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GEOGRAPHY PART 2

UPSC MATERIAL

Student Notes:

CLIMATE OF INDIA

Contents

Student Notes:

1. Introduction

Climate is an important element of the physical environment of mankind. It is the aggregate of atmospheric conditions involving heat, moisture and air movement. In a developing country **like India climatic characteristics have a dominant role in affecting the economic pattern**, way of life, mode of living, food preferences, costumes and even the behavioural responses of the people. In India despite a lot of scientific and technological developments our dependence on monsoon rainfall for carrying out successful agricultural activities, has not been minimized.

The climate of India belongs to the '**tropical monsoon type**' indicating the impact of its location in tropical belt and the monsoon winds. Although a sizeable part of the country lying north of the Tropic of Cancer falls in the northern temperate zone but the shutting effects of the Himalayas and the existence of the Indian Ocean in the south have played significant role in giving **India a distinctive climatic characteristics.**

1.1. Salient Features of Indian Climate

Following are the salient features of the Indian climate:

- **Reversal of winds** – the Indian climate is characterized by the complete reversal of wind system with the change of season in a year. During the winter season winds generally blow from north-east to south-west in the direction of trade winds. These winds are dry, devoid of moisture and are characterized by low temperature and high pressure conditions over the country. During summer season complete reversal in the direction of the winds is observed and these blow primarily from south-west to north-east.
- **Formation of Alternatively High and Low pressure areas over the land** – there is a change in the atmosphere pressure conditions with the change of season. During **winter season** due to low temperature conditions **high pressure areas is formed over the northern part** of the country. On the other hand the intense heating of the land during **summer season** leads to the formation of a thermally induced **low pressure cell** over the north-western part of the country. These pressure areas control the direction and intensity of wind.
- **Seasonal and variable rainfall** – In India over 80 per cent of annual rainfall is obtained in the latter part of the summer whose duration ranges from 1-5 months in different parts of the country. Since the rainfall is in the form of heavy downpour, it creates problems of floods and soil erosion. Sometimes there is continuous rain for many days and sometimes there is a long spell of dry period. Similarly, there is a spatial variation in the general distribution of rainfall. Cherrapunji has received in a single day an amount equal to 10 years of rainfall at Jaisalmer, Rajasthan.

  In fact Indian climate is so varied and complex that it denotes climatic extremes and climatic varieties. While it provides enough heat to grow crops and carry on agricultural activities all over the country it also helps in the cultivation of a number of crops belonging to tropical, temperate as well as frigid[1] areas.

- **Plurality of seasons** – the Indian climate is characterized by constantly changing weather conditions. There are **three main seasons** but on broader consideration their number goes to six a year (winter, fall of winter, spring, summer, rainy and autumn).
- **Unity of Indian Climate** – the Himalayas and the associated mountain ranges extend to the north of India from east to west. These tall mountain ranges prevent the cold northerly winds of Central Asia from entering into India. Therefore, even the parts of India extending

[1] The Polar Regions have a very cold climate. These places are sometimes called the Frigid Zones.

north of the Tropic of Cancer experience a tropical climate. These ranges force the monsoon winds to cause rainfall over India and the entire country comes under the influence of the monsoon winds. In this manner the climate in the entire country becomes monsoon type.

- **Diversity of Indian Climate** – In spite of the unity of Indian climate, it is characterized by regional differences and variations. For example, while in the summer the mercury occasionally touches 55°C in the western Rajasthan, it drops down to as low as minus 45°C in winter around Leh. These differences are visible in terms of winds, temperature, rainfall, humidity and aridity etc. These are caused by differences in the location, altitude, distance from the sea, distance from mountains and general relief conditions at difference places.
- **Characterized by natural calamities** – Due to its peculiar weather conditions especially rainfall the Indian climate is characterized by natural calamities like floods, droughts, famines and even epidemics.

2. Factors Determining the Climate of India

India's climate is controlled by a number of factors which can be broadly divided into two groups –

- Factors related to Location and Relief
- Factors related to air pressure and winds

2.1. Factors Related to Location and Relief

- **Latitude** - the Tropic of Cancer passes through the central part of India in east-west direction. Thus, northern part of the India lies in sub-tropical and temperate zone and the part lying south of the Tropic of Cancer falls in the tropical zone. The tropical zone being nearer to the equator, experiences high temperatures throughout the year with small daily and annual range. Area north of the Tropic of Cancer being away from the equator, experiences extreme climate with high daily and annual range of temperature.
- **The Himalayan Mountains** – as already discussed, the lofty Himalayas in the north along with its extensions act as an effective climatic divide between central Asia and Indian subcontinent. The cold and chilly winds that originate near the Arctic Circle are obstructed by the Himalayas and give a distinctive taste to climate of India.
- **Distribution of Land and Water** – India is flanked by the Indian Ocean on three sides in the south and girdled by a high and continuous mountain-wall in the north. **As compared to the landmass, water heats up or cools down slowly**. This **differential heating of land and sea creates different air pressure zones** in different seasons in and around the Indian subcontinent.
- **Distances from the Sea** – With a long coastline, large coastal areas have an equable climate. Areas in the interior of India are far away from the moderating influence of the sea. Such areas have extremes of climate. That is why, the people of the Konkan coast have hardly any idea of extremes of temperature and the seasonal rhythm of weather. On the other hand, the seasonal contrasts in weather at places in the interior of the country such as Kanpur and Amritsar affect the entire sphere of life.
- **Altitude** – Temperature decreases with height. Due to thin air, places in the mountains are cooler than places on the plains[2]. For example, Agra and Darjiling are located on the same latitude, but temperature of January in Agra is 16°C whereas it is only 4°C in Darjiling.

[2] Thin air=> low pressure=> low temperature

Student Notes:

- **Relief** – The physiography or relief of India also affects the temperature, air pressure, direction and speed of wind and the amount and distribution of rainfall. The windward sides of Western Ghats and Assam receive high rainfall during June-September whereas the southern plateau remains dry due to its leeward situation along the Western Ghats.

2.2. Factors Related to Air Pressure and Wind

Air pressure and wind system is different at different altitude which affects the local climates of India. Consider the following factors:

- Distribution of pressure and surface winds.
- Upper air circulation and the movement of different air masses and the jet stream.
- Rainfall caused by the westerly disturbances in winter and the tropical depressions in south-west monsoon season.

The mechanism of these three factors can be understood with reference to winter and summer seasons of the year separately.

2.3. Weather Conditions in Water

- **Surface Pressure and Winds** – During northern hemisphere's winter, high pressure is built up in the Central and West Asia. This centre of high pressure gives rise to the flow of air at the low level from the north towards the Indian subcontinent, south of the Himalayan mountain range, in the form of a dry continental air mass. These continental winds come in contact with trade winds over northwestern India. The contact zone is not stable and sometimes it shifts up to the middle Ganga valley thus bringing the entire north-western India under the influence of the north-westerly winds.

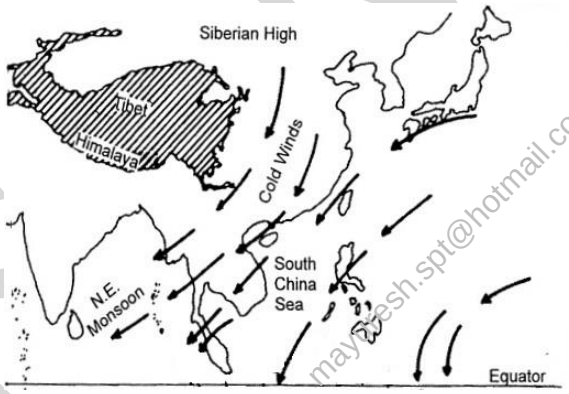


Figure 1 – Winter Monsoon: Surface Winds

- **Jet stream and Upper Air Circulation** – a different pattern of air circulation is observed at a height of about 3 km above the surface. Direction and velocity of winds at this height are different from those of the surface winds. All of Western and Central Asia remains under the influence of westerly winds along the altitude of 9-13 km from west to east (Figure 2). These winds blow across the Asian continent at latitudes north of the Himalayas roughly parallel to the Tibetan highlands. These are known as Jet Streams[3]. Tibetan highlands act as a barrier in the path of these jet streams. As a result, jet streams gets bifurcate – one to the south and other to the north of this mountain chain along 25° N latitude. This jet stream is

[3] For more details about jet stream, See document "INSOLATION, EARTH'S HEAT BALANCE, DIFFERENT ATMOSPHERIC…"

responsible for bringing western disturbances[4] from the Mediterranean region into Indian sub-continent. Winter rain and hail storms in northwestern plains and occasional heavy snowfall in hilly regions are caused by these disturbances.

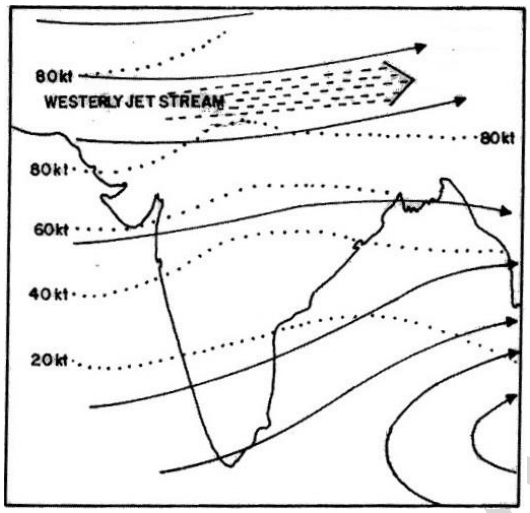


Figure 2 - Direction of Winds in India in winter at the Height of 9-13 km

- **Western Cyclonic Disturbance and Tropical Cyclones** – The western cyclonic disturbances which enter the Indian subcontinent from the west and the northwest during the winter months originate over the Mediterranean Sea and are brought into India by the westerly jet stream. An **increase in the prevailing night temperature** generally indicates an advance in the arrival of these cyclones disturbances. It brings little rain in winter months. This rain is considered to be very good for wheat crops in northern plains.

  Tropical cyclones originate over the Bay of Bengal and the Indian Ocean. These tropical cyclones have very high wind velocity and heavy rainfall and hit the Tamil Nadu, Andhra Pradesh and Orissa coast. Most of these cyclones are very destructive due to high wind velocity and torrential rain that accompanies it.

2.4. Weather Conditions in the Summer Reason

- **Surface Pressure and Winds** - As the summer sets in and the sun shifts northwards, the wind circulation over the subcontinent undergoes a **complete reversal** at both, the lower as well as the upper levels. By the middle of July, the low pressure belt nearer the surface, termed as Inter Tropical Convergence Zone (ITCZ), shifts northwards, roughly parallel to the Himalayas between 20° N and 25° N (Figure 3). It extends from Punjab to the Chota Nagpur plateau. By this time, the westerly jet stream withdraws from the Indian region. There is a cause and effect relationship between the northward shift of the ITCZ and the withdrawal of the westerly jet stream from over the North Indian Plain.

  Being an area of low pressure, the ITCZ attracts winds from all around. The maritime tropical airmass (mT) from the southern hemisphere, after crossing the equator, rushes to the low pressure area in the general southwesterly direction (Figure 4). These winds cross the Equator between 40°E and 60°E longitudes. Blowing over the ocean for a long distance, they pick up a large amount of moisture. It is this moist air current which is popularly known as **the southwest monsoon**.

[4] For more details about extra-tropical cyclones (known as western disturbances in Indian subcontinent), See document "INSOLATION, EARTH'S HEAT BALANCE, DIFFERENT ATMOSPHERIC…"

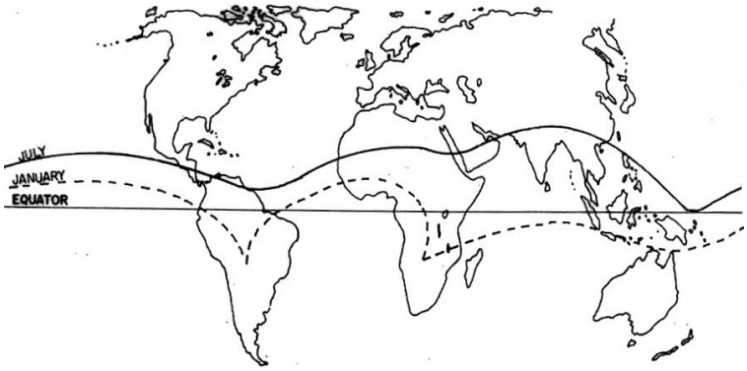


Figure 3 – position of Inter-tropical Convergence Zone (ITCZ) in the month of January and July

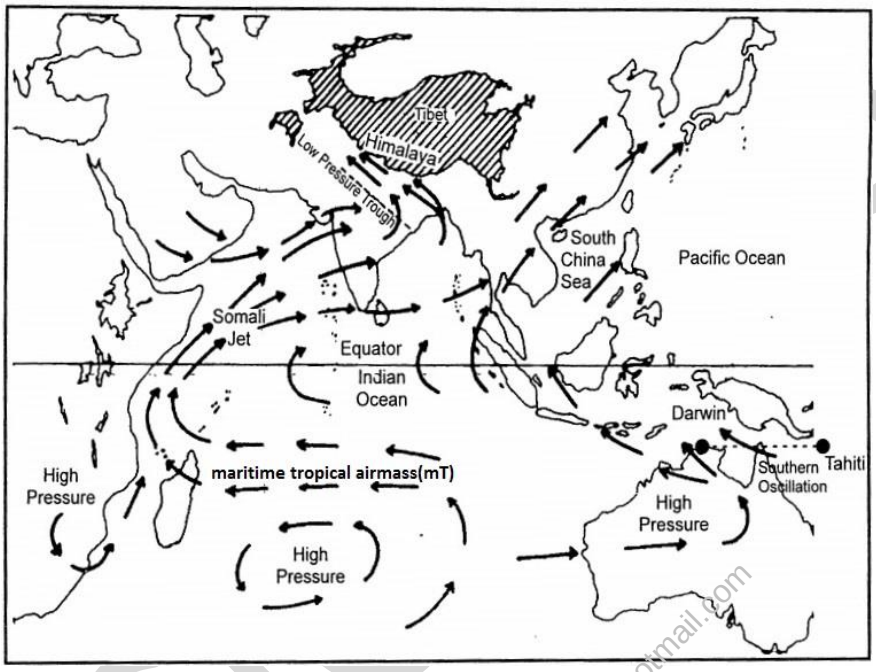


Figure 4 – summer monsoon winds: Surface circulation

- **Jet Streams and Upper Air Circulation** – at the upper layers of the troposphere, the winds blow in a direction reverse to that of the surface winds. An easterly jet stream flows over the southern part of the Peninsula in June, and has a maximum speed of 90 km per hour (Figure 5). In August, it is confined to 15° N latitude, and in September up to 22° N latitudes.

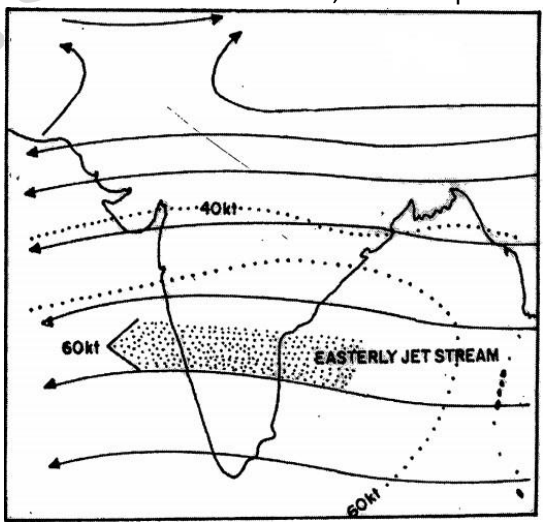


Figure 5 – The direction of winds at upper atmosphere in summer season

- **Tropical cyclones** – The easterly jet stream steers the tropical depressions into India. These depressions play a significant role in the distribution of monsoon rainfall over the Indian subcontinent. The tracks of these depressions are the areas of highest rainfall in India. Their frequency, direction and intensity determine the rainfall pattern during the southwest monsoon period.

3. Indian Monsoon

We already know that India's climate is 'tropical monsoon' type. The word '**monsoon'** has been derived from the Arabic word 'Mausim' which **means 'season'**. Originally, this word was used by Arab traders to describe a system of seasonal reversal of winds along the shores of the Indian Ocean. Monsoons are especially prominent within the tropics on the eastern sides of the great landmass, but in Asia, it occurs outside the tropics in China, Korea and Japan.

Monsoon is a complex meteorological phenomenon. Experts of meteorology have developed a number of concepts about the origin of the monsoon. Some of the important concepts about the origin of monsoon have been given as under.

3.1. Thermal Concept

Halley, a noted astronomer, hypothesized that the primary cause of the annual cycle of the Indian monsoon circulation was the differential heating effects of the land and the sea. According to this concept monsoon are the extended land breeze and sea breeze on a large scale. During winter the huge landmass of Asia cools more rapidly than the surrounding oceans with the result that a strong high pressure centre develops over the continent. On the other hand, the pressure over adjacent oceans is relatively lower. As a consequence the pressure-gradient directed from land to sea. Therefore there is an outflow of air from the continental landmass towards the adjacent oceans so that it brings cold, dry air towards the low latitudes.

In summer the temperature and pressure conditions are reversed. Now, the huge landmass of Asia heats quickly and develops a strong low pressure centre. Moreover, the pole-ward shift of the Inter-tropical Convergence Zone (ITCZ) to a position over Southern Asia reinforces the thermally induced low pressure centre. The pressure over the adjacent oceans being high, a sea-to-land pressure gradient is established. The surface air flow is, therefore, from the highs over the oceans towards the lows over the heated land. The air that is attracted into the centers of low pressure from over the oceans is warm and moist.

Halley's concept is **criticized** on following lines:

- It **fails to explain the intricacies of monsoon** such as sudden burst of monsoon, breaks in monsoon, spatial and temporal distribution of monsoon.
- The low pressure areas are not stationary. The rainfall is not only convectional but a mix of orographic, cyclonic and convectional rainfall.

