gradually gaining ground, one can notice detectable changes in the character of Indian tourism, with a tilt from pilgrimage to pleasure trips. Today, the majority of the tourists feel that travelling for sheer *pleasure* offers much wider scope than that offered by *pilgrimage* and thus the former is always more colourful, lively, intimate, soothing to mind and body and hence, more enjoyable. Sometimes, people combine pilgrimage with pleasure trips to draw the benefit of both.

Organised tourism in India began in the 1950s with the genesis of planned development. Over the years, Indian tourism has grown considerably as is

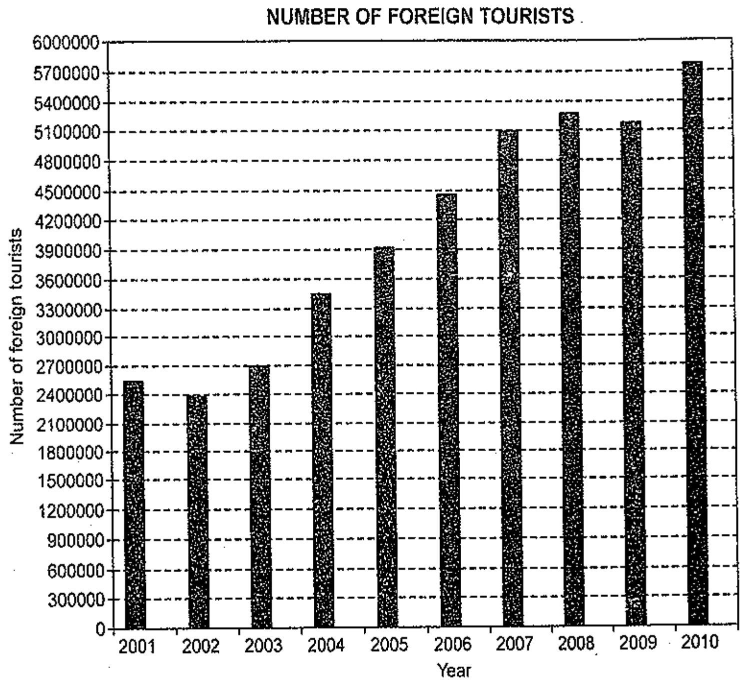

Fig. 28.3. Number of foreign tourists to India (Based on Statistical Year Book India, 2013)

indicated by the arrival of foreign tourists (*see* **Fig. 28.3**). This shows that the number of foreign tourists visiting India has increased substantially from about 2.5 million in 2001 to 5.77 million in 2010. This means that the number of foreign tourists visiting India has doubled within tone decade from 2001 to 2010. According to World Tourism Organisation, by the year 2020, it is expected that India will become the leader of tourism industry in South Asia. Of late the Indian tourism economy has been deemed as the second most rapidly increasing (8.8%) tourism economy in the world, by World Travel and Tourism.

With the successful launch of very penetrative ad campaign—Incredible India—there seems to be revival of increasing trend in the tourist arrivals. This, coupled with the open sky policy and good private-government partnership, is bringing back foreign tourists to India. Visa-on-Arrival (VoA) scheme was started from January 2010 on pilot basis for nationals of five couintries, namely Finland, Japan, Luxembourg, New Zealand and Singapore. A total of 5,644 VoA were issued during January-November, 2010. The scheme is being extended to five more countries, namely Colombia, Laos, Philippines, Myanmar and Vietnam from January, 2011.

Figure 28.4 shows that a maximum of 16% foreign tourists to India visit from the U.S.A. which is followed by the U.K. (13%). Our neighbouring countries namely Bangladesh and Sri Lanka account for 8% and 5% respectively of the total foreign tourists visiting India. Canada, France and Germany each send 4% foreign tourists to India while Australia, Japan and Malaysia account for 3% each.

Business Tourism

Another healthy trend in the foreign tourism in India since 1991 has been a conspicuous increase in business travel with its spinoff effects in upgradation of accommodation and introduction of new technology in communications and other services. The metropolitan cities like Delhi, Mumbai, Chennai, Kolkata, Bengaluru, Hyderabad, etc. have experienced phenomenal growth in travel by business class people, some of whom combine business with pleasure. This trend has encouraged entrepreneurs and industrial houses to invest in hotel business apart

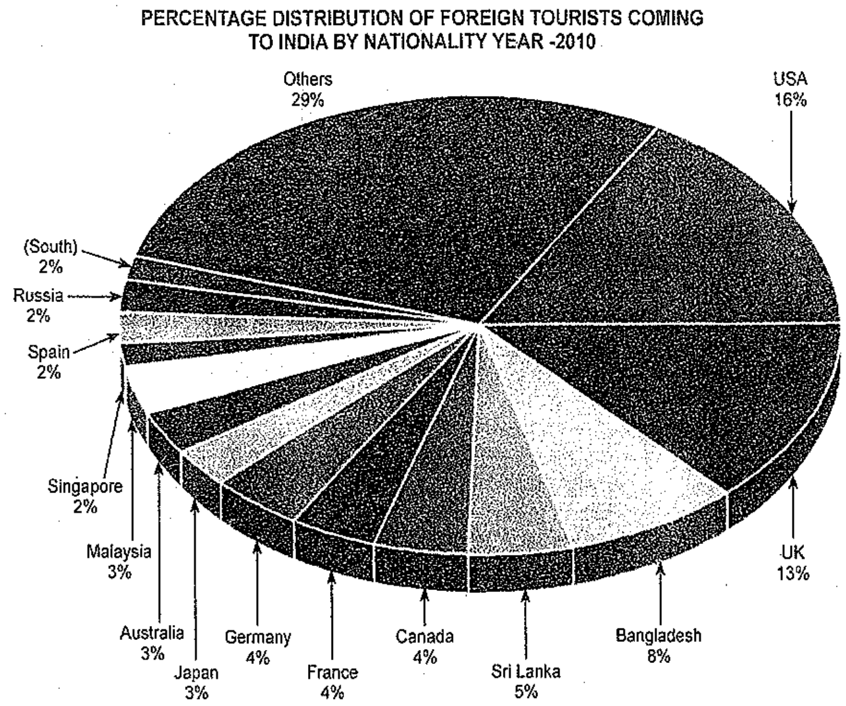

Fig. 28.4. Percentage distribution of foreign tourists coming to India by nationality (2010) (Based on Statistical Year Book, India, 2013)

from the existing chains to go in for large scale expansion and diversification of the hotel industry. On an average, a foreign tourist stays for about 27 days in India, but there are wide variations in the duration of stay by people from different parts of the world. The duration of stay of the foreign tourists in India is an important indicator of foreign exchange earned by the country.

Medical Tourism

Medical tourism is a recent trend which India is increasingly experiencing and is gaining a lot in terms of foreign exchange and goodwill—both in terms of medical treatment and tourist destination. India is fast emerging as a potential destination for medical tourism as foreign patients flee the chronic inefficiency of their own health services to more economical and effective alternatives in New Delhi and other Indian cities.

A report by the consultancy firm McKinsey in 2009 stated that the travel trade could earn upmarket hospitals around $ 2.17 billion by 2012; with thousands of people travelling to India for medical treatment. Patients in U.K. and U.S.A., South Africa, West Asia and South-East Asia are increasingly opting for private Indian hospitals. They are tempted by hospitality, swift treatment, economical pricing and world class quality of treatment. For example, a heart bypass costs £ 500 in India as against £ 5,000 in the U.K. British hip replacement surgery costs £ 6,600 in U.K. while in India it is available for just £ 860. In addition to cost factor, speed is a powerful incentive in India as there is no need for referrals or long waits. This important factor has led to Britain negotiating with some of the top hospitals in New Delhi to bring some of the patients to India who would otherwise have to wait for months or even for years to undergo routine operations on its National Health Service. Besides, patients in U.K. and the U.S.A. cannot avail of their insurance for not-critical treatment, such as knee replacement or cosmetic surgery. Under such circumstances, cost becomes an imperative factor and patients opt for cheapter and good quality good treatment in India.