3.2. Recent Concept about the Origin of Indian Monsoon

After world war second, the upper atmospheric circulation has been studied significantly. It is now believed that the differential heating of sea and land alone can't produce the monsoon circulation. Apart from it, **recent concept of monsoon** rely heavily on the role of

- Himalayas and Tibetan plateau as a physical barrier and a source of high-level heat.
- Circulation of upper air jet streams in the troposphere.
- Existence of upper air circum-polar whirl over north and south poles in the troposphere.
- The occurrence of ENSO (El-Nino and Southern Oscillation) in the South Pacific ocean
- Walker cell in Indian Ocean.
- Indian Ocean Dipole

3.2.1. Role of Himalayas and Tibetan Plateau

In 1970s, it was found that Tibet plateau plays a crucial role in initiating the monsoon circulation. The plateau of Tibet extends over an area of about 4.5 million sq. km. The average height of these highlands is 4000 m. Due to its enormous height it receives 2-3°C more insolation than the neighbouring areas. Heating of these areas leads to a clockwise air circulation in the middle troposphere and two-wind streams originate from this area. One of these wind streams blow southward and develops into the tropical easterly jet stream (TEJ). The other stream blows in an opposite direction towards the North Pole and becomes the westerly jet stream over Central Asia.

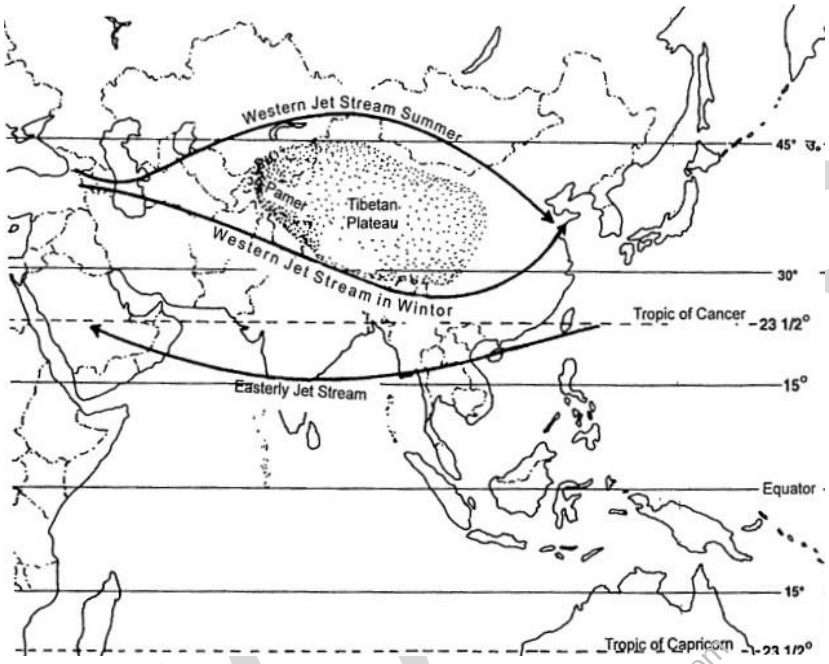


Figure 6 – Tibet anti-cyclone and Easterly Jet stream

3.2.2. Role of Jet Stream

As already discussed, sub-tropical westerly jet stream is bifurcated by the high-land Tibet in winters. Northward branch extends up to 20°N-35°N (Figure 6). Tropical easterly jet stream (TEJ), that branch off from anticyclone developed over Tibet, sometimes reaches to the tip of Peninsular India. Apart from this, Jet speed winds are also reported over other parts of Peninsular. This jet descends over the Indian Ocean and intensifies its high pressure cell known as **Mascarene High**. It is from this high pressure cell that the onshore winds start blowing towards the thermally induced low pressure area, developed in the northern part of the Indian subcontinent. After crossing the equator such winds become south-westerly and are known as the south-westerly summer monsoon.

3.2.3. Role of ENSO

The Indian monsoon is also influenced by EL-Nino, southern oscillation and Somalian current. We know that El Nino is the reversal of normal condition in the Pacific Ocean's sea surface temperature. Though there is no direct correlation between bad monsoon and El Nino, but both are generally associated. There are years when India faced severe drought and those are not El Nino years and vice-versa. Southern Oscillation is the see-saw pattern of atmospheric pressure between the eastern and western Pacific Ocean. The oscillation has a period varying from 2-7 years. It is measured with **Southern Oscillation Index (SOI)** by measuring pressure difference between two points in Pacific Ocean (Tahiti and Darwin). A negative value of SOI implies high pressure over north Indian Ocean during the winter season and a poor monsoon.

The **Somalian current** changes its direction of flow after every six months. During the North-East Monsoon the Somali Current flows to the south-west, while during the South-West Monsoon it is a major western boundary current, comparable with the Gulf Stream (Figure 7). Normally, there remains a low pressure area along the eastern coast of Somalia. In exceptional years, after every six or seven years, the low pressure area in western Arabian Sea becomes a high pressure area. Such a pressure reversal results into a weaker monsoon in India.

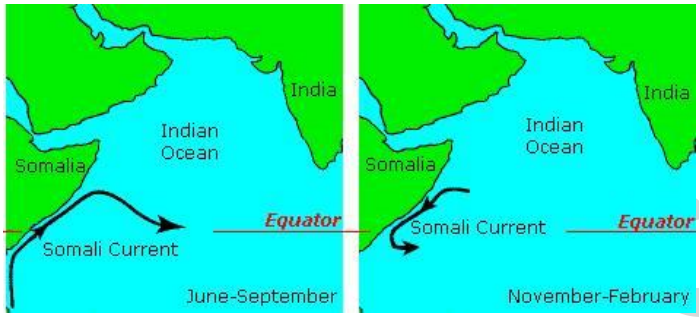


Figure 7 – Somali current

3.2.4. Walker Cell

It is observed that there is an **east-west atmospheric circulation** over the tropical oceanic regions. Such circulation in Pacific Ocean is generally called walker cell. However, many scientists use the term 'walker cell' for all east-west circulations in different oceans. Walker cell is associated with southern oscillation and its strength fluctuates with that of Southern Oscillation Index (SOI). With a high positive SOI, there would be a zone of low atmospheric pressure over Australia and Indonesian archipelago. The rising air from this region deflects in upper atmosphere in both directions towards Africa and South America. In Indian Ocean, the air descends down at high pressure zone from where surface winds blow as Southwest monsoon towards Indian sub-continent in summers. During La-Nina Indian ocean branch of walker cell get strengthen and surface winds are more intense. **La-Nina condition is generally associated with good monsoon.**

During appearance of El-Nino or negative SOI, the ascending branch of the walker cell shifts to the central regions of the Pacific Ocean from west pacific region (Figure 8). In result, the Indian Ocean cell shifts towards east. The surface winds or Southwest monsoon winds are weaker than normal conditions.

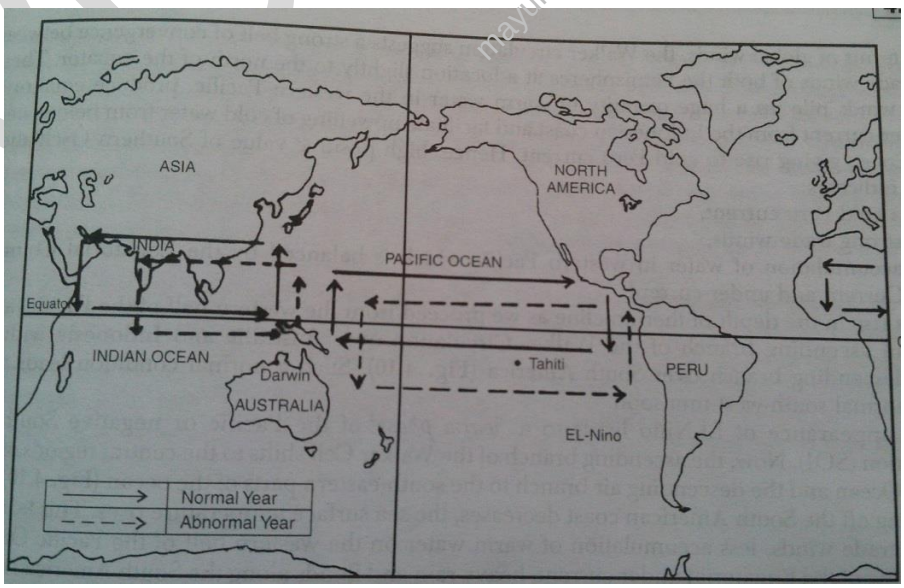


Figure 8 – walker cell and Indian Monsoon

3.2.5. Indian Ocean Dipole

The Indian Ocean Dipole (IOD) also known as the Indian Nino is a coupled Ocean-atmosphere phenomenon in the Indian Ocean. It is defined by the difference in sea surface temperature between two areas (or poles, hence a dipole) – a western pole in the Arabian Sea (western Indian Ocean) and an eastern pole in the eastern Indian Ocean south of Indonesia. The IOD involves a periodic oscillation of sea-surface temperatures (SST), between "positive", "neutral" and "negative" phases. A **positive phase** sees greater-than-average sea-surface temperatures and greater precipitation in the western Indian Ocean region, with a corresponding cooling of waters in the eastern Indian Ocean—which tends to cause droughts in adjacent land areas of Indonesia and Australia (Figure 9). The negative phase of the IOD brings about the opposite conditions, with warmer water and greater precipitation in the eastern Indian Ocean, and cooler and drier conditions in the west.

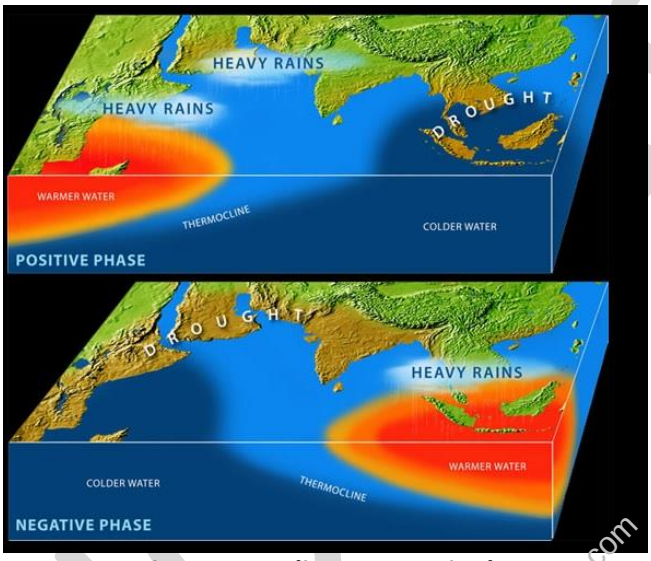


Figure 9 – Indian Ocean Dipole

The IOD is one aspect of the general cycle of global climate, interacting with similar phenomena like the El Niño-Southern Oscillation (ENSO) in the Pacific Ocean. Positive and negative IOD both has been seen coupled with La Nina. Thus, there is no direct correlation between IOD and ENSO.

The IOD also affects the strength of monsoons over the Indian subcontinent. Positive IOD which is associated with warm sea-surface temperatures of western Indian Ocean is favourable for monsoon in Indian subcontinent.

3.3. Nature of Indian Monsoon

Systematic studies of the causes of rainfall in the South Asian region help to understand the salient features of the monsoon, particularly some of its important aspects, such as:

- Onset and advance of monsoon
- Rain-bearing systems and the relationship between their frequency and distribution of monsoon rainfall.
- Break in the monsoon
- retreat of the monsoon

3.4. Onset and Advance of Monsoon

The differential heating of land and sea is still believed to be the primary cause of the monsoon by many meteorologists. Low pressure at ITCZ which is located over north India in month of

May becomes so intense that it pulls the trade winds of the southern hemisphere northwards (Figure – summer monsoon winds). These southeast trade winds cross the equator and enter the Bay of Bengal and the Arabian Sea, only to be caught up in the air circulation over India. Passing over the equatorial warm currents, they bring with them moisture in abundance. With the northwards shift of ITCZ, an easterly jet stream develops over 15°N.

The rain in the south-west monsoon season begins rather abruptly. One result of the first rain is that it brings down the temperature substantially. This sudden onset of the moisture-laden winds associated with violent thunder and lightning, is often termed as the "break" or "burst" of the monsoons.

Southwest monsoon first of all reaches in Andaman-Nicobar Islands on 15th May. Kerala coast receives it on 1st June. It reaches Mumbai and Kolkata between 10th and 13th June. By 15th of July, Southwest monsoon covers whole of India (Figure 10).

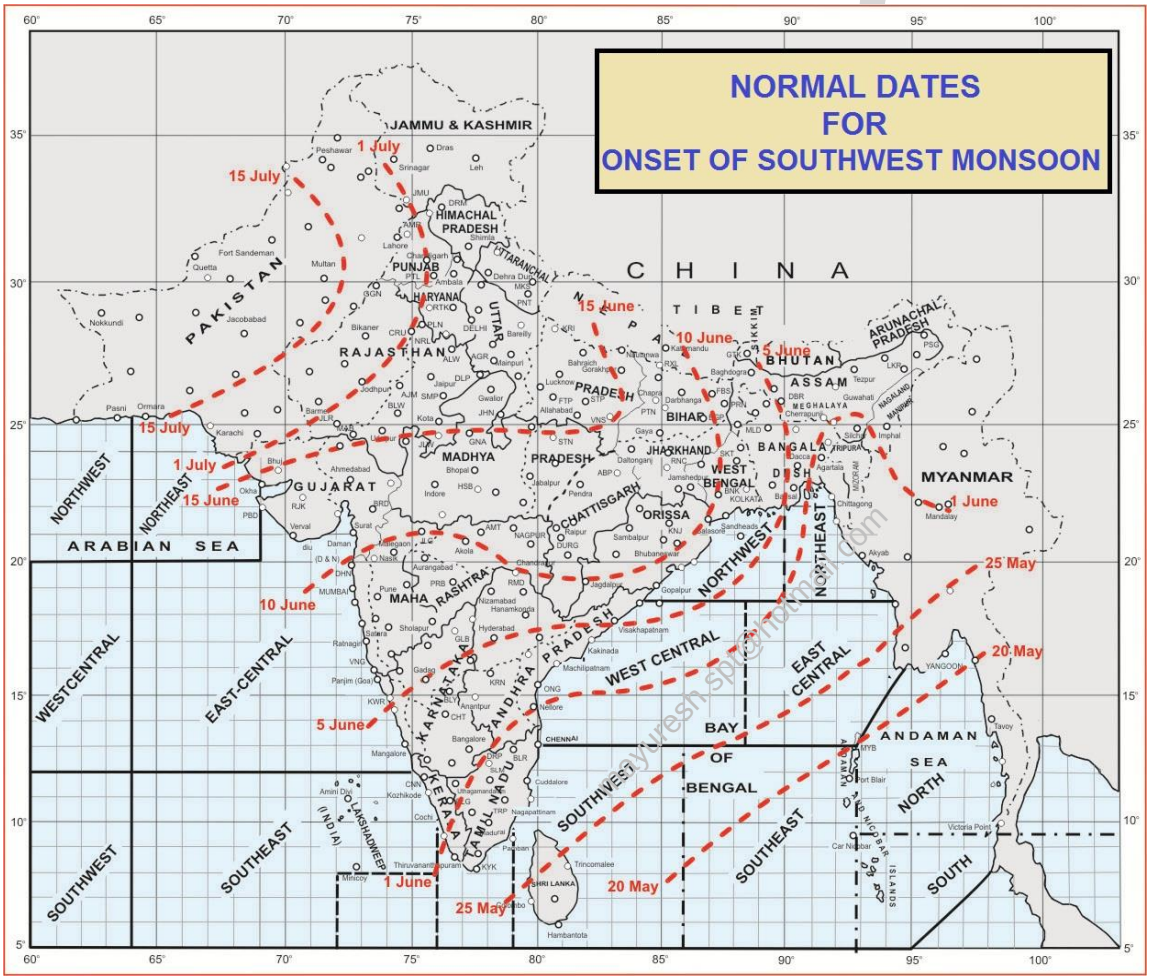


Figure 10 – India: Normal dates of Onset of the Southwest Monsoon

3.5. Rain Bearing Systems and Distribution of Rainfall

The southwest monsoon splits into two branches, the Arabian Sea Branch and the Bay of Bengal Branch near the southernmost end of the Indian Peninsula. Hence, it arrives in India in **two branches: the Bay of Bengal branch and the Arabian Sea Branch** (Figure 11). First originate in the Bay of Bengal causing rainfall over the plains of north India. Second is the Arabian Sea current of the southwest monsoon which brings rain to the west coast of India. The latter extends toward a low-pressure area over the Thar Desert and is roughly three times stronger than the Bay of Bengal branch.

The monsoon winds originating over the **Arabian Sea** further split into **three branches**:

- One branch is **obstructed by the Western Ghats**. These winds climb the slopes of the Western Ghats and as a result of orographic rainfall phenomenon, the windward side of Ghats receives very heavy rainfall ranging between 250 cm and 400 cm. After crossing the Western Ghats, these winds descend and get heated up. This reduces humidity in the winds. As a result, these winds cause little rainfall east of the Western Ghats. This region of low rainfall is known as the **rain-shadow area.**
- Another branch of the Arabian Sea monsoon **strikes the coast north of Mumbai**. Moving along the Narmada and Tapi river valleys, these winds cause rainfall in extensive areas of central India. The Chotanagpur plateau gets 15 cm rainfall from this part of the branch. Thereafter, they enter the Ganga plains and mingle with the Bay of Bengal branch.