It is interesting to note that the main demand for medical tourism comes from about 20 million Indians living abroad, although the number of foreigners who are keen to avail of speedy, inexpensive and quality treatment in India is growing at a rapid pace. Two major factors influencing this trend are (*i*) world class private hospitals, and (*ii*) abundant experience of doctors, as many of them have already studied and practised medicine abroad.

The idea of medical tourism picked up fast after 1996 and the number of foreign patients seeking treatment or diagnosis in India, with holiday included, increased rapidly. For example, people from West Asia avoided visiting the U.S.A. and European countries for medical treatment after terrorist attack on the U.S.A. on 11th September, 2001 (known as 9/11 attack) and on London (U.K.) on 7th July, 2005 (known as 7/7 attack) and opted for India instead. Besides, value added services such as transfers from the airport, special food for foreigners and translators for patients not conversant with English have given a much needed boost to medical tourism. Realising the potential of health/medical tourism, top hospitals in Delhi and other major cities of India have initiated a new concept of treatment supplemented by vacation. Some hospitals have gone a step forward and are offering the patients and their relatives/friends stay in the hospital complex with all the luxuries of a five star hotel.

Keeping in view the above developments McKinsey had predicted that medical tourism will account for 3 to 5 per cent of the total health care delivery market by 2012. Industry estimates indicate that the market is growing at an average annual rate of about 30 per cent and medical tourism is easily the next big business in India after Information Technology (IT) revolution.

MEDICAL TOURISTS IN INDIA

- 1,66,000 total number of medical tourists visited India in 2012.
- **From Where**
  1. Asia-Pacific 47.8%, 2. West Asia and North Africa 40.5%, 3. Europe 8.6%, 4. North and South America 2.6%
- **For What**
  1. Cardiology, 2. Cardiothoracic, 3. Orthopaedic, 4. Dentistry, 5. Gastroenterology, 6. Bariatric, 7. Opthalmology and 8. Urology.
- **Globe Trotters**

  Medical tourism as proportion to overall tourism
  1. Thailand 10-11%, 2. Singapore 7-8%, 3. Mexico 4-5%, 4. India 2-3%.

According to PHD Chamber's Medical and Wellness Tourism Report released on July 25, 2014, India is among world's top 5 medical tourism hotspots. As many as 1.66 lakh medical tourists visited India in 2012 and this industry is set to grow to ₹ 36,060 crore by 2018. For details see box.

Domestic Tourism

Domestic tourism is an important segment of the overall tourist scenario although no reliable data are available in this regard. It is relatively easy to keep record of foreign tourists as they are registered at entry points like international airports which is not possible in case of domestic tourists. It may be emphasised here that domestic tourism is no less pronounced than the foreign tourism. In fact, domestic tourists far outnumber foreign tourists. This is by far the largest segment of market with a potential of 20 crore local tourists travelling annually. It is domestic tourism which fosters a sense of unity in the otherwise diverse environment of the country and contributes to national integration. Even if 10 per cent of the population travels outside the native state, it involves a massive movement of over 12.5 crore people who develop the feeling that they are travelling within their own country.

Domestic tourism has increased considerably during the last couple of decades. The improved economy and greater exposure through mass media have developed increasing awareness among the people about tourism; a new dimension to their life style. Larger income, longer holidays coupled with certain incentives given by public and private organisations to their workers, have contributed a lot in infusing interest among the hitherto stay-at-home people, to look around for a place for an annual or biannual visit with family members.

Employment Opportunities in Tourism. Tourism in India has vast employment potential, much of which still awaits exploitation. At present about 20.44 million persons are directly employed by hospitality services. This is about 5.6 per cent of the total work force of the country. By 2020, it would

provide 30 million jobs. In addition, the industry provides indirect employment to about 40 million persons. Further, it is interesting to note that the employment generation in proportion to investment is very high in tourist industry. According to one estimate, an investment of ₹ 10 lakh creates 89 jobs in hotel and restaurant sector as against 44.7 jobs in agriculture and 12.6 in manufacturing industries. The ratio further increases if one takes into account the ancillary services associated with hotels and restaurants. Further, it has been estimated that a spend of $ 1 million in this sector supports 407 jobs as compared to communication services (381 jobs), financial services (329 jobs) and manufacturing (315 jobs). Globally, every unit of investment in travel and tourism directly employs six times more than automotive manufacturing industry, five times more than chemical industry, four times more than mining industry and three times more than financial services industry. Another important aspect of employment in tourism is that it employs a large number of women, both educated and uneducated, as well as skilled and unskilled. In fact, women are greater in number than men in hotels, airline services, travel agencies, handicraft making and cultural activities, etc. Tourism is a labour-intensive industry and is likely to offer more jobs in the coming years. And since most of the natural beauty and wildlife are to be found in non-urban areas, rural people could find employment as guides and transporters; with proper training. More jobs in rural areas would also help reduce continuous migration of people to towns.

The Approach Paper of 12th Five Year Plan highlights the need to adopt "pro-poor tourism" for increasing net benefit to the poor and ensuring that tourism growth contributes to poverty reduction. Tourism plays a key role in socio-economic progress through creation of jobs, entreprise, infrastructure and revenue earnings. The Planning Commission has identified tourism as the second largest sector in the country in providing employment opportunities for low skilled workers.

Hotel Accommodation. The hotel sector forms the key segment of tourism industry. Most of the foreign exchange earned by tourist industry is accounted for by hotel segment. Realising the importance of hotel segment, the Government has taken intiatives to encourage hotel indsutry by providing tax benefits and other incentives. The Industrial Policy has now placed the hotels and tourism related activities as a priority industry. Foreign investment and collaborations are now facilitated under the new economic policy.

The Department of Tourism classifies functioning hotels under the *star system* into various categories from one to five-star deluxe and Heritage (Heritage Classic, Grand and Heritage Renaissance) and Apartment Hotels from three star to five star deluxe. The Department also reclassifies these hotels after every five years to ensure that requisite standards are maintained by them. Heritage hotels have been introduced to cover functioning hotels in palaces, *havelies*, castles, forts and residences built

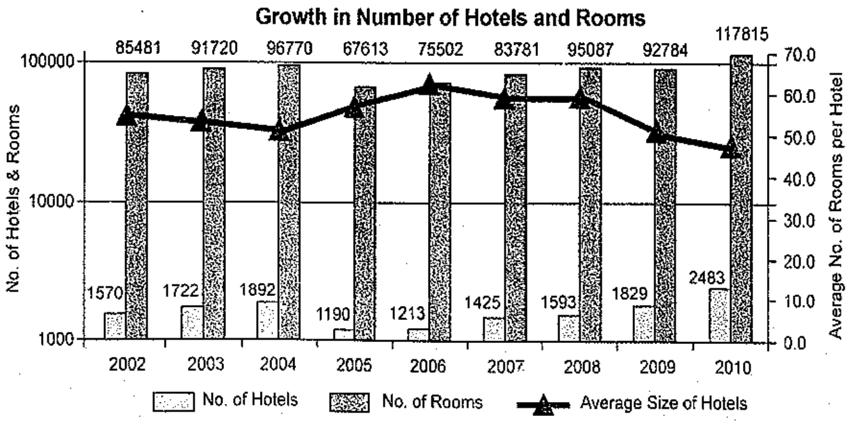

FIG. 28.5. Growth in number of hotels and hotel rooms in India

prior to 1950. Since foreign tourists are crazy about Indian culture and heritage, care has been taken to preserve the original form of the buildings while developing them as heritage hotels. So far, 32 properties have been classified in heritage hotel category providing a room capacity of 972 rooms. Another 38 heritage hotels projects comprising of 710 rooms are in the pipeline. The hotel industry has shown a spectacular growth during the last one decade. Industrial Policy has now placed hotels and tourism related activities as a priority industry. Foreign investment and collaborations are now facilitated under the new economic policy. Automatic approval is available for foreign direct investment (FDI) upto 100 per cent in hotel and tourism sector.