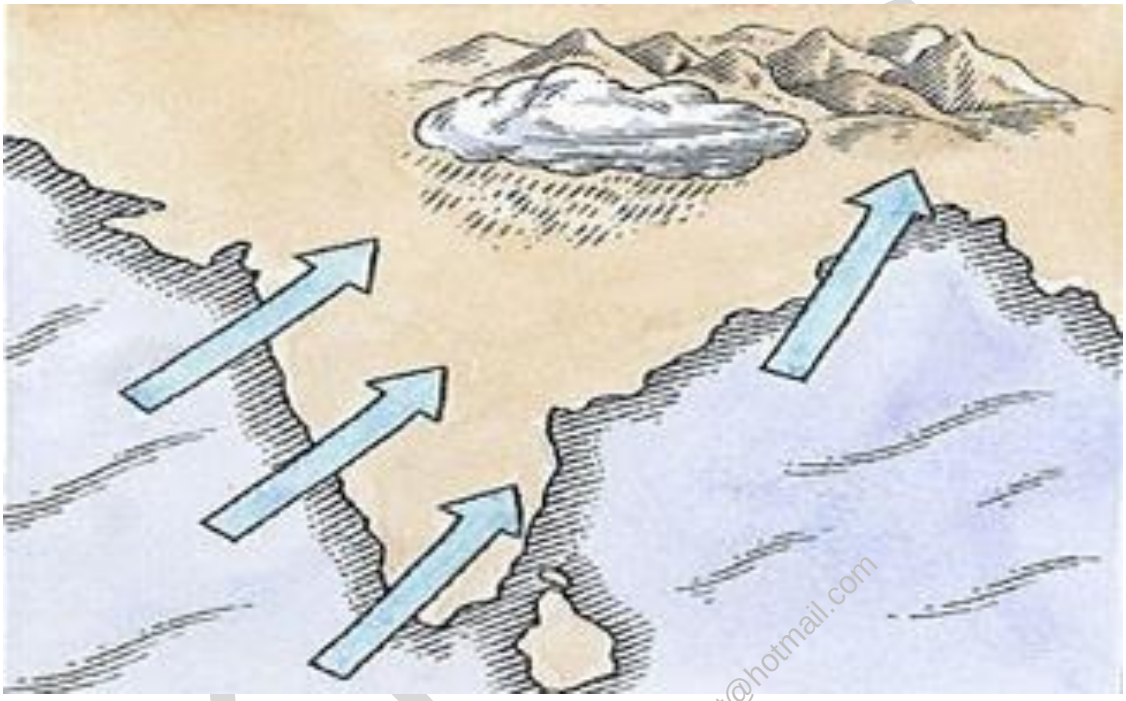


Figure 11 – Arabian Sea and Bay of Bengal branches of Southwest Monsoon

- A third branch of this monsoon wind **strikes the Saurashtra Peninsula and the Kutch**. It then passes over west Rajasthan and along the Aravallis, causing only a scanty rainfall. In Punjab and Haryana, it too joins the Bay of Bengal branch. These two branches, reinforced by each other, cause rains in the western Himalayas.
- The intensity of rainfall over the west coast of India is, however, related to two factors:
  - The offshore meteorological conditions.
  - The position of the equatorial jet stream along the eastern coast of Africa.

The Bay of Bengal branch strikes the coast of Myanmar and part of southeast Bangladesh. But the Arakan Hills along the coast of Myanmar deflect a big portion of this branch towards the Indian subcontinent. The monsoon, therefore, enters West Bengal and Bangladesh from south and southeast instead of from the south-westerly direction. From here, this branch splits into two under the influence of the Himalayas and the thermal low is northwest India.

- One branch moves westward along the **Ganga plains** reaching as far as the Punjab plains.
- The other branch **moves up the Brahmaputra valley** in the north and the northeast, causing widespread rains. Its sub-branch strikes the Garo and Khasi hills of Meghalaya. **Mawsynram**, located on the crest of Khasi hills, receives the **highest average annual rainfall** in the world.

- The Tamil Nadu coast remains dry during this season because it is situated in rainshadow area of Arabian Sea branch of the south-west monsoon and lies parallel to the Bay of Bengal branch of south-west monsoon.

Frequency of tropical depressions originating over the Bay of Bengal varies from year to year. The path of these depressions also keeps changing with the position of the ITCZ, also known as **monsoon trough** (Figure – position of Inter-tropical Convergence Zone (ITCZ) in the month of January and July). As the axis of the monsoon trough oscillates with the apparent movement of sun between Tropic of Cancer and Tropic of Capricorn, there are fluctuations in the track and direction of these depressions, and the intensity and the amount of rainfall vary from year to year. The amount of rainfall in north India varies with the frequency of the tropical depressions. On an average, one to three depressions are observed every month and the life span of one depression is about one week [4].

The rain which comes in spells, displays a declining trend from west to east over the west coast, and from the southeast towards the northwest over the North Indian Plain and the northern part of the Peninsula. Rajasthan desert receives low rainfall in spite of being in the path of Arabian Sea branch of monsoon. This branch blows parallel to Aravalis mountain chain without obstruction and thus, does not release moisture here.

3.6. Break in the Monsoon

During the south-west monsoon period after having rains for a few days, if rain fails to occur for one or more weeks, it is known as break in the monsoon. These dry spells are quite common during the rainy season. These breaks in the different regions are due to different reasons:

1. In northern India rains are likely to fail if the rain-bearing storms are not very frequent along the monsoon trough or the ITCZ over this region.
2. Over the west coast the dry spells are associated with days when winds blow parallel to the coast.

3.7. Retreat of Monsoon

Monsoon starts retreating in September (Figure 12). On the first of September it starts retreating from north-western part of India. This day is the last day of rainy season in Jaisalmer and Barmer in Rajasthan. By 15th September, monsoon leaves Punjab, Haryana, Rajasthan and Gujarat. The area under the monsoon influence shrinks slowly and the monsoon retreats from all parts of India except the southern peninsular region. Monsoon winds in most parts of the country are replaced by the north-easterly trade winds. These winds blowing over the Bay of Bengal pick up moisture from there and cause rainfall in Tamil Nadu.

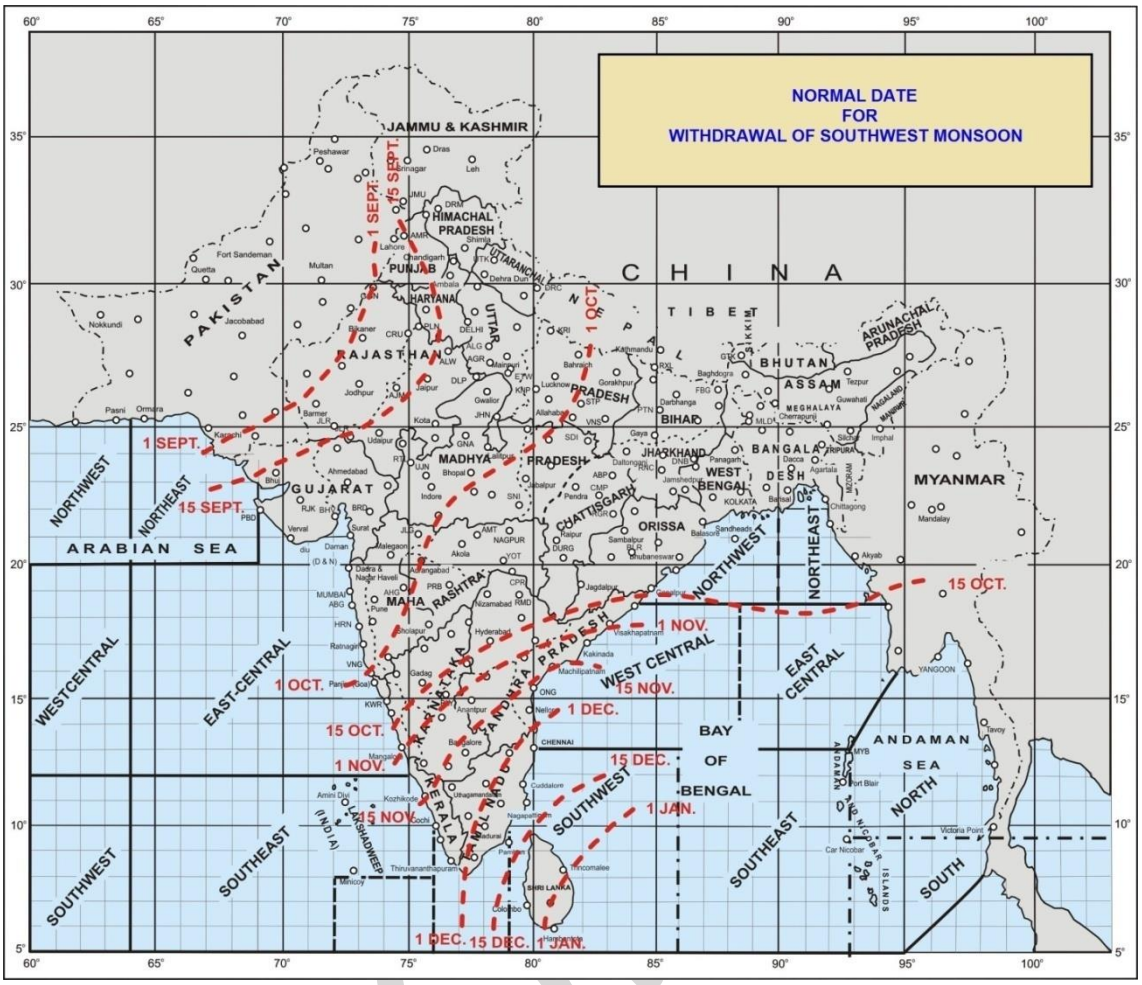


Figure 12 – India: Normal dates of withdrawal of the Southwest Monsoon

3.8. Features of Monsoon Rainfall

- Monsoon rain is **seasonal** in character which occurs between June and September.
- Spatial distribution of rainfall is largely **governed by relief** or topography. For instance the windward side of the Western Ghats registers a rainfall of over 250 cm. Again, the heavy rainfall in the northeastern states can be attributed to their hill ranges and the Eastern Himalayas. Rainfall ranges from 20 cm in western Rajasthan to more than 400 cm in certain parts of Western Ghats and North-East India.
- The monsoon rainfall has a declining trend with increasing distance from the sea. Rainfall decreases from east to west in plains as one branch of monsoon enters from eastern side. Kolkata receives 119 cm, Allahabad 76 cm and Delhi 56 cm only.
- Breaks (discussed above) in rainfall are related to the cyclonic depressions mainly formed at the head of the Bay of Bengal, and their crossing into the mainland. Besides the frequency and intensity of these depressions, the passage followed by them determines the spatial distribution of rainfall.
- The rains sometimes end considerably earlier than usual, causing great damage to standing crops and making the sowing of winter crops difficult.

3.9. Monsoons and the Economic Life in India

- Monsoon is that axis around which revolves the entire agricultural cycle of India. It is because about 64 per cent people of India depend on agriculture for their livelihood and agriculture itself is based on southwest monsoon.

- Except Himalayas all the parts of the country have temperature above the threshold level to grow the crops or plants throughout the year.
- Regional variations in monsoon climate help in growing various types of crops.
- Agricultural prosperity of India depends very much on timely and adequately distributed rainfall. If it fails, agriculture is adversely affected mainly in areas where irrigation is not developed.
- Sudden monsoon burst creates problem of soil erosion over large areas in India.

4. Seasons

Seasons are a special feature of Indian climate. Temperature, pressure, wind direction and the amount and duration of rain varies from one season to the other. Meteorologists identify four seasons in India. They are described briefly in table 1 below

Season	Duration	General characteristics	Temperature	Wind, disturbances	rainfall
Winter season	Mid-November to February	Clear skies, fine weather, low humidity	Mean daily temperature below 21°C in North India. Some part experience temperature below freezing point. Temperature increases from north to south.	High pressure over north-western India. Winds blow from north-west to south-east. Around four or five westerly disturbances are carried by westerly jet stream.	Westerly disturbances cause rainfall in northern plains. Rainfall decreases from west to east in plains but increases in north-east again as it catch water from Bay of Bengal. North-east monsoon causes winter rainfall in southern Andhra Pradesh, Tamil Nadu etc.
Summer season	April, May, June	Excessive heat, hot loo, dust storms and dryness	Temperature rises up to 45°C in north India. Temperature has increased to 50°C in Ganganagar earlier. Summer in south India is not so extreme.	Low pressure over north-western part of India and high pressure over southern parts of Bay of Bengal. ITCZ shifts to Ganges plain. Wind direction varies from one part of India to the other. Dust storms are frequency experienced in the afternoon in northern plains.	Completely dry season. Dust storms and thunder storms provide some rainfall. Eastern regions receives more rainfall comparatively.

South-west monsoon	June – September	Whole of India under south-west monsoon. India faces severe cyclones, thunderstorms etc.	June is the hottest month. Temperature remains low during July and August which rises high in September with decreasing amount of precipitation.	Winds are south-westerly over mainland India.	India receives its 80% precipitation in this season. There is decline of rainfall from east to west in plains. Details are discussed under 'monsoon' above.
Retreating monsoon	October-November	Monsoon winds are retreating gradually and sudden rise of temperature with October heat.	Day temperature is high and nights are cool and pleasant. The average minimum temperature fall below 20°C.	Winds are north-easterly. Clear skies and gentle breeze are characteristics of this season.	Southern Peninsular region (Tamil Nadu, Kerala, and Southern Andhra Pradesh) receives rain. Cyclonic activities are more frequent in Peninsular region.

Table 1 – Different seasons of India with their characteristics

4.1. Traditional Indian Seasons

In the Indian tradition, a year is divided into six two-monthly seasons. This cycle of seasons, which the common people in north and central India follow is based on their practical experience and age-old perception of weather phenomena. However, this system does not match with the seasons of south India where there is little variation in the seasons.

Season	Months according to Indian Calendar	Months according to English Calendar
Vasanta	Chaitra-Vaisakha	March-April
Grishma	Jyaistha-Asadha	May-June
Varsha	Sravana-Bhadra	July-August
Sharada	Asvina-Kartika	September-October
Hemanta	Margashirsa-Pausa	November-December
Shishira	Magha-Phalguna	January-February

Table 2 – Indian seasons

5. Distribution of Annual Rainfall

The distribution of average annual rainfall in India is shown in figure 13. A glance on this map indicates that the distribution of rainfall in India is uneven. On the basis of the distribution of rainfall, India can be divided into the following four regions as shown below in table 3.

Category	Rainfall in cms	regions
Heavy Rainfall	More than 200	Western coast, western ghats, sub-Himalayan region of north-east, Garo, Khasi and Jaintia hills of Meghalaya. In some parts, rain exceeds 1000 cm.
Moderate rainfall	Between 100 to 200	100 cm isohyet extends from Gujarat to south up to Kanyakumari parallel to western

		ghats. Northern Andhra Pradesh, eastern part of Maharashtra, Madhya Pradesh, Odisha, some parts of Jammu and Kashmir
Low rainfall	Between 60 to 100	Most parts of Tamil Nadu, Karnataka, Andhra Pradesh, eastern Rajasthan, south-western Uttar Pradesh
Inadequate rainfall	Less than 60	Punjab, Haryana, north-western Rajasthan, Kachchh, Kathiawar

Table 3 – Different rainfall regions of India

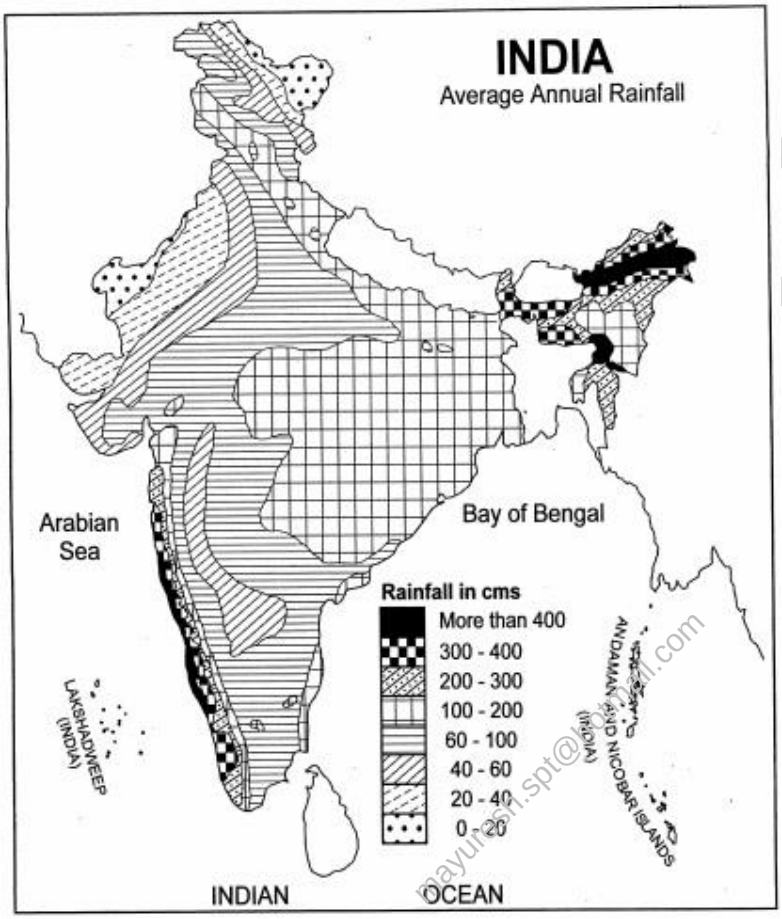


Figure 13 – India: Annual rainfall

6. Variability of Annual Rainfall

Variability of rainfall refers to **variations in rainfall from the average amount**. The variability of rainfall is computed with the help of the following formula:

C.V. = (Standard Deviation / Mean) x 100; where C.V. is the coefficient of variation.

Study of variability of rainfall in an agricultural country such as India is very important. The rainfall in India is highly variable. The actual rainfall of a place in a year deviates from its average rainfall by 10 to over 60 per cent. The mean annual rainfall variability of rainfall in India has been plotted in figure 14. Description of annual rainfall's variability is details as:

- It may be noted from figure 13 and figure 14 that the highest variability is found in the areas where the average annual rainfall is the lowest such as desert areas of Rajasthan. Here, variability of rainfall is around 60 per cent.

- Contrary to this, in the areas where the average annual rainfall is over 200 cm (Meghalaya plateau, Western Ghats), the annual variability of rainfall is less than 10 per cent.
- A very large part of India falls in the category of 15 to 30 per cent annual variability of rainfall. Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra etc. fall in this category
- Variability of annual rainfall increases from the western coast to the interior of the Peninsular region and from West Bengal and Odisha towards north and north-west.