As per information on approved hotels maintained by the Ministry of Tourism, number of rooms increased by 38% in 2010 compared to 2002. while the number of hotels increased by 58% during the same period. It indicates that the average size of the hotels has decreased. This may be in tune with the increasing number of rising middle class budget conscious traveller and growth in demand for that segment.

PLACES OF TOURIST INTEREST

Places of tourist interest are so numerous and of varied nature that it is not easy to describe these places comprehensively. These include places of archaeological and historical importance, pilgrimage centres, sanctuaries and national parks, hill resorts, sea beaches, etc. (**Fig. 28.6**). They are distributed throughout the length and breadth of the country. A brief description of the distribution of tourist places of India is as under :

The Himalayan Region. The Himalayan region is at present, one of the main tourist destinations, not only in India but in the whole of South Asia. Its lofty peaks, snow clad ranges, lush green valleys, turbulent rivers and varied fauna and flora offer a large variety of tourist attractions, games and for skiing, hiking and trekking. The entire length of the Himalayas starting from Jammu and Kashmir in the west to Arunachal Pradesh and Meghalaya in the east is dotted with different types of tourist centres.

Srinagar, Gulmarg, Pahalgam, Patnitop, Jammu, Sonamarg, Amarnath, Vaishno Devi and Leh are the important tourist centres of Jammu and Kashmir. In Himachal Pradesh, there are places like Shimla, Dalhousie, Kangra, Kullu-Manali, Chamba, Kasauli, etc. which attract tourists from far and wide. In the adjoining Himalayan region of Uttarakhand are located famous religious places like Haridwar, Rishikesh, Kedarnath, Badrinath, Gangotri, Yamnotri, Gomukh, etc. Mussoorie, Almora and Nainital are hill stations. The Valley of Flowers presents a unique site in the higher Himalayas. Corbett has the world famous national park.

Towards the east are the famous hill resorts of Darjeeling, Mirik and Kalimpong in West Bengal, Gangtok in Sikkim and Shillong in Meghalaya. Some other places of tourist interest are Kohima in Nagaland, Imphal in Manipur, Aizawl in Mizoram and Agartala in Tripura. At the foothills in Assam are Mannas sanctuary, Soni-Rupa sancturary and Pabha sanctuary for protection of animals like one horned rhinoceros, wild buffaloe, etc.

The Great Plain of North India. Although monotonous from the view point of relief, this vast plain extends from the sandy stretches of Rajasthan in the west to the Sundarbans in the east and possesses a large number of tourist places. These places are of historical, archaeological, religious and industrial importance. It includes large parts of Rajasthan, Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal and Assam, besides the union territories of Delhi and Chandigarh.

The whole of Rajasthan is famous for its palaces, forts, religious places and above all the vast stretches of sand dunes. More than half of the state to the west of the Aravali Range forms part of the Great Plain of North India. Here, Jaisalmer has become very popular during the recent years. Along with Jodhpur and Bikaner, it forms the famous **desert triangle**. In Punjab, Amritsar is an important seat of sikh religion. Jalandhar, Ludhiana, Patiala, Bhatinda and Sirhind are other tourist centres of Punjab. Haryana Tourism has developed several places as tourist centres. They include Ambala, Kurukshetra, Karnal, Panipat, Pinjour, Morni, Pehowa and Faridabad. Surajkund near Faridabad has become famous all over India due to its *annual crafts mela*. Delhi is the capital of the country and represents India in miniature. It has almost all sorts of tourist attractions including historical and administrative buildings, religious

places, museums, parks and gardens, art galleries, etc. Chandigarh, the city beautiful, is one of the few planned cities of India. It is well known for its world famous rock garden, rose garden and Sukhna lake.

The plains of Uttar Pradesh present a grand mixture of Hindu and Islamic cultures. Mathura, Vrindaban, Allahabad, Varanasi, Ayodhya, Sarnath are the sacred cities of Hindu religion. Lucknow,

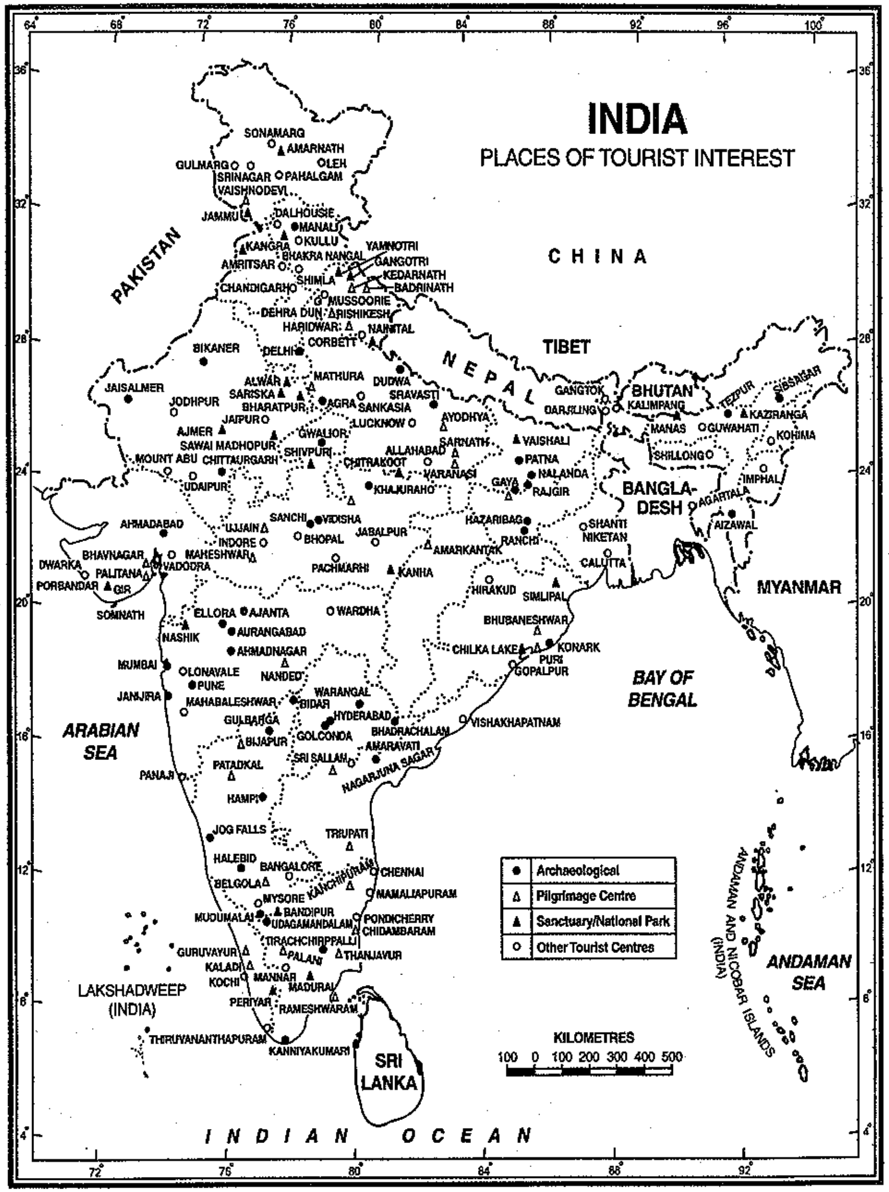

FIG. 28.6. India : Places of Tourist Interest

Agra and Aligarh represent Islamic religion, culture and history. Sarnath is an important Buddhist religious centre. Agra is known for its world famous Taj Mahal. Any foreign tourist who visits Delhi makes it a definite point to visit the Taj at Agra. As a matter of fact, Delhi, Agra and Jaipur form the world famous **Golden Triangle.** In the Bihar Plain are located Patna, Nalanda, Vaisali, Munger and Sitamarhi. In West Bengal, Kolkata is the most important place. This is the capital of West Bengal and is the second largest metropolitan city of India, after Mumbai. Kolkata is often called the nerve centre of the entire eastern region. Shanti Niketan is famous for being the work place of Nobel laureate Gurudev Rabindranath Tagore. Sundarbans, the abode of the Royal Bengal Tigers offers much to the tourists. Murshidabad, Malda and Bishnupur are historical centres. In the Assam plain are located Barpeta, Hajo, Tejpur, Sibsagar and Guwahati. Besides, Orang, Ladkhowa, Golaghat and Kaziranga have wild life sanctuaries.