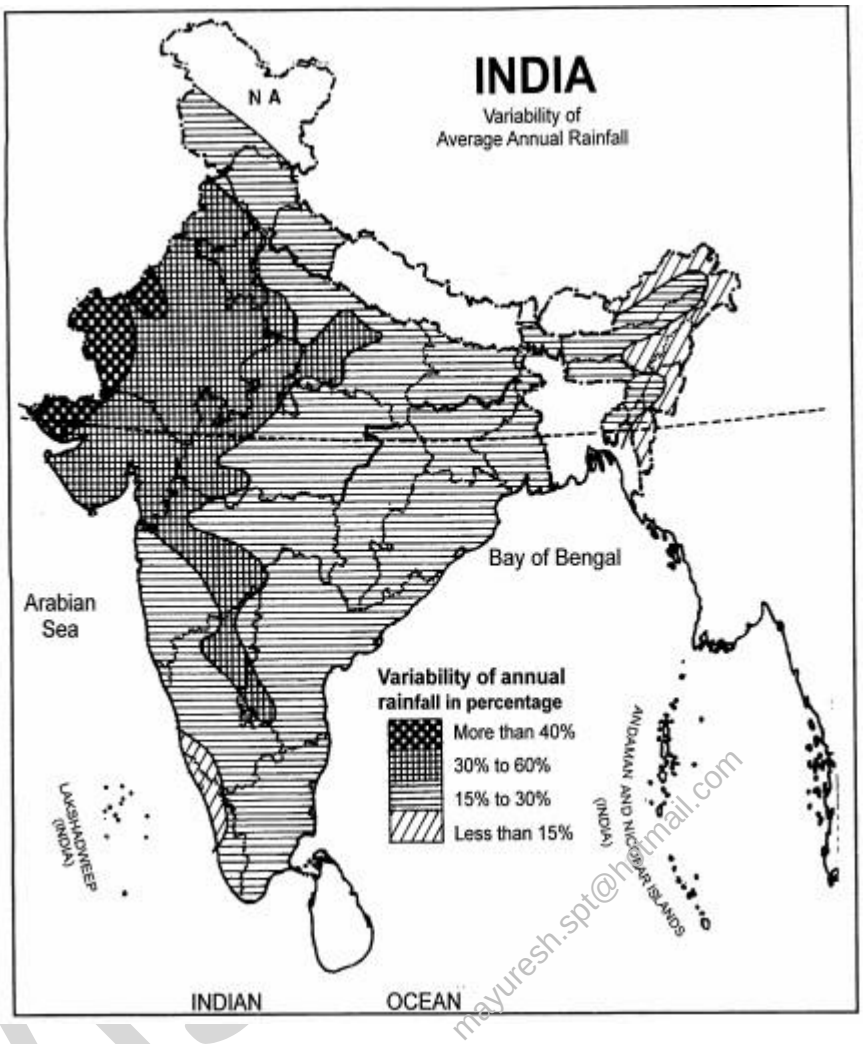


Figure 14 – India: variability of annual rainfall

7. Climatic Regions of India

India is often referred to as a country with tropical monsoon type of climate. However, the large latitudinal extent, the presence of Himalayas in the north, the India Ocean in the south have resulted in great variations in the distribution of temperature and precipitation in the India. The **climate of north is different from that of south** and so is the climate of east from that of the west.

To study the variations of climate in various parts, India is divided into a large number of climatic regions of small size. A climatic region is that area which possesses a broad uniformity of climatic conditions caused by the combined effects of climatic elements – temperature, pressure, winds, humidity and precipitation. Temperature and rainfall are two important elements which are considered to be decisive in all the schemes of climatic classification. There are different schemes of classification of climate. Major climatic types of India based on **Koeppen's scheme** have been show in figure 15.

Figure 15 – India: Climatic regions according to Koeppen scheme

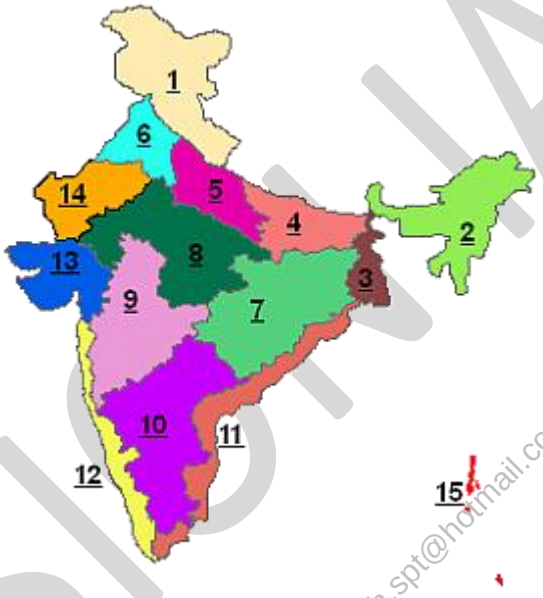
Koeppen based his scheme of Climatic classification on monthly values of temperature and precipitation. India's climate is divided into the following climatic regions:

- Monsoon type with short dry season (Amw) – the western coastal region south of Goa experiences this type of climate.
- Monsoon type with dry season in summers (AS) – the region of this type of climate extends along the coromandel coast.
- Tropical Savannah type (Aw) – almost the entire peninsular region except for some coastal parts experiences this type of climate.
- Semi-arid steppe climate (BShw) – this climatic region includes the interior parts of the peninsular plateau and some parts of Gujarat, Rajasthan, Haryana, Punjab and Jammu & Kashmir.
- Hot desert type (BWhw) – this type of climate is found only in the western part of Rajasthan.
- Monsoon type with dry winters (Cwg) – Largely Northern plains of India experiences this type of climate.

- Cold-humid winter type with short summer (Dfc) – this climate of characterized by a short summer season. This region covers the north-eastern parts of India.
- Polar type (E) – this type of climate is experienced in Jammu & Kashmir and the neighbouring mountain ranges.

7.1. Agro Climatic Zones of India

The agro-climatic classification is nothing but an extension of the climate classification keeping in view the suitability to agriculture. Generally, the climate types may be distinguished on the rainfall, temperature and as these two characteristics are influenced by altitude, the climate can also be classified on the basis of above three parameters. National commission on agriculture (1971) classified the country into 127 agro-climatic zones. The planning commission, as a result of mid. term appairasal of planning targets of VII plan (1985 - 90) divided the country into 15 broad agro - climatic zones based on physiographic and climate. The emphasis was given on the development of resources and their optimum utilization in a suitable manner with in the frame work of resource constraints and potentials of each region.



Agro climatic zones of India: (Planning commission 1989)

1	Western Himalayan Region	Ladakh, Kashmir, Punjab, Jammu etc.brown soils & silty loam, steep slopes.
2	Eastern Himalayan Region	Arunachal Pradesh, Sikkim and Darjeeling. Manipur etc. High rainfall and high forest covers heavy soil erosion, Floods.
3	Lower Gangatic plants Regions	West Bengal Soils mostly alluvial & are prone to floods.
4	Middle Gangatic plans Region	Bihar, Uttar Pradesh, High rainfall 39% irrigation, cropping intensity 142%
5	Upper Gangatic Plains Region	North region of U.P. (32 dists) irrigated by canal & tube wells good ground water
6	Trans Gangatic plains Region	Punjab Haryana Union territory of Delhi, Highest sown area irrigated high
7	Eastern Plateaus & Hills Region	Chota Nagpur, Garhjat hills, M.P, W. Banghelkhand plateau, Orissa, soils Shallow to medium sloppy, undulating Irrigation tank & tube wells.
8	Central Plateau & hills Region	M. Pradesh
9	Western Plateau & hills Region	Sahyadry, M.S. M.P. Rainfall 904 mm Sown area 65% forest 11% irrigation 12.4%

10	Southern Plateau & Hills Region	T. Nadu, Andhra Pradesh, Karnataka, Typically semi and zone, Dry land Farming 81% Cropping Intensity 11%
11	East coast plains & hills Region	Tamil Nadu, Andhra Pradesh Orissa, Soils, alluvial, coastal sand, Irrigation
12	West coast plains & Hills Region	Sourashtra, Maharashtra, Goa, Karnataka, T. Nadu, Variety of cropping Pattern, rainfall & soil types.
13	Gujarat plains & Hills Region	Gujarat (19 dists) Low rainfall arid zone. Irrigation 32% well and tube wells.
14	Western Dry Region	Rajasthan (9 dists) Hot. Sandy desert rainfall erratic, high evaporation. Scanty vegetation, femine draughts.
15	The Island Region	Eastern Andaman, Nikobar, Western Laksh dweep. Typical equatorial, rainfall 3000 mm (9 months) forest zone undulating.

8. UPSC Previous Years' Mains Questions on Climate

1. List the significant local storms of the hot-weather season in the country and bring out their socio-economic impact. (UPSC 2010/12 Marks)
2. Bring out the significance of the various activities of the Indian Meteorological Department. (UPSC 2009/15 Marks)
3. Write about Nor'westers in 20 words. (UPSC 2008/15 Marks)
4. The winter rains in North India are largely related to Jet Streams and Western Disturbances. Bring out the relationship. (UPSC 2008/15 Marks)
5. Write note on winter rains in India. (UPSC 2006/2 Marks)
6. Discuss the distribution of winds and rainfall over India in the summer monsoon season. (UPSC 2002/10 Marks)
7. Explain the causes of the Indian Monsoon. (UPSC 2001/10 Marks)
8. Write short note on Mango Showers. (UPSC 2000/2 Marks)
9. Mention the agro-climatic regions of India starting the basis of classification. (UPSC 2000/10 Marks)
10. Discuss the origin of Monsoon in India. (UPSC 1997/15 Marks)
11. What is 'intensity of rainfall'? Discuss its importance to Indian farmers. (UPSC 1995/15 Marks)
12. Which part of India receives more rainfall from the north-east monsoon than from the south-west monsoon? Explain why it is so? (UPSC 1994/15 Marks)
13. What is the basis of Monsoon forecasts now prepared by the Indian Meteorological Department, which have been reasonably correct for the last three successive years? (UPSC 1991/20 Marks)
14. How far is it justifiable to state that the financial budget of this country is a gamble, against the Indian monsoon? To what extent have developmental measures solved the problem? (UPSC 1986/20 Marks)
15. Why is India undertaking expeditions to Antarctica? Describe the influence of Antarctica and Antarctic Ocean on the climate of India and on the nutrient and energy supply to Indian Ocean.
16. "Monsoon is known to be an energy released by the sea." Explain. How does this energy benefit the entire economic system of our country? In what ways could this country prepare itself to fight the vagaries of the monsoons? (UPSC 1982/30 Marks)
17. Unlike most other parts of the country, why is the Tamil Nadu coast wettest in November-December and not in July-August? (UPSC 1980/3 Marks)

Student Notes:

9. UPSC Previous Years' Prelims Questions on Climate

1. La Nina is suspected to have caused recent floods in Australia. How is La Nina different from El Nino?

1. La Nina is characterised by unusually cold ocean temperature in equatorial Indian Ocean whereas El Nino is characterised by unusually warm ocean temperature in the equatorial Pacific Ocean.
2. El Nino has adverse effect on south-west monsoon of India, but La Nina has no effect on monsoon climate.

Which of the statements given above is/are correct? **(2011)**

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

2. With reference to India, which one of the following statements is not correct? **(2002)**

(a) About one-third of the area of the country records more than 750 millimetres of annual rainfall
(b) The dominant source of irrigation in the country is wells
(c) Alluvial soil is the predominant type of soil in the northern plains of the country
(d) The mountain areas account for about thirty percent of the surface area of the country

3. The jet aircrafts fly very easily and smoothly in the lower stratosphere. What could be the appropriate explanation? **(2011)**

1. There are no clouds or water vapour in the lower stratosphere.
2. There are no vertical winds in the lower stratosphere.

Which of the statements given above is/are correct in this context?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

4. The average annual temperature of a meteorological station is 260C, its average annual rainfall is 63 cm and the annual range to temperature is 90C. The station in question is **(2002).**

(a) Allahabad (b) Chennai
(c) Cherrapunji (d) Kolkata

5. If there were no Himalayan ranges, what would have been the most likely geographical impact on India?

1. Much of the country would experience the cold waves from Siberia.
2. Indo-gangetic plain would be devoid of such extensive alluvial soils.
3. The pattern of monsoon would be different from what it is at present.

Which of the statements given above is/are correct? **(2010)**

(a) 1 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Student Notes:

CLIMATE AND DIFFERENT WORLD CLIMATE

Contents

Student Notes:

1. Introduction

Climate holds an important place in our own life. Our life and various economic activities (agriculture, industries, commerce, etc.) are affected by climate. Climate has also an important place in physical geography. Climate is a measure of the average pattern of variation in temperature, humidity, atmospheric pressure, wind, precipitation, atmospheric particle count and other meteorological variables in a given region over long periods of time. Any independent study of each of these elements does not present any comprehensive view of climate. On the basis of these elements, there could be thousands of types of climates in the world.

2. Climate & Weather

The *difference* between weather and climate is that weather consists of the short-term (minutes to months) changes in the atmosphere while climate is the average of weather over time and space. In most places, weather can change from minute-to-minute, hour-to-hour, day-to-day, and season-to-season. Climate, however, is the average of weather over time and space.

2.1. Comparison between Weather and Climate

	Climate	Weather
Definition	Describes the average conditions expected at a specific place over a long period of time. A region's climate is generated by the climate system, which has **five components**: atmosphere, hydrosphere, cryosphere, land surface and biosphere.	Describes the atmospheric conditions at a specific place at a **specific point in time**. Weather generally refers to day-to-day temperature and precipitation activity
Components	Climate may include precipitation, temperature, humidity, sunshine, and wind velocity, phenomena such as fog, frost, and hail storms over a long period of time.	Weather includes sunshine, rain, cloud cover, winds, hail, snow, sleet, freezing rain, flooding, blizzards, ice storms, thunderstorms, steady rains from a cold front or warm front, excessive heat, heat waves and more
Forecast	By aggregates of weather statistics over periods of 30 years	By collecting meteorological data, like air temperature, pressure, humidity, solar radiation, wind speeds and direction etc.
Determining factors	Aggregating weather statistics over periods of 30[1] years.	Real-time measurements of atmospheric pressure, temperature, wind speed and direction, humidity, precipitation, cloud cover and other variables.
Time period	Measured over a long period	Measured for short term
Study	Climatology	Meteorology

2.2. Importance of Climate and Weather

The influence of climate and weather can be seen in day to day activities of human beings. Forces of nature have regulated to a very great extent the sort of food we eat, what we wear,

[1] NCERT mentions 50 years but according to WMO it is 30 years.

how we live and work. Conditions of temperature, precipitation and humidity may promote or discourage the growth of fungus and diseases which may be injurious to both men and crops. Today, our activities are becoming more and more dependent upon meteorological services. Meteorological stations are set up all over the globe to provide weather updates and predict future conditions. A fair knowledge of the weather is not only useful but often essential.

2.3. Elements of Climate

There are various environmental elements which have *significant influence* on the climate of a region. Among them, *temperature, pressure, precipitation and winds* are the most important because of their far reaching global influence. These elements are affected in different manner by the following climatic factors: *latitude, altitude, continentality, ocean currents, insolation, prevailing winds, slope and aspect, natural vegetation and soil*.

2.4. Factors Affecting Climate

Latitude: Due to the earth's inclination, the mid-day sun is almost overhead within the tropics but the sun's rays reach the earth at an angle outside the tropics. Thus, temperature diminishes from equatorial regions to the poles.

Altitude: Earth's atmosphere is mainly heated through conduction from the surface, so places near the surface are warmer than those higher up. Thus temperature decreases with increasing height above sea level. This rate of decrease in temperature with altitude *(lapse rate)* is never constant, varying from place to place and from season to season. However, for all practical purposes, it may be reckoned that a fall of 6.5°C occurs with an ascent of 1000 meters or *1°C per 165 meters.*

Continentality (**Distance from sea**): Land surfaces have higher specific heat capacity of heat as compared to water bodies i.e. it takes less energy to raise the temperature of a given volume of land by 1°C as compared to same volume of water body. This accounts for temperature extremes in the continental interiors as compared to maritime areas.

Oceans Currents: Marine areas are influenced by the *warm or cold ocean currents*. Ocean currents like the Gulf Stream or the North Atlantic Drift warm the coastal districts of Western Europe keeping their ports ice-free. Ports located in the same latitude but washed by cold currents, such as the cold Labrador Current off north-east Canada, are frozen for several months. Cold currents also lower the summer temperature, particularly when they are carried landwards by on-shore winds.

Local winds: If winds are warm i.e. they have been blown from a hot area, they will raise temperatures. If winds have been blown from cold areas, they will lower temperatures. Local winds like Fohn, Chinook, Sirocco and Mistral also produce marked changes in temperature.

Relief and Topography: Climate can be affected by mountains. Mountains receive more rainfall than low lying areas because as air is forced over the higher ground it cools, causing moist air to condense and fall out as rainfall. The higher the place is above sea level the colder it will be. This happens because as altitude increases, air becomes thinner and is less able to absorb and retain heat.

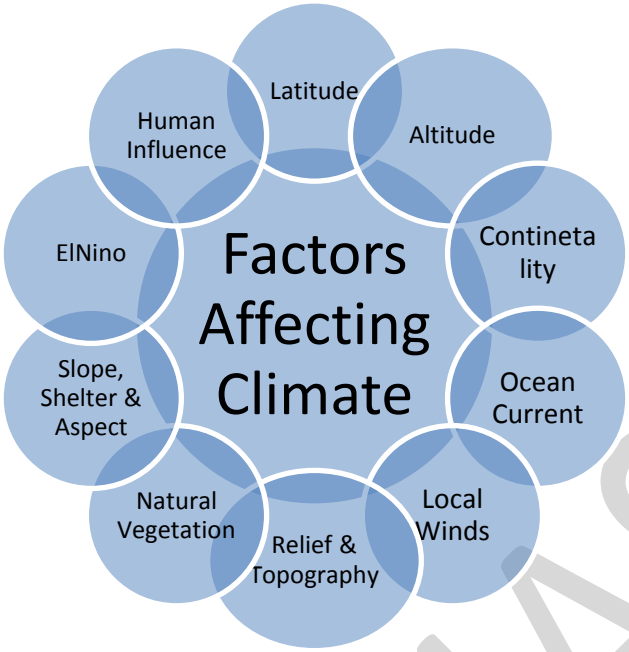


Fig 1: Factors Affecting Climate

Natural Vegetation and Soil: Natural vegetation affects the temperature of the region significantly. Often areas with dense forest cover like areas in thick foliage of Amazon jungles receive less insolation and are, often, cooler than the areas in open space. Light soils reflect more heat than darker soils which are better absorbers. Such soil differences may give rise to slight variations in the temperature of the region. As a whole, dry soils like sands are very sensitive to temperature changes, whereas wet soils, like clay, retain much moisture and warm up or cool down more slowly.

Slope, **Shelter and Aspect**: A steep slope experiences much rapid change in temperature as compared to a gentle slope. Mountain ranges that have an east-west alignment like the Alps show a higher temperature on the *south-facing 'sunny slope'* than the north facing 'sheltered slope'. The greater insolation of the southern slope is better suited for vine cultivation and has a more flourishing vegetative cover. Consequently, there are more settlements and it is better utilised than the 'shady slope'.

El Niño Effect: El Niño, which affects wind and rainfall patterns, has been blamed for droughts and floods in countries around the Pacific Rim. ***El Niño* refers to the irregular warming of surface water in the Pacific**. The warmer water pumps energy and moisture into the atmosphere, altering global wind and rainfall patterns. The phenomenon has caused tornadoes in Florida, smog in Indonesia, and forest fires in Brazil. *El Niño* is Spanish for 'the Boy Child' because it comes about the time of the celebration of the birth of the Christ Child. **The cold counterpart to *El Niño* is known as *La Niña***, Spanish for 'the girl child', and it also brings with it weather extremes.