The Peninsular Plateau and the Coastal Plains. This is a vast area with varied types of physical and cultural landscape and offers wide choice to the tourists. It encompasses a large number of states like Gujarat, Maharashtra, Goa, Madhya Pradesh, Chhattisgarh, Jharkhand, Odisha. Andhra Pradesh, Telangana, Karnataka, Tamil Nadu and Kerala and the union territories of Puducherry, Daman and Diu and Dadra and Nagar Haveli. Besides it includes eastern parts of Rajasthan extending upto Aravali range.

In **Rajasthan** there are several places of tourist interest along the Aravali range and in areas to the east of this range. These include Jaipur, Ajmer, Chittaurgarh, Udaipur, Mount Abu, Alwar, Sariska, Bharatpur, Dholpur, Bundi, Ranthambhor, Sawai Madhopur and many more.

Gujarat was ruled by princely states and is dotted by places of historical and cultural significance. Some of the important towns of this type are Vadodara, Rajkot, Jamnagar, Bhavnagar and Junagadh. Somnath and Dwarka are important places of Hindu religion. Palitana is the sacred hill of Jains. Porbander is famous for being the birth place of Mahatma Gandhi. Gir forest is the sanctuary for lions, the only one of its kind in India. Ahmedabad is an important industrial and archaeological centre.

Maharashtra is very rich in tourist resorts. The state has the world famous Ajanta, Ellora and Aurangabad Caves. There are about 1,545 caves created in India by followers of Buddhist-Hindu and Jain creed, out of which more than 1,200 caves are clustered in Deccan Trap formation of Western Maharashtra. Panchaghani, Mahabaleshwar, Khandala, Lonavala and Matheran are important hill stations on the Western Ghats. The important among the cultural, historical and religious centres are Pune, Nagpur, Nashik, Kolhapur, Aurangabad, Ahmadnagar, Shirdi, Nanded, Wardha and Melghat. Above all, Mumbai is the commercial capital of India and offers several opportunities to tourists.

Goa is a picturesque land full of scenic beauty and abounding places of tourist interest. Tourism forms a major segment of Goa's economy, contributing over 16 per cent of the total earnings of the state. About 20 per cent Goans earn their livelihood directly and indirectly through tourism. Nowhere in India, a tourist will find such a large number of tourist places, in such a small area as in Goa. Goa's forts, churches, temples, evergreen hills, winding rivers, bays, creeks and above all the pearl white palm fringed beaches would leave any visitor to the state spell bound. Goa has more beaches than any other state of comparable size. Among the important beaches are Anjuna, Calangute, Kolva, Vagator, Kandoli, Betul and Palolen. The Western Ghats just touch the coast giving this area a unique combination of sea and hill topography of scenic beauty.

Madhya Pradesh is the state with varied landforms and a unique mixture of Indo-Aryan and the aboriginal cultures. As many as 125 places with potential for tourist attraction have been identified, out of which 16 major tourist places have been taken into account for development to attract foreign tourists. They include places of different varieties such as historical and archaeological (Gwalior, Mandu, Khajuraho, Orchha, Sanchi, Udaigiri, Gyaraspur), natural setting (Marble rocks, Pachmarhi), religious (Amarkantak, Chitrakoot, Maheshwar, Ujjain) and wildlife (Bandhavgarh National Park, Kanha National Park and Shivpuri National Park). In *Chhattisgarh*, most of the places of tourist interest are in Bastar area.

The **Chota Nagpur** plateau of Jharkhand is a combination of mineral wealth, cultural heritage and natural beauty. Ranchi, Gunha, Dumka, Jamshedpur, Dhanbad, etc. are the main centres of tourist interest.

Odisha has several tourist centres. The major centres are Puri, Bhubaneshwar, Cuttack, Konarka, Chilka lake and Gopalpur beach. The other places are Baripada, Khiching, Bauda, Koraput, Bolangir, Jajpur and Udayagiri.