Human Influence: The factors above affect the climate naturally. However, we cannot forget the influence of humans on our climate. Early on in human history our effect on the climate would have been quite small. However, as populations increased and trees were cut down in large numbers, so our influence on the climate increased. The number of trees being cut down has also increased, reducing the amount of carbon dioxide that is taken up by forests.

2.5. Classification of Climate

If we were to compare the climates of different places on the basis of climatic elements, we would come across many such places which would have similarity between one and more of these elements. On the basis of these very regional similarities and differences of climatic elements, attempts have been made to classify climate for easy understanding, description and analysis.

Three broad approaches have been adopted for classifying climate. They are empirical, genetic and applied. Empirical classification is based on observed data, particularly on temperature and precipitation. Genetic classification attempts to organise climates according to their causes. Applied classification is for specific purpose.

Heat Zones Classification: The Greek philosophers were the first to present classification of climates. The temperature of the earth was the main bases of their classifications. They had divided the earth into Torrid, Temperate and Frigid zones.

1. ***Tropical or Torrid Zone*:** This zone lies between the Tropic of Cancer and the Tropic of Capricorn. In this zone the sunrays are almost vertical throughout the year. The temperature always remains high. There is no winter season in this zone.
2. ***Temperate Zone*:** There are two zones lying between the Tropic of Cancer - the Arctic Circle and the Tropic of Capricorn - the Antarctic Circle.

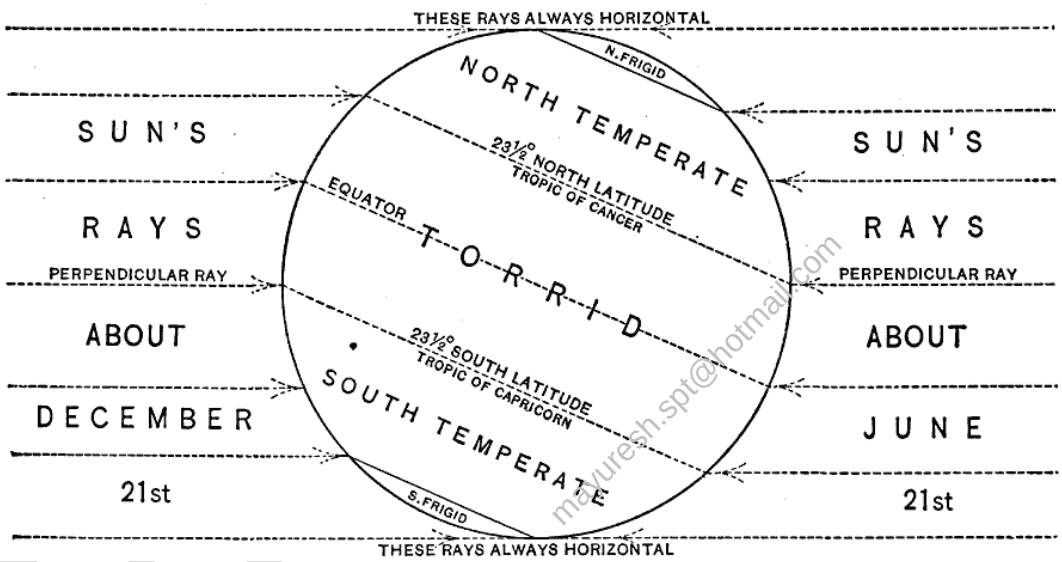


Fig 2: Heat Zones Classifications

3. ***Frigid Zone*:** This zone lies between Arctic Circle and North Pole and the Antarctic Circle and the South Pole. The sunrays in these two zones in the Northern and Southern Hemisphere fall in slanting form throughout the year. Therefore these zones experience very low temperature and high degree of coldness. Therefore, these latitudinal zones are known as Frigid Zone.

Koeppen Classification

The most widely used classification of climate is the climate classification scheme developed by German climatologist and plant geographer V. Koeppen. in 1918. The annual as well as monthly *averages of temperature and precipitation* formed the basis of Koeppen classification of climate. He also based his classification on the distribution of weather conditions. This classification is both *empirical and genetic type*. Koeppen in his classification laid great emphasis that all the characteristics of climate can well be expressed through the *distribution of*

natural vegetation that's why he tried to associate his climate types with vegetation zones of the world. He made use of annual averages of temperature and precipitation in fixing the climate regions of the world. He presented *five main climate types*. Each of these climate types was represented by capital English alphabets of A, B, C, D and E. He used the letter 'H' for highland type of climates. While keeping temperature and precipitation variations in view these five climate types were further subdivided as shown in the following table:

S.N.	Chief Climatic Groups	Climatic Types
A	Tropical Climate (Average temperature of the coldest month is 18° C or higher)	1. Tropical rain forest type climate 2. Savannah type climate 3. Monsoon type climate
B	Dry Climate (Potential evaporation exceeds precipitation)	4. Desert climate 5. Steppe (Semi-desert) climate
C	Temperate Climate (The average temperature of the coldest month is higher than minus 3°C but below 18°C)	6. Mediterranean climate 7. China type climate 8. West European type climate
D	Continental Climate (The average temperature of the coldest month is minus 3° C or below)	9. Taiga climate 10. Eastern coastal cold climate 11. Continental climate
E	Polar Climate (Average temperature for all months is below 10° C)	12. Tundra climate 13. Snow-capped region type climate
H	Highland Climate (Cold due to elevation)	

Thornthwaite Classification:

Thornthwaite was an American climatologist. He presented his first climate classification in 1931. In 1931, his classification looked similar to Koeppen. Like Koeppen, Thornthwaite also thought that vegetation is the indicator of climate type. Two basic features of this classification are (i) *Precipitation Effectiveness*, (ii) *Temperature Efficiency*. On the basis of these two indicators, Thornthwaite divided the world into five humidity regions. Each region had its own special type of vegetation as shown in the table below:

Sr. No.	Humidity Region	Special type of Vegetation
A	Very Humid	Rain Forest
B	Humid	Forest
C	Semi Humid	Grassland
D	Semi Dry	Steppe
E	Dry	Desert

On the basis of distribution of seasonal rainfall the above types of humidity regions were further divided into following subdivisions:

Y = Heavy rainfall in all seasons
s = Scarcity of rainfall in summer season
w = Scarcity of rainfall in winter season
d = Scarcity of rainfall in all seasons
After linking precipitation effectiveness and seasonal distribution of rainfall to temperature anomalies, the climates could be of 120 different types.

3. Global Climate Classification

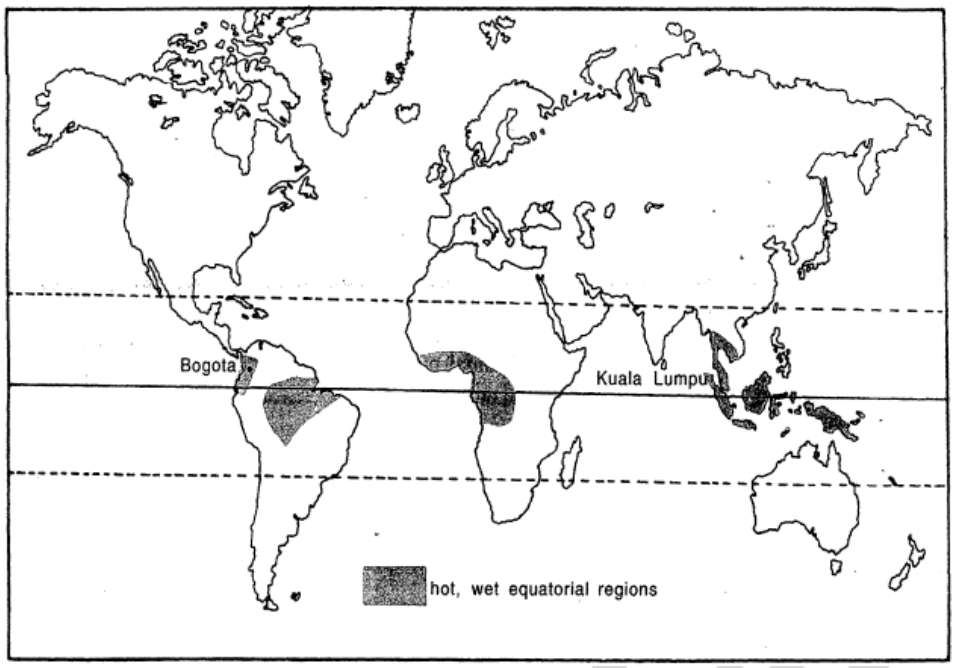
The global climatic conditions can be studied under the following twelve classifications.

Climatic Zone	*Latitude (Approximate)*	*Climatic Type*	*Rainfall Regime (with approx. total)*	*Natural Vegetation*
Equatorial Zone	0^0-10^0N and S	1. Hot, wet equatorial	Rainfall all year round : 80 inches	Equatorial rain forests
Hot Zone	10^0-30^0N and S	2. a) Tropical Monsoon b) Tropical Marine	Heavy summer rain: 80 inches Much summer rain: 70 inches	Monsoon forests
		3. Sudan Type	Rain mainly in summer: 30 inches	Savanna (tropical grassland)
		4. Desert: a) Saharan type b) Mid-latitude type	Little rain: 5 inches	Desert vegetation and scrub
Warm Temperate Zone	30-^{0}40^{0}N & S	5. Western Margin (Mediterranean type)	Winter rain: 35 inches	Mediterranean forests and shrub
		6. Central Continental (Steppe type)	Light summer rain: 20 inches	Steppe or temperate grassland
		7. Eastern Margin: a) China type b) Gulf type c) Natal type	Heavier summer rain: 20 inches	Warm, wet forests and bamboo
Cool Temperate Zone	45^0-65^0N & S	8. Western Margin (British type)	More rain in autumn & winter: 30 inches	Deciduous forests
		9. Central Continental (Siberian type)	Light summer rain: 25 inches	Evergreen coniferous forests
		10. Eastern Margin (Laurentian type)	Moderate summer rain: 40 inches	Mixed forests (coniferous and deciduous)
Cold Zone	65^0-90^0 N & S	11. Arctic or Polar	Very light summer rain: 10 inches	Tundra, mosses, lichens
Alpine Zone		12. Mountain climate	Heavy rainfall (variable)	Alpine pastures, conifers, fern, snow

3.1. The Hot, Wet Equatorial Climate

Distribution

The equatorial, hot, wet climate is found between 5° and 10 ° north and south of the equator. Its greatest extent is found in the lowlands of the Amazon, the Congo, Malaysia and the East Indies. Further away from the equator, the influence of the on-shore Trade Winds, gives rise to a modified type of equatorial climate with *monsoonal influences.*



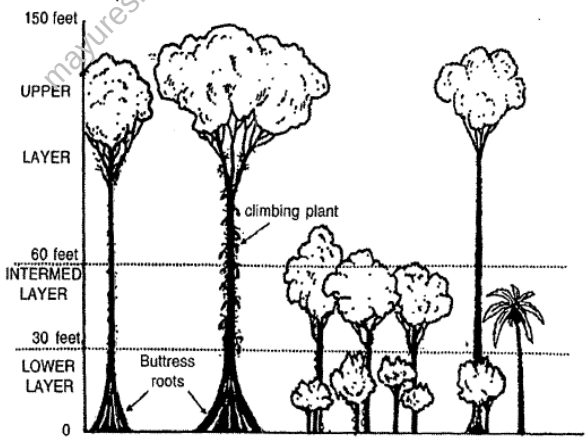
Climatic Conditions

Temperature: The most outstanding feature of the equatorial climate is its great uniformity of temperature throughout the year. The mean monthly temperatures are always around 27°C with very little variation. There is no winter. Cloudiness and heavy precipitation moderates the daily temperature, so that even at the equator itself, the climate is not unbearable. The diurnal range of temperature is small, and so is the annual range.

Precipitation: Precipitation is heavy, between 60 inches and 100 inches, and well distributed throughout the year. There is no month without rain and a distinct dry season like those of the Savannah or the Tropical Monsoon Climates, is absent. Due to the great heat in the equatorial belt, mornings are bright, and sunny. There is much evaporation and convectional air currents are set up, followed by heavy downpours.

Natural Vegetation: It supports a luxuriant type of vegetation – the tropical rain forest. Amazon tropical rain forest is known as Selvas. It comprises a multitude of evergreen trees that yield tropical hardwood, e.g. mahogany, ebony, greenheart, cabinet wood. Lianas, epiphytic and parasitic plants are also found. Trees of single species are very scarce in such vegetation.

Fig. 123 Sketch to show the three distinct layers of an equatorial forest

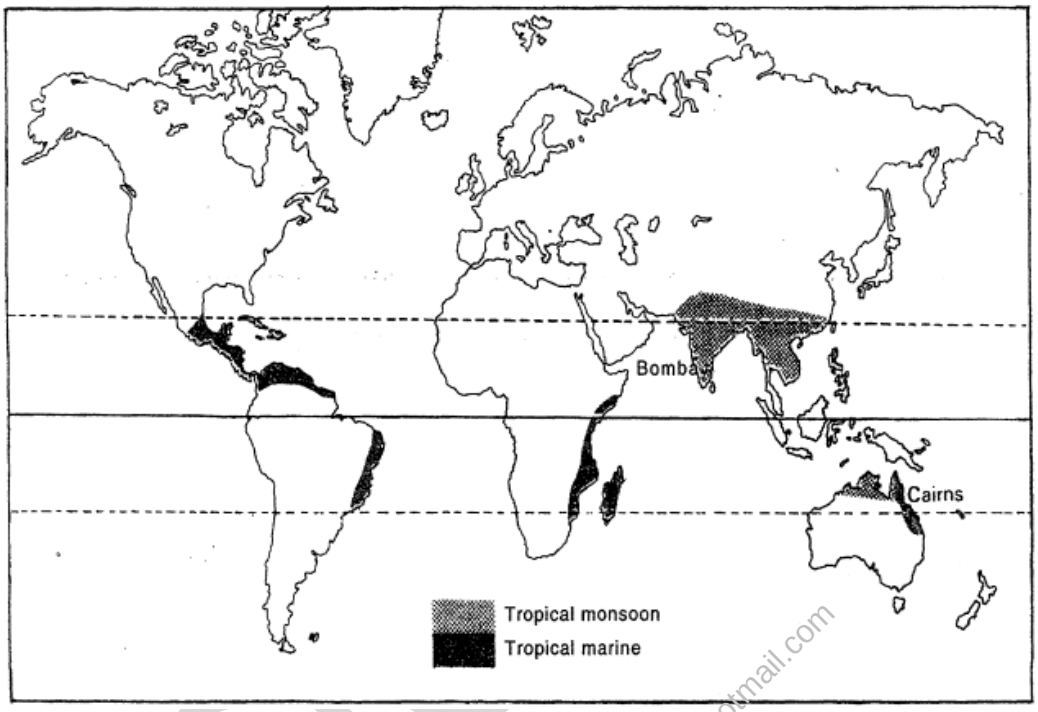


Life and Development in the Equatorial Regions: The equatorial regions are generally sparsely populated. In the forests most primitive people live as *hunters and collectors* and the more advanced ones practise shifting cultivation. In the Amazon basin, the Indian tribes collect wild rubber, in the Congo Basin the Pygmies gather nuts and in the jungles of Malaysia the Orang Asli make all sorts of cane products and sell them to people in villages and towns. In the clearings for shifting cultivation, crops like manioc (tapioca), yams, maize, bananas and groundnuts are grown.

3.2. The Tropical Monsoon and Tropical Marine Climates

Distribution: It is found in the zones between 5° and 30° latitudes on either side of the equator. These areas are the **tropical monsoon** lands with on-shore wet monsoons in the summer and off-shore dry monsoons in the winter. They are best developed in the Indian sub-continent, Burma, Thailand, Laos, Cambodia, parts of Vietnam and south China and northern Australia.

Outside this zone, the climate is modified by the influence of the on-shore Trade Winds all the year round, and has a more evenly distributed rainfall. Such a climate, better termed the **Tropical Marine** Climate, is experienced in Central America. West Indies, north-eastern Australia, the Philippines, parts of East Africa, Madagascar, the Guinea Coast and eastern Brazil.



Climatic Conditions:

The basic cause of monsoon climates is the difference in the rate of heating and cooling of land and sea. Average temperature of warm dry summer months ranges between 27°C and 32°C. In the summer, when the sun is overhead at the Tropic of Cancer, the great land masses of the northern hemisphere are heated. The seas, which warm up much slower, remain comparatively cool. At the same time, the southern hemisphere experiences winter, and a region of high pressure is set up in the continental interior of Australia. Winds blow outwards as the South-East Monsoon, to Java, and after crossing the equator are drawn towards the continental low pressure area reaching the Indian sub-continent as the South-West Monsoon. In the winter, conditions are reversed. The sun is overhead at the Tropic of Capricorn, central Asia is extremely cold, resulting in rapid cooling of the land. A region of high pressure is created with out-blowing winds-the North-East Monsoon.

The Seasons of Tropical Monsoon Climate: In regions like the Indian sub-continent which have a true Tropical Monsoon Climate, *three* distinct seasons are distinguishable - The cool, dry season (October to February), the hot dry season (March to mid-June) and the rainy season (mid-June to September).

The Tropical Marine Climate: This type of climate is experienced along the eastern coasts of tropical lands, receiving steady rainfall from the Trade Winds all the time. The rainfall is both *orographic*, where the moist trades meet upland masses as in eastern Brazil, and *convectional*

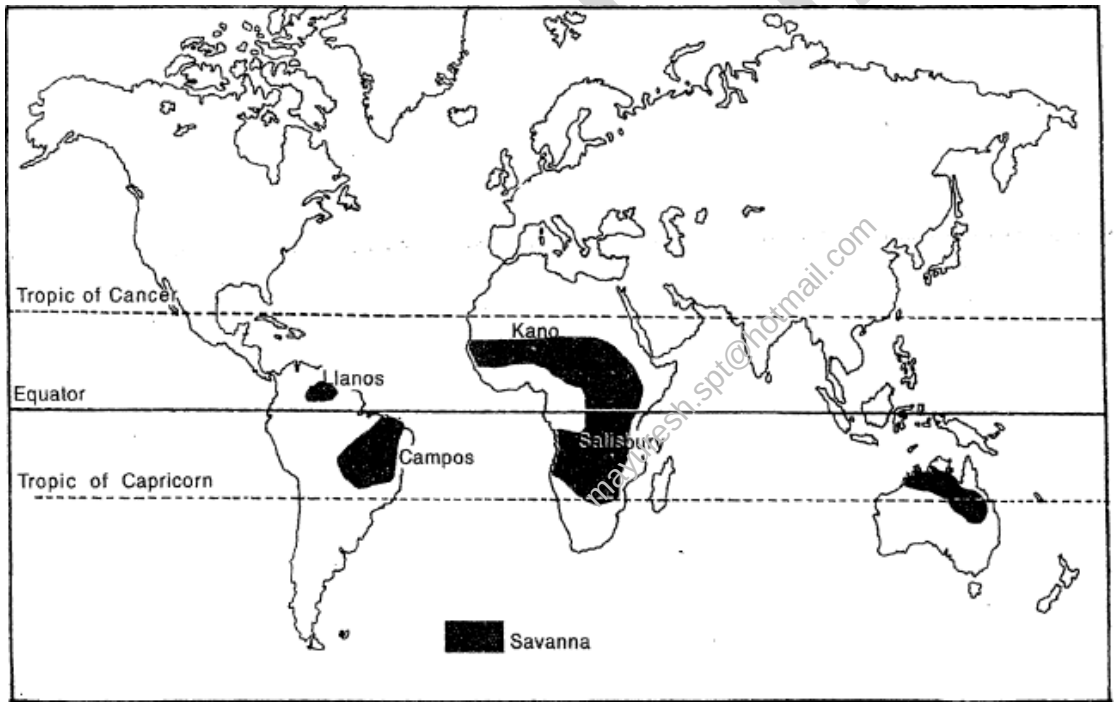
due to intense heating during the day and in summer. Its tendency is towards a summer maximum as in monsoon lands, but without any distinct dry period.

Natural Vegetation: The natural vegetation of tropical monsoon lands depends on the amount of the summer rainfall. Trees are normally deciduous because of the marked dry period, during which they shed their leaves to withstand the drought. Where the rainfall is heavy, e.g. in southern Burma, peninsular India, northern Australia and coastal regions with a tropical marine climate, the resultant vegetation is forest. The forests are more open and less luxuriant than the equatorial jungle and there are far fewer species. Most of the forests yield valuable timber, and are prized for their durable hardwood. Amongst these teak is the best known.

Economy: The main economic activity of the people is agriculture. Major agricrops are rice, cane sugar, jute etc.

3.3. The Savannah or Sudan Climate

Distribution: The Savannah or Sudan Climate is a transitional type of climate found between the equatorial forest and the trade wind hot deserts. It is confined within the tropics and is best developed in the Sudan where the dry and wet seasons are most distinct, hence its name the Sudan Climate. The belt includes West African Sudan, and then curves southwards into East Africa and southern Africa north of the Tropic of Capricorn. In South America, there are two distinct regions of *savannah* north and south of the equator, namely the *llanos* of the Orinoco basin and the *Campos* of the Brazilian Highlands.



Climatic Conditions:

The Savannah climate is characterized by distinct wet and dry seasons. Mean high temperature throughout the year is between 24°C and 27° C. The annual range of temperature is between 3°C and 8°C, but the range increases as one move further away from the equator. The extreme diurnal range of temperature is a characteristic of Sudan type of climate. The average annual rainfall ranges between 100 cm and 150 cm. The prevailing winds of the region are the Trade Winds which bring rain to the coastal districts.

Natural Vegetation: The savannah landscape is typified by tall grass and short trees. The terms *'parkland'* or *'bush-veld'* perhaps describe the landscape better. Trees grow best towards the

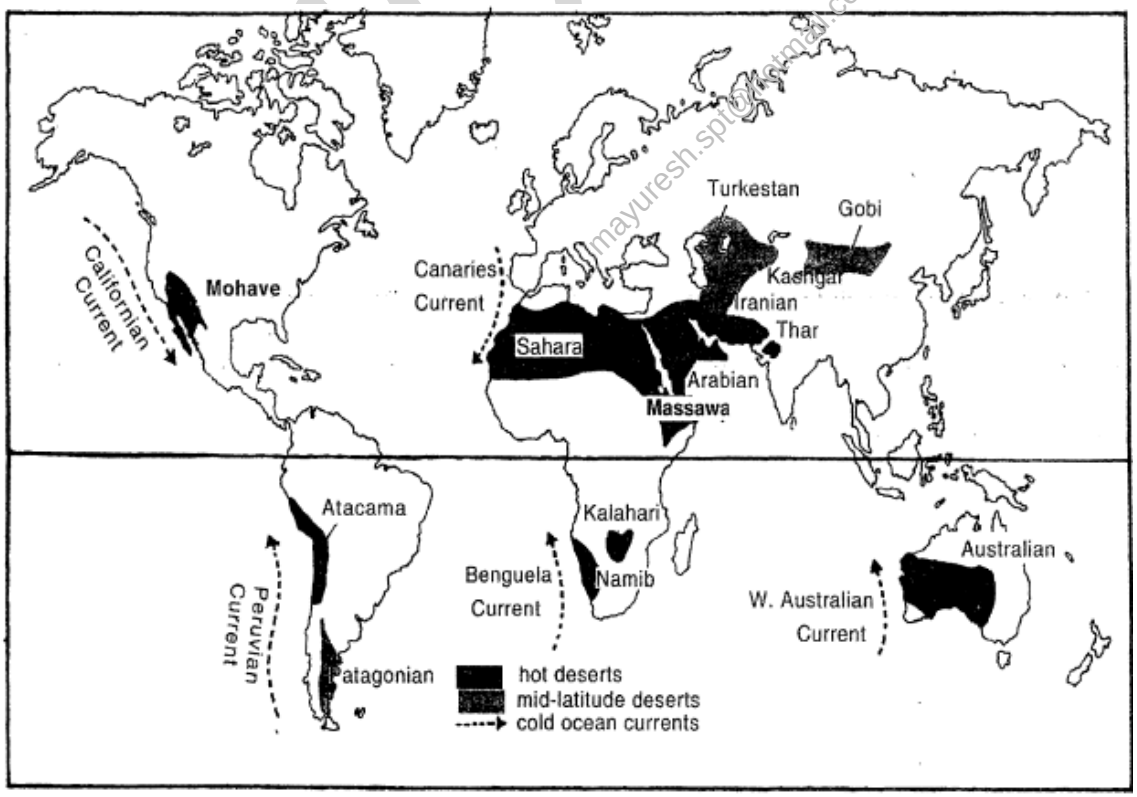
equatorial humid latitudes or along river banks but decrease in height and density away from the equator. The trees are deciduous, shedding their leaves in the cool, dry season to prevent excessive loss of water through transpiration, e.g. acacias. Others have broad trunks, with water-storing devices to survive through the prolonged drought such as baobabs and bottle trees. Trees are mostly hard, gnarled and thorny and may exude gum like *gum arabic*.

Animal Life of the Savannah: The savannah, particularly in Africa, is the home of wild animals. It is known as the 'big game country' and thousands of animals are trapped or killed each year by people from all over the world. Some of the animals are tracked down for their skins, horns, tusks, bones or hair, others are captured alive and sent out of Africa as zoo animals, laboratory specimens or pets.

Economy: Many tribes live within the Savannah lands. Some tribes live as pastoralists like the Masai and other as settled cultivators like the Hausa of northern Nigeria. However, agriculture is not much developed.

3.4. The Hot Desert and Mid-latitude Desert Climates

Distribution: Deserts are regions of scanty rainfall which may be hot like the hot deserts of the Saharan type or temperate as are the mid- latitude deserts like the Gobi. The major hot deserts of the world are located on the western coasts of continents between latitudes 15º and 30ºN and S. They include the Sahara Desert, the largest single stretch of desert, which is 3,200 miles from east to west and at least 1,000 miles wide. The next biggest desert is the Great Australian Desert which covers almost half of the continent. The other hot deserts are the Arabian Desert, Iranian Desert, Thar Desert, Kalahari and Namib Deserts. In North America, the desert extends from Mexico to USA and is called by different names at different places, e.g. the Mohave Sonoran, Californian and Mexican Deserts. In South America, the Atacama or Peruvian Desert is the driest of all deserts with less than 0.5 inches of rainfall annually. The Patagonian Desert is more due to its rain- shadow position on the leeward side of the lofty Andes than to continentality.



Climatic Conditions:

Rainfall: The aridity of deserts is the most outstanding feature of the desert climate. Few deserts whether hot or mid-latitude have an annual precipitation of more than 10 inches while in others less than 0.02 inches. The hot deserts lie astride the Horse Latitudes or the Sub-Tropical High Pressure Belts where the air is descending, a condition least favourable for precipitation of any kind to take place. The rain bearing trade winds blow off shore and the Westerlies, that are on-shore, blow outside the desert limits. Whatever winds reaches the deserts blow from the cooler to the warmer regions, and their relative humidity is lowered, making condensation almost impossible.

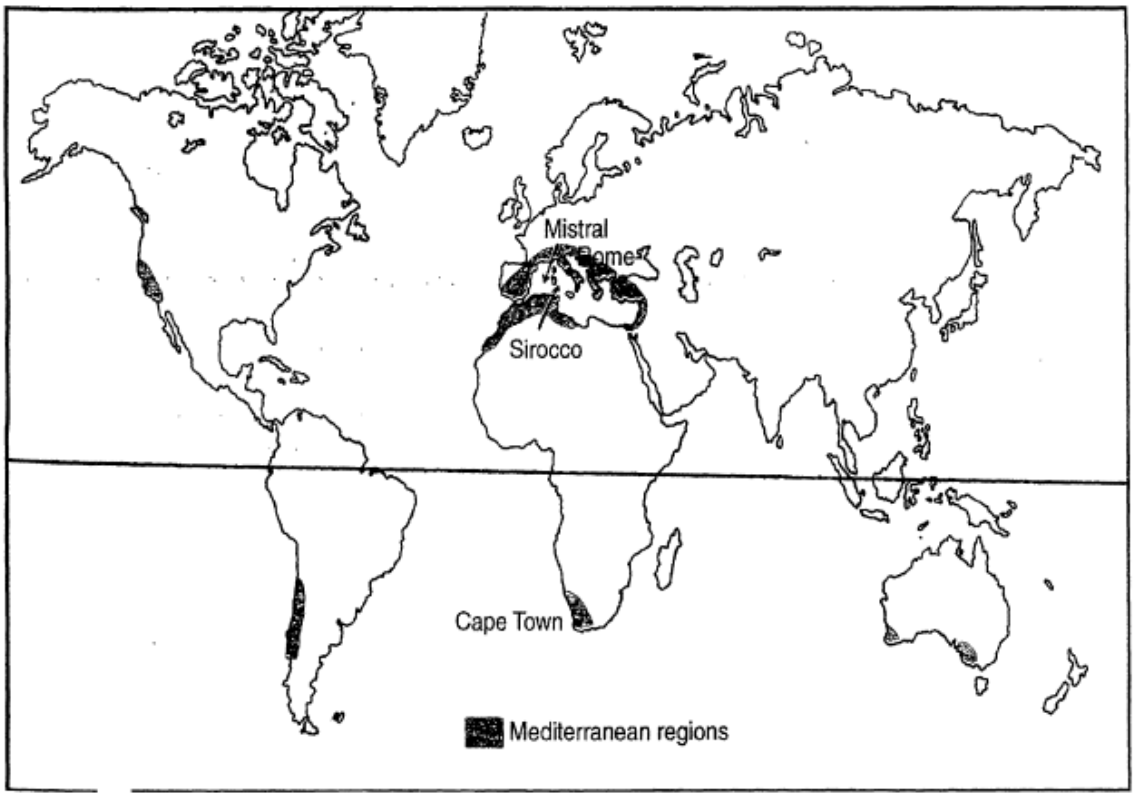
Temperature: The deserts are some of the hottest spots on earth and have high temperatures throughout the year. There is no cold season in the hot deserts and the average summer temperature is around 30°C. The highest shade temperature recorded is 58°C at Al Azizia, 25 miles south of Tripoli, Libya, in the Sahara. The diurnal range of temperature in the deserts is very great.

Natural Vegetation: All deserts have some form of vegetation such as grass, scrub, herbs, weeds, roots or bulbs. Though they may not appear green and fresh all the time, they lie dormant in the soil awaiting rain which comes at irregular intervals or once in many years. The environment, so lacking in moisture and so excessive in heat, is most unfavourable for plant growth and significant vegetation cannot be expected. The predominant vegetation of both hot and mid-latitude deserts is xerophytes or drought-resistant scrub. This includes the bulbous cacti, thorny bushes, long-rooted wiry grasses and scattered dwarf acacia. Trees are rare except where there is abundant ground water to support clusters of date palms.

Life in the Deserts: Despite its inhospitality, the desert has always been peopled by different groups of inhabitants. They struggle against an environment deficient in water, food and other means of livelihood. The desert inhabitants may be grouped under the following categories - The primitive hunters and collectors (The Bushmen and The Bindibu), the nomadic herdsmen (The Tuaregs of the Sahara, the Gobi Mongols and The Bedouin of Arabia), the caravan traders, the settled cultivators and the mining settlers.

3.5. The Warm Temperate Western Margin (Mediterranean) Climate

Distribution: The Warm Temperate Western Margin Climate is found in relatively, few areas in the world. They are entirely confined to the western portion of continental masses, between 30° and 45° north and south of the equator. The basic cause of this type of climate is the shifting of the wind belts. Though the area around the Mediterranean Sea has the greatest extent of this type of 'winter rain climate', and gives rise to the more popular name Mediterranean Climate. Other Mediterranean regions include California (around San Francisco), the south-western tip of Africa (around Cape Town), southern Australia (in southern Victoria and around Adelaide, bordering the St. Vincent and Spencer Gulfs), and south-west Australia (Swanland).



Climatic Conditions: The Mediterranean type of climate is characterized by very distinctive climatic features - a warm summer with off-shore trades, a concentration of rainfall in winter with onshore westerlies, bright, sunny weather with hot dry summers and wet, mild winters and the prominence of local winds around the Mediterranean Sea (Sirocco, Mistral). Since all regions with a Mediterranean climate are near large bodies of water, temperatures are generally moderate with a comparatively small range of temperature res between the winter low and summer high. Areas with this climate receive almost all of their yearly rainfall during the winter season, and may go the summer without having any significant precipitation.

Natural vegetation: Trees with small broad leaves are widely spaced and never very tall. Though there are many branches they are short and carry few leaves. The absence of shade is a distinct feature of Mediterranean lands. Growth is slow in the cooler and wetter season, even though more rain comes in winter. The warm, bright summers and cool, moist winters enable a wide range of crops to be cultivated. The Mediterranean lands are also known as the world's **orchard lands**. A wide range of citrus fruits such as oranges, lemons, limes, citrons and grapefruit are grown. Wine production is another speciality of the Mediterranean countries, because the best wine is essentially made from grapes. Some 85 per cent of grapes produced, go into wine. The long, sunny summer allows the grapes to ripen and then they are hand-picked.

Economy: The area is important for fruit cultivation, cereal growing, wine-making and agricultural industries as well as engineering and mining.

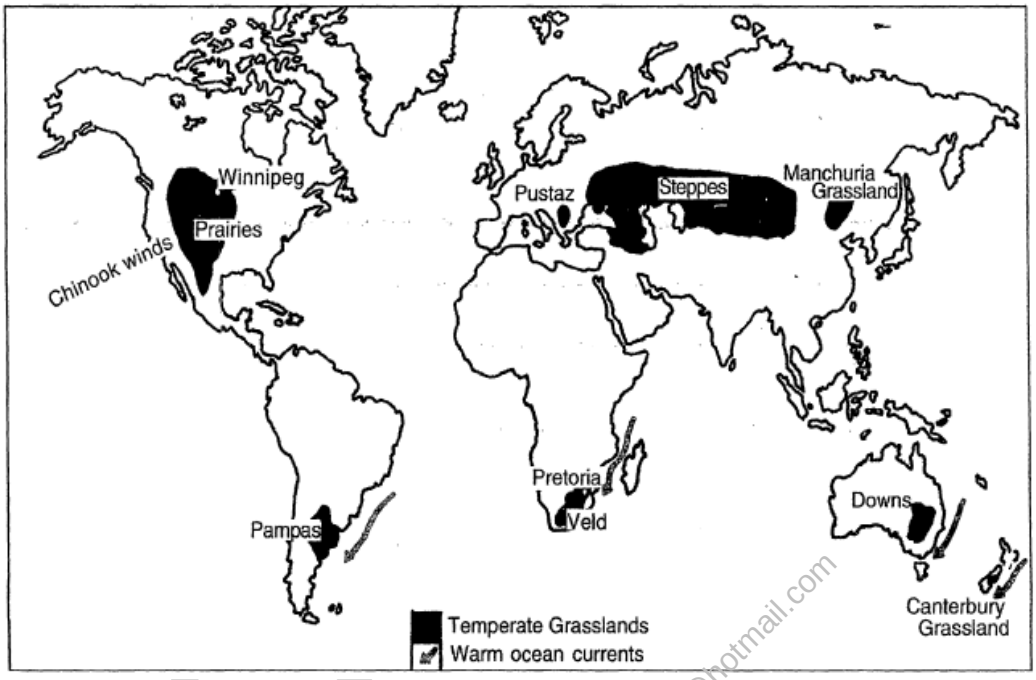
3.6. The Temperate Continental (Steppe) Climate

Distribution

Bordering the deserts, away from the Mediterranean regions and in the interiors continents are the temperate grasslands. Though they lie in the Westerly wind belt, they are so remote from maritime influence that the grasslands are practically treeless. *These grasslands* are so distinctive in their natural vegetation that, although those which occur in the southern

hemisphere have a much more moderate climate, they are often dealt with together. In the northern hemisphere, the grasslands are far more extensive and are entirely continental. In Eurasia, they are called the ***Steppes*** and stretch eastwards from the shores of the Black Sea across the Great Russian plain to the foothills of the Altai Mountains, a distance of well over 2,000 miles. There are isolated sections in the *Pustaz* of Hungary and the plains of Manchuria. In North America, the grasslands are also quite extensive and are called **Prairies**. They lie between the foothills of the Rockies and the Great Lakes astride the American Canadian border.

In the case of the **Pampas** of Argentina and Uruguay, the grasslands extend right to the sea and enjoy much maritime influence. In South Africa, the grasslands are sandwiched between the Drakensberg and the Kalahari Desert; and are further subdivided into the more tropical Bush-**veld** in the north, and the more temperate High Veld in the south.