Andhra Pradesh and Telangana attract large number of tourists, both foreign and domestic, for its historical places like Hyderabad, Golconda Fort and Warangal and relgious centres like Tirupati, Tirumala, Sri Kalahasti, Sri Sailam, Mahanadi and Mukhalingapuram. Besides, there are other tourist centres like Nagarjuna Sagar, Kolleru and Mangunapudi.

Karnataka is famous for its gardens, historical and religious places and natural beauty spots. The Brindavan Garden near Mysore could be the envy of any beautiful garden in the world. Bengaluru, the garden city, is the capital of the state and is famous for many industries. Some of the important historical and religious centres are Mysore, Bijapur, Gulbarga, Bidar, Nandi Hill, Shravan Belgola, Shrirangapattam, Chamundi, Belur, Halebid, Chitradurga, etc. Ranganthitto bird sanctuary, Bandipur and Dendilio wildlife sanctuary, Jog Falls on Sharavati river along with Madog Falls and Lushington falls and the beaches of Murudesvar, Maravanthe, Malpe, etc. are the other major tourist attractions.

Tamil Nadu is famous for its renowned temples at Rameshwaram, Madurai, Thanjavur, Tiruchchirappalli, Tiruvannamalai, Kanchipuram, etc. The state also boasts of famous hill stations like Udagamnadlam (Ooty). Kodaikanal, Coonoor and Yercaued. The capital city of Chennai with its Marina beach and Golden beach and several religious and historical buildings, is a great tourist attraction. Kanniyakumari is the southern-most tip of the mainland of the country where waters of Arabian Sea, Bay of Bengal and Indian Ocean merge with one another. It is world famous for its Rock Memorial. Mudumalai, Anaimalai and Mundanthurai have wildlife sanctuaries.

Kerala is not lagging behind with respect to tourism. The state is blessed with several places having buildings of historical and architectural importance, beautiful sea beaches, wildlife sanctuaries and some hill resorts. The main places of tourist interest are Thiruvananthapuram, Kochi, Alappuzha, Kannur, Thrissur, Kozhikode, Ernakulam, Malayatoor, Idukki, Periyar, Munnar, Thekdi, etc.

Among the union territories, Puducherry has the famous Aurobindo Ashram along with some other places of historical and religious importance. Daman and Diu on the Arabian Sea coast have a beach and some religious and historical places.

Islands. India has two groups of islands. They are having picturesque landscape and are fast becoming major tourist attractions. The Andaman and Nicobar Islands in the Bay of Bengal have beautiful beaches, lush green tropical rain forests and a vast variety of oceanic life in the blue seas surrounding them. Port Blair is the main tourist spot. The Lakshadweep group of islands is of coral origin and attracts tourists from far and wide.

PROBLEMS AND PROSPECTS

Although India has progressed a lot since 1950s with respect to tourism, she is still way behind the developed or even the developing countries. India's share in the tourist arrival has been growing at a snails pace from 0.23 per cent in 1975 to 0.28 per cent in 1980 and 0.42 per cent in 2004. Even now, it is less than one per cent of the world tourist arrivals and is much less than he other South Asian countries like Singapore, Malaysia, Thailand, Hong Kong, Macao, etc. Even the diminutives like Maldives and Bhutan present an appreciable model of sustainable tourism by integrating environment and tourism. In India, tourism provides 5.6 per cent of the total jobs, China that just pulled away its iron curtain, is doing better with 7 per cent. Torn apart by civil war Sri Lanka still has 7.4 per cent of its jobs coming from the tourism sector. Travel is a happening business in Thailand, generating 11.2 per cent of the total jobs.

Still there are large areas which are untapped from the tourist point of view. Traditionally a popular destination, North India still draws about 49 per cent of the tourists; whereas only 4 per cent go to east. West is doing better getting 29 per cent of the tourist inflow. South, despite its beaches, temples, hills, etc. gets only 18 per cent of foreign and domestic tourists. Thus there is great potential for development of

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