Climatic Conditions

Temperature: Their location in the heart of continents means that they have little maritime influence. Their climate is thus continental with extremes of temperature. **Summers are very warm**, over 19°C. **Winters are very cold** in the continental steppes of Eurasia because of the enormous distances from the nearest sea. The winter months are well below freezing. In contrast, the steppe type of climate in the southern hemisphere is never severe. The winters are mild. Temperatures below freezing point even in midwinter (July in the southern hemisphere) are exceptional.

Precipitation: In its continental position, the annual precipitation of the Steppe Climate is light. The average rainfall may be taken as about 20 inches, but this again varies according to location from 10 inches to 30 inches. The maritime influence in the steppe type of climate of the southern hemisphere is even better brought out by the rainfall regime. Its annual precipitation is always more than the average 20 inches because of the warm ocean currents that wash the shores of the steppe-lands.

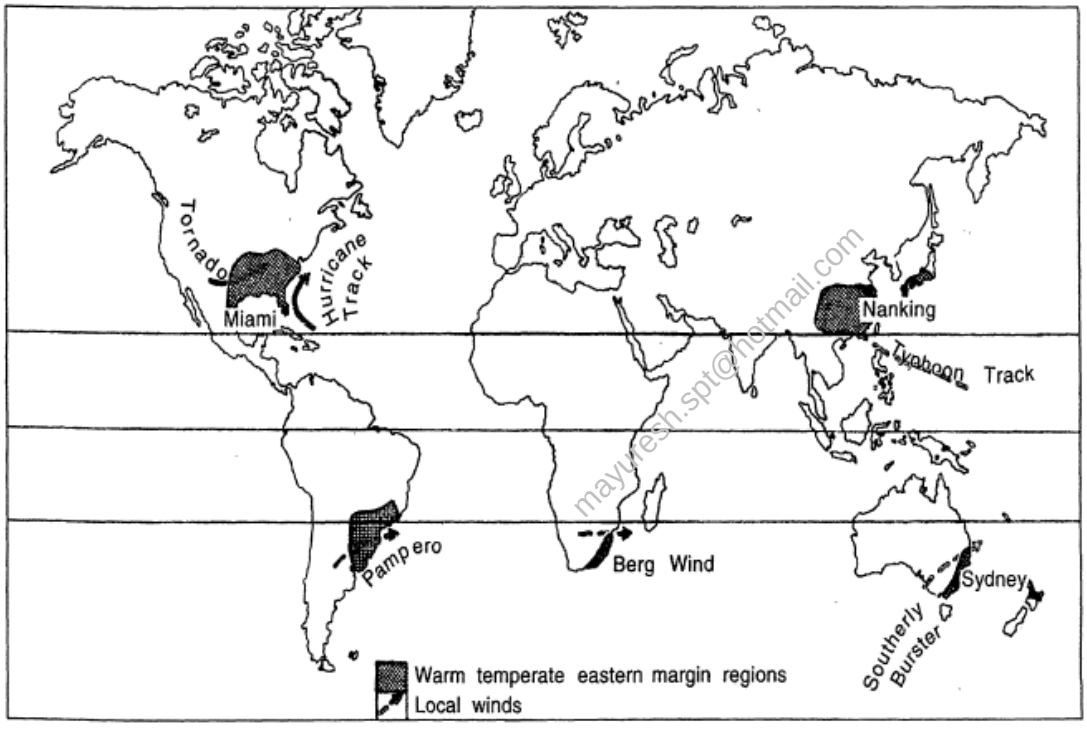
Natural Vegetation: The reference to steppe grassland is taken to mean the **temperate grasslands** of the mid-latitudes, the Steppes, Prairies, Pampas, Veld and Downs. The steppes are grass covered, differing only in the *density* and *quality* of the grass. Their greatest difference from the tropical savannah is that they are practically treeless and the grasses are much

shorter. Where the rainfall is moderate, above 20 inches, the grasses are tall, fresh and nutritious and are better described as long prairie grass. The *appearance* of the temperate grasslands varies with seasons. Trees are very scarce in the steppes, because of the scanty rainfall, long droughts and severe winters.

Economy: The grasslands have been ploughed up for extensive, mechanized wheat cultivation and are now the 'granaries of the world'. Besides wheat, maize is increasingly cultivated in the warmer and wetter areas. The tufted grasses have been replaced by the more nutritious Lucerne or alfalfa grass.

3.7. The Warm Temperate Eastern Margin (China Type) Climate

Distribution: This type of climate is found on the **eastern margins of continents** in warm temperate latitudes, just outside the tropics. It has comparatively more rainfall than the Mediterranean climate in the same latitudes, coming mainly in the summer. It is, in fact, the climate of most parts of China –a modified form of monsoonal climate. It is thus also called the *Temperate Monsoon or China Type* of climate. In south-eastern U.S.A., bordering the Gulf of Mexico, continental heating in summer induces an inflow of air from the cooler Atlantic Ocean. It is sometimes referred to as the Gulf type of climate. In the southern hemisphere, this kind of climate is experienced along the warm temperate eastern coastlands of all the three continents: in New South Wales with its eucalyptus forests; in Natal where cane sugar thrives; and in the maize belt of the Parana-Paraguay-Uruguay basin.



Climatic Condition:

The Warm Temperate Eastern Margin Climate is typified by a **warm moist summer and a cool, dry winter**. The mean monthly temperature varies between 5°C and 25°C and is strongly modified by maritime influence. The relative humidity is a little high in mid-summer. Rainfall is more than moderate, anything from 25 inches to 60 inches. Another important feature is the **fairly uniform distribution of rainfall throughout the year**. There is rain every month, except in the interior of central China, where there is a distinct dry season. Rain comes either from convectional sources or as orographic rain in summer, or from depressions in prolonged showers in winter. Local storms, e.g. typhoons, and hurricanes, also occur.

It can be sub-divided into three main types – a) The China type: central and north China (including southern Japan (temperate monsoonal). b) The Gulf type: south-eastern United States, (slight-monsoonal). c) The Natal type: the entire warm temperate eastern margin (non-monsoonal areas) of the southern hemisphere including Natal, eastern Australia and southern Brazil-Paraguay-Uruguay and northern Argentina.

Natural Vegetation: The eastern margins of warm temperate latitudes have a much heavier rainfall than either the western margins or the continental interiors and thus have luxuriant vegetation. The lowlands carry both evergreen broad-leaved forests and deciduous trees quite similar to those of the tropical monsoon forests. On the highlands, are various species of conifers such as pines and cypresses that are important softwood.

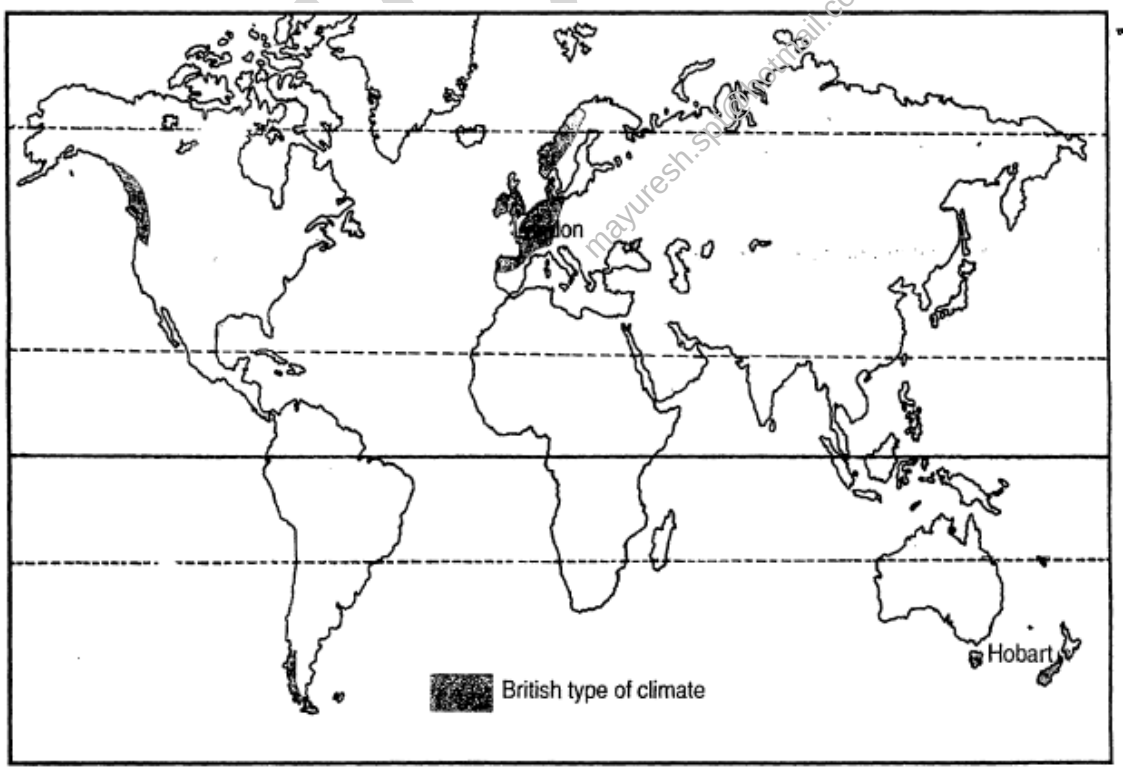
Economy: The warm temperate eastern margins are the most productive parts of the middle latitudes. Besides the widespread cultivation of. Maize and cotton in the Corn and Cotton Belts of U.S.A. fruit and tobacco are also grown. Rice, tea and mulberries are extensively grown in monsoon China.

Elsewhere are found other products of economic importance, e.g. cane sugar in Natal, coffee and maize in South America and dairying in New South Wales and Victoria.

3.8. The Cool Temperate Western Margin (British Type) Climate

Distribution Climate

The cool temperate western margins are under the permanent influence of the Westerlies all round the year. They are also regions of much cyclonic activity, typical of Britain, and are thus said to experience the British type of climate. From Britain, the climatic belt stretches far inland into the lowlands North-West Europe, including such regions as northern and western France, Belgium, the Netherlands, Denmark, western Norway and also north-western Iberia. In the southern hemisphere, the climate is experienced in southern Chile, Tasmania and most parts of New Zealand, particularly in South Island.



Climatic Conditions

Temperature: The mean annual temperatures are usually between 5°C and 15°C. The annual range of temperature is small. Summers are, in fact, never very warm. Monthly temperatures of over 18°C even in mid-summer are rare.

Precipitation: The British type of climate has adequate rainfall throughout the year with a tendency towards a slight winter or autumn maximum from cyclonic sources. Since the rain-bearing winds come from the west, the western margins have the heaviest rainfall. The amount decreases eastwards with increasing distance from the sea.

Natural Vegetation: The natural vegetation of this climatic type is deciduous forest. The trees shed their leaves in the cold season. This is an adaptation for protecting themselves against the winter snow and frost. Shedding begins in autumn, the 'fall' season, during which the leaves fall and are scattered by the winds. Some of the more common species include oak, elm, ash, birch, beech, poplar, and hornbeam. Unlike the equatorial forests, the deciduous trees occur in pure stands and have greater lumbering value from the commercial point of view. The deciduous hardwoods are excellent for both fuel and industrial purposes.

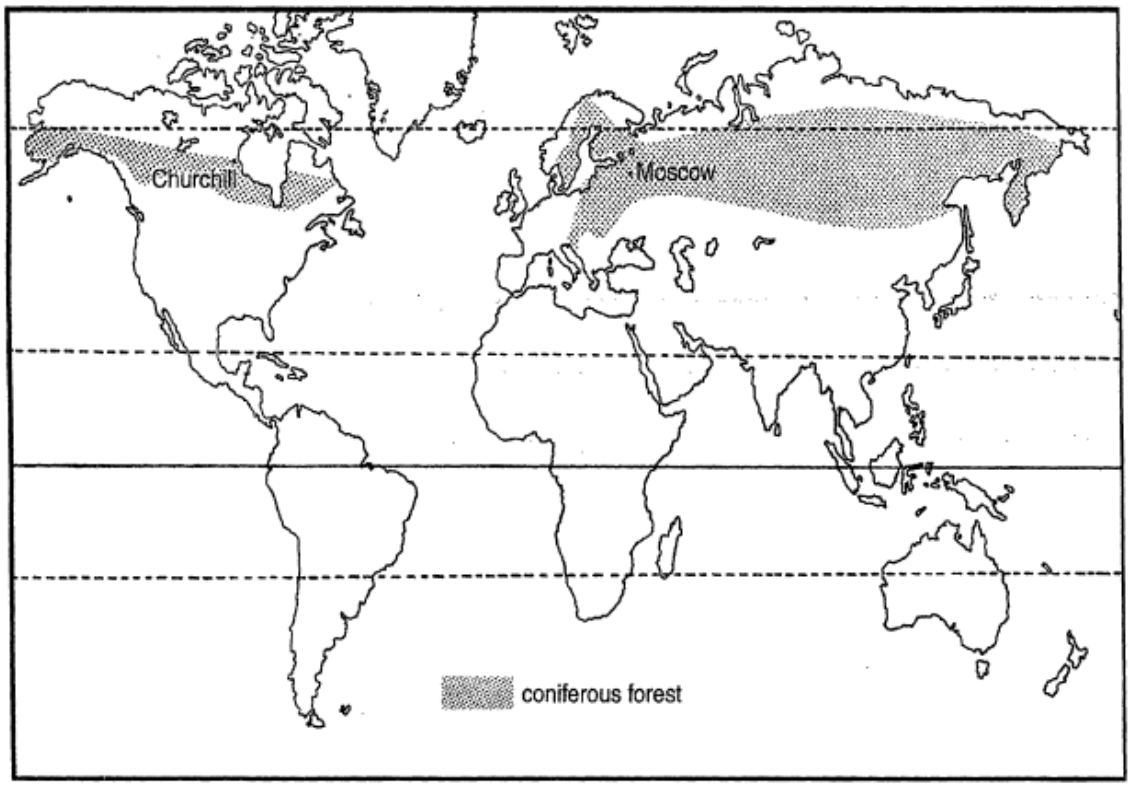
Economy: The region differs from many others in its unprecedented industrial advancement. The countries are

concerned in the production of machinery, chemicals, textiles and other manufactured articles rather than agriculture, fishing or lumbering, though these activities are well represented in some of the countries. Fishing is particularly important in Britain, Norway and British Columbia. A very large part of the deciduous woodlands have been cleared for fuel, timber or agriculture.

3.9. The Cool Temperate Continental (Siberian) Climate

Distribution

The Cool Temperate Continental (Siberian) Climate is experienced only in the northern hemisphere where the continents within the high latitudes have a broad east-west spread. On its pole ward side, it merges into the Arctic tundra of Canada and Eurasia at around the Arctic Circle. The Siberian Climate is conspicuously absent in the southern hemisphere because of the narrowness of the southern continents in the high latitudes. The strong oceanic influence reduces the severity of the winter and coniferous forests are found only on the mountainous uplands of southern Chile, New Zealand, Tasmania and south-east Australia.



Climatic Conditions:

Temperature: The climate of the Siberian type is characterized by a bitterly cold winter of long duration, and a cool brief summer. Spring and autumn are merely brief transitional periods. The extremes of temperature are so great in Siberia that it is often referred to as the 'cold pole of the earth'. Some of the lowest temperatures in the world are recorded in Verkhoyansk.

Precipitation: The interiors of the Eurasian continent are so remote from maritime influence that annual precipitation cannot be high. Generally speaking, a total of 15 to 25 inches is typical of the annual precipitation of this sub-Arctic type of climate. It is quite well distributed throughout the year, with **a summer maximum** from convectional rain.

Natural Vegetation

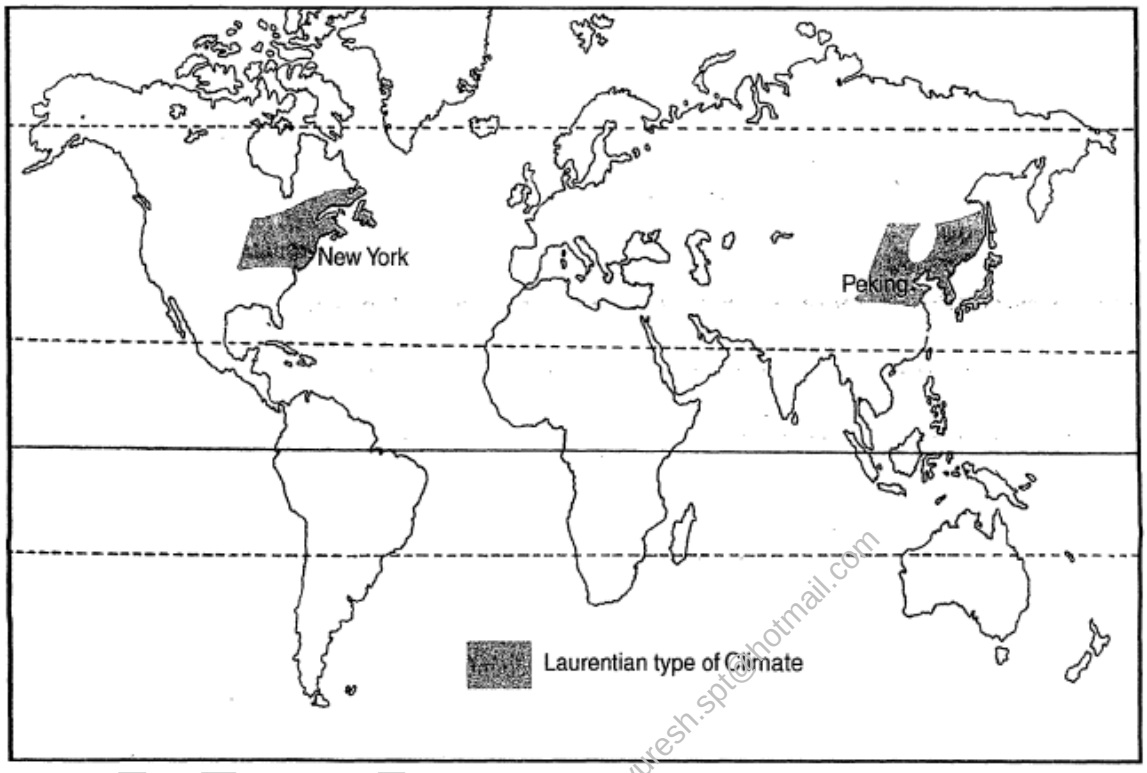
No other trees are as well adapted as the conifers to withstand such an inhospitable environment as the Siberian type of climate. The coniferous forest belts of Eurasia and North America are the richest sources of softwood for use in building construction, furniture, matches, paper and pulp, rayon and other branches of the chemical industry, The world's greatest softwood producers are U.S.S.R, U.S.A., Canada and the Fenoscandian countries (Finland, Norway and Sweden). In the field of newsprint, Canada has outstripped all other producers, accounting for almost half of the world's total annual production. There are four major *species* in the coniferous forests – a) Pine, e.g. white pine, red pine, Scots pine, Jack pine, b) Fir, e.g., Douglas fir and balsam fir, c) Spruce and d) Larch.

Economy: The coniferous forest regions of the northern hemisphere are comparatively little developed. Only in the more accessible areas are the forests cleared for lumbering. There is little agriculture, as few crops can survive in the sub-Arctic climate of these northerly lands. Many of the Samoyeds and Yakuts of Siberia, and some Canadians are engaged in hunting, trapping and fishing.

3.10. The Cool Temperate Eastern Margin (Laurentian) Climate

Distribution

The Cool Temperate Eastern Margin (Laurentian) Climate is an **intermediate type of climate between the British and the Siberian type of climate**. It has features of both the maritime and the continental climates. The Laurentian type of climate is found only in two regions. One is north-eastern North America, including eastern Canada, north-east U.S.A., (i.e. Maritime Provinces and the New England states), and Newfoundland. This may be referred to as the North American region. The other region is the eastern coastlands of Asia, including eastern Siberia, North China, Manchuria, Korea and northern Japan. It may be referred to as the Asiatic region. In the southern hemisphere, this climatic type is absent because only a small section of the southern continents extends south of the latitude of 40° S.



Climatic Conditions:

The Laurentian type of climate has cold, dry winters and warm, wet summers. Winter temperatures may be well below freezing-point and snow falls to quite a depth. Summers are as warm as the tropics (21° - 27°C) and if it were not for the cooling effects of the off-shore cold currents from the Arctic, the summer might be even hotter. Though rain falls throughout the year, there is a distinct **summer maximum** from the easterly winds from the oceans. Of the annual precipitation of 30 to 60 inches, two-thirds come in the summer. Winter is dry and cold, because the winds are dry Westerlies that blowout from the continental interiors.

Natural Vegetation

The predominant vegetation of the Laurentian type of climate is cool temperate forest. The heavy rainfall, the warm summers and the damp air from fogs, all favour the growth of trees. Generally speaking, the forest tends to be coniferous north of the 50° N. parallel of latitude. The increase in the length and severity of the winter excludes forests that are not adaptable to cold conditions. Oak, beech, maple and birch are the principal trees.

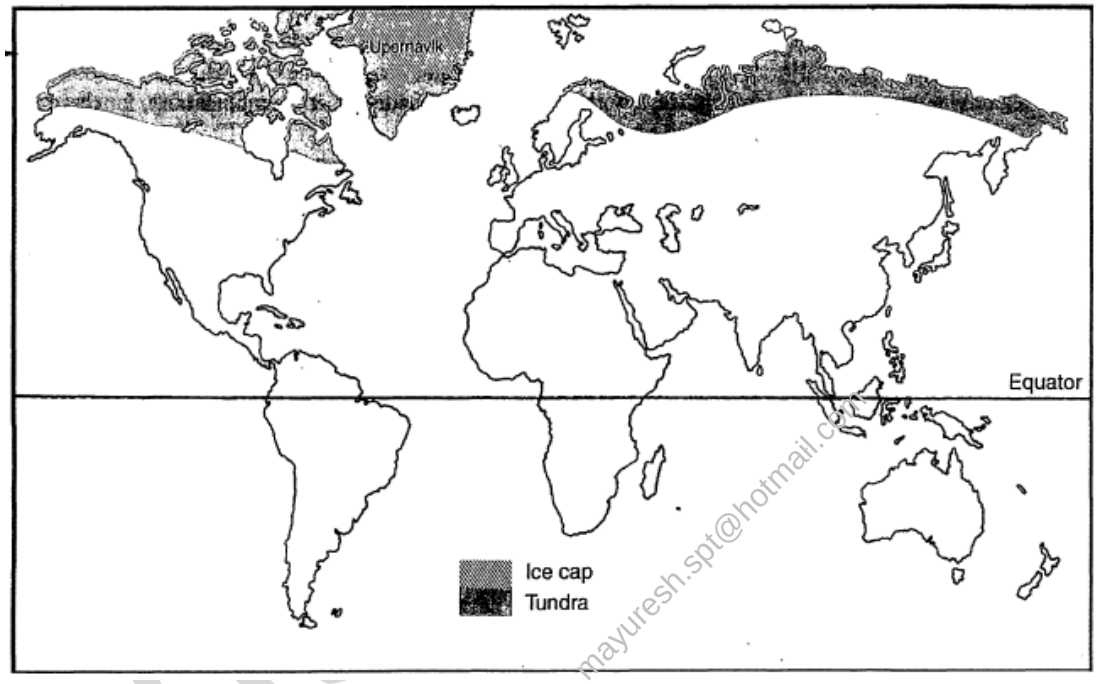
Economy

Lumbering and its associated timber, paper and pulp industries are the most important economic undertaking. Agriculture is less important in view of the severity of the winter and its long duration. Fortunately the maritime influence and the heavy rainfall enable some hardy crops to be raised for local needs. The fertile Annapolis valley in Nova Scotia is the world's most renowned region for apples. Fishing is, however, the most outstanding economic activity of the Laurentian climatic regions.

3.11. The Arctic or Polar Climate

Distribution

The polar type of climate and vegetation is found mainly north of the Arctic Circle in the northern hemisphere. The ice-cap is confined to Greenland and to the highlands of these high-latitude regions, where the ground is permanently snow-covered. The lowlands, with a few months ice-free, have tundra vegetation. They include the coastal strip of Greenland, the barren grounds of northern Canada and Alaska and the Arctic seaboard of Eurasia.



Climatic Conditions

Temperature: The polar climate is characterized by a very low mean annual temperature and its warmest month in June seldom rises to more than 10°C. In mid-winter (January) temperatures are as low as – *35*°C and much colder in the interior. Winters are long and very severe; summers are cool and brief.

Precipitation: Precipitation is mainly in the form of snow, falling in winter and being drifted about during blizzards. Snowfall varies with locality; it may fall either as ice crystals or large, amalgamated snowflakes. Convectional rainfall is generally absent because of the low rate of evaporation and the lack of moisture in the cold polar air. There is normally a summer maximum, and the precipitation is then in the form of rain or sleet.

Natural vegetation

In such an adverse environment as the tundra, few plants survive. The greatest inhibiting factor is the region's deficiency in heat. With a growing season of less than three months and the

warmest month not exceeding 10° C (the tree-survival line), there are no trees in the tundra. Such an environment can support only the lowest form of vegetation, mosses, lichens and sedges. Drainage in the tundra is usually poor as the sub-soil is permanently frozen. Ponds and marshes and waterlogged areas are found in hollows.

Economy:

Human activities of the tundra are largely confined to the coast. Where plateaux and mountains increase the altitude, it is uninhabitable, for these are permanently snow-covered. The few people who live in the tundra live a semi-nomadic life and have to adapt themselves to the harsh environment. The Arctic region, once regarded as completely useless, is now of some economic importance. Apart from the efforts of the various governments in assisting the advancement of the Arctic inhabitants the Eskimos, Lapps, Samoyeds etc., new settlements have sprung up because of the discovery of minerals.

4. Mains Questions

1. Major hot deserts in northern hemisphere are located between 20-30 degree north and on the western side of the continents. Why? (UPSC 2013/10 Marks)
2. "As regards the increasing rates of melting of Arctic ice, the interests of the Arctic Council nations may not coincide with those of the wider world. "Explain. (UPSC 2011/12 Marks)
3. Why is India undertaking expeditions to Antarctica? Describe the influence of Antarctica and Antarctic ocean on the climate of India and on the nutrient and energy supply to Indian Ocean.

5. Prelims Questions

1. "Climate is extreme, rainfall is scanty and the people used to be nomadic herders."
The above statement best describes which of the following regions? (2013)
(a) African Savannah (b) Central Asian Steppe
(c) North American Prairie (d) Siberian Tundra

2. Which one of the following is the **(2012)**
Characteristic climate of the Tropical Savannah Region?
(a) Rainfall throughout the year (b) Rainfall in winter only
(c) An extremely short dry season (d) A definite dry and wet season

3. What could be the main reason/reasons of the formation of African and Eurasian desert belt? **(2011)**
1. It is located in the sub-tropical high pressure cells.
2. It is under the influence of warm ocean currents.
Which of the statements given above is/are correct in this context?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

4. A geographic region has the following distinct characteristics:
1. Warm and dry climate
2. Mild and wet winter
3. Evergreen oak trees
The above features are the distinct characteristics of which one of the following regions? (2010)
(a) Mediterranean (b) Eastern China
(c) Central Asia (d) Atlantic coast of North America

Student Notes:

5. Consider the following statements: **(2002)**

1. In equatorial regions, the year is divided into four main seasons.
2. In Mediterranean region, summer receives more rain.
3. In China type climate, rainfall occurs throughout the year.
4. Tropical highlands exhibit vertical zonation of different climates.

Which of these statements are correct/

(a) 1, 2, 3 and 4 (b) 1, 2 and 3

(c) 1, 2 and 4 (d) 3 and 4

6. The temperature and rainfall of a meteorological station are given below:

Temperature (0C) Rainfall (cm) **(2001)**

	Temperature (°C)	Rainfall (cm)
J	9.4	12.2
F	10.6	9.1
M	11.7	7.9
A	12.2	2.5
M	13.3	1.8
J	13.9	0.3
J	13.9	–
A	14.4	–
S	15.6	0.8
O	15.0	2.5
N	13.3	6.1
D	10.6	11.7

Average Temperature: 12.80C

Average Rainfall: 54.9 cm per annum

Identify the region having the above climatic pattern from amongst the following:

(a) Mediterranean region (b) Monsoon region

(c) Steppe region (d) N.W. European region

7. Consider the following statements:

1. The annual range of temperature is greater in the Pacific Ocean than that in the Atlantic Ocean.
2. The annual range of temperature is greater in the Northern Hemisphere than that in the Southern Hemisphere.

Which of the statements given above is/are correct? **(2007)**

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

Student Notes:

MISCELLANEOUS TOPICS LIKE EL NINO, LA NINA, ENSO, URBAN CLIMATE, APPLIED CLIMATOLOGY, HEAT ISLAND ETC.

Contents

1. El Niño

Near the end of each year as the southern hemispherical summer is about to peak, a weak, warm counter-current[1] flows southward along the coasts of Ecuador and Peru in the eastern equatorial Pacific Ocean, replacing the cold Peruvian current (an eastern boundary current along South America). In the past, local residents referred to this annual warming as "El Niño," (Spanish: meaning "The Boy Child") due to its appearance around the Christmas season. For Peruvian fishermen, it signifies the end of the fishing season. Normally, these warm counter-currents last for at most a few weeks when they again give way to the cold Peruvian current.

However, every three to seven years, this counter-current is unusually warm and strong. It lasts for several months and is often accompanied by heavy rainfall in the arid coastal regions of Ecuador and northern Peru. Over time the term El Niño began to be used in reference to these major warm episodes.

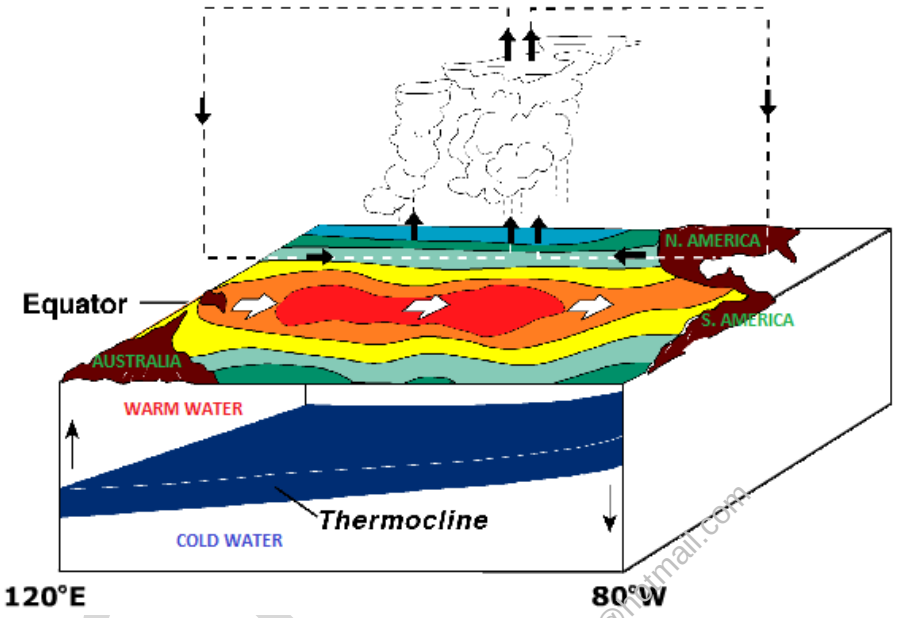


Figure 1 – El Nino conditions: Warm water pool approaches the South American coast. The absence of cold upwelling increases warming.

Under normal conditions, the cold Peruvian current flows equatorward along the coast of Ecuador and Peru (figure 2). The Peruvian current is slow and thus not very strong. Near the coast, it is only about 200m deep, while increasing to 700m offshore. In the absence of an El Niño, prevailing surface winds deviates water considerably to the left or away from the coast, with subsequent upwelling of cold water from below. This upwelling of deep, nutrient-filled waters is the primary food source for millions of fish, particularly anchovies along the Pacific Coast of South America.

During El Niño, surface winds are weaker than their average value. Weaker surface winds are beneficial for warm counter-equatorial current that becomes strong and replaces Peruvian

[1] Counter-equatorial current - Between the North and South Equatorial currents, there is a surface current moving down slope west to east, the Equatorial Countercurrent. This current helps to return surface water accumulated against the eastern coast of continents by the Equatorial currents. It is this counter-current in Pacific Ocean that increases in strength and triggers an El-Niño event.

current along the coast of South America. This current carries warm water of west Pacific Ocean to central and eastern Pacific Ocean. It increases the Pacific Ocean's sea surface temperature (SST).

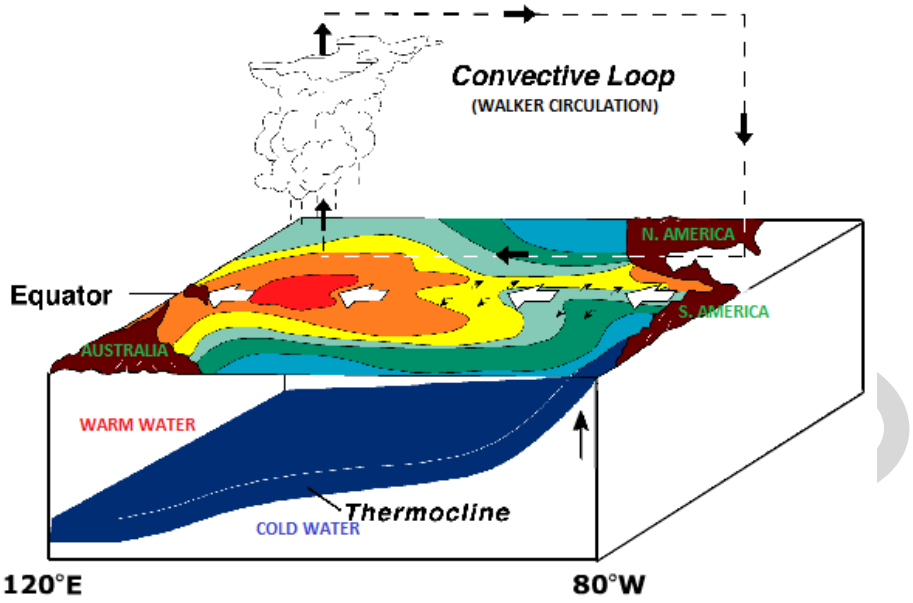


Figure 2 – Normal Pacific pattern: Equatorial winds gather warm water pool toward the west. Cold water upwells along South American coast.

1.1. El Niño – Southern Oscillation (ENSO)

ENSO consists of **two components**. The first, mainly oceanic, is known as **El Niño**. The second, mainly atmospheric, component of ENSO has been described as the **Southern Oscillation**. We already know that El Niño is the unusual warm oceanic water at pacific coast of South America.

Major El Niño events are intimately related to large-scale atmospheric circulation. Each time an El Niño occurs, the barometric pressure drops over large portions of the south-eastern Pacific, whereas in the western Pacific, near Indonesia and northern Australia, the pressure rises. Then, as a major El Niño event comes to an end, the atmospheric pressure difference between these two regions swings back in the opposite direction. This see-saw pattern of atmospheric pressure between the eastern and western Pacific is known as the "Southern Oscillation".

The strength of the Southern Oscillation is measured by the **Southern Oscillation Index** (SOI). The SOI is computed from fluctuations in the surface air pressure difference between Tahiti, French Polynesia and Darwin, Australia. El Niño episodes are associated with negative values of the SOI, meaning there is below normal pressure over Tahiti and above normal pressure of Darwin.

ENSO appears to be a necessary mechanism for maintaining long-term global climate stability by transporting heat from the Tropics to the higher latitudes.

Effects of EL NINO/ENSO

- The abnormally strong winds originating from the west push masses of warm surface water from the equatorial region against the South-American coast, and are ultimately deflected towards Mexico, Peru, and Ecuador, creating an area of warm water thousands of

kilometers in length. The sun warms the surface layer still further, thus enhancing the effect. The thermocline[2] falls, and along with it the pool of nutrient rich water.

- In an immediate effect, this warm blob of water blocks off the upwelling of colder along South American coast, nutrient rich water driving anchovies fish into starvation. These fish do no longer support large population of fish-feeding birds, whose droppings (guano) are mined for fertilizer. With the disappearance of anchovies and other marine organisms, predators like seabirds, further up the food-chain, experience a drastic decline in nutritional resources.
- In a long-lasting ENSO event, the dissolved seawater oxygen content becomes depleted. This favours production of foul-smelling hydrogen-sulfide and other gases, blackening the "lead paint" on ships and producing other discoloring effects
- During El Nino, some inland areas of South America that are normally arid receive an uncommon abundance of rain. Here pastures and cotton fields have yields far above the norm.
- Most important aspect of an ENSO event is the change in the precipitation patterns over the globe (Figure 3).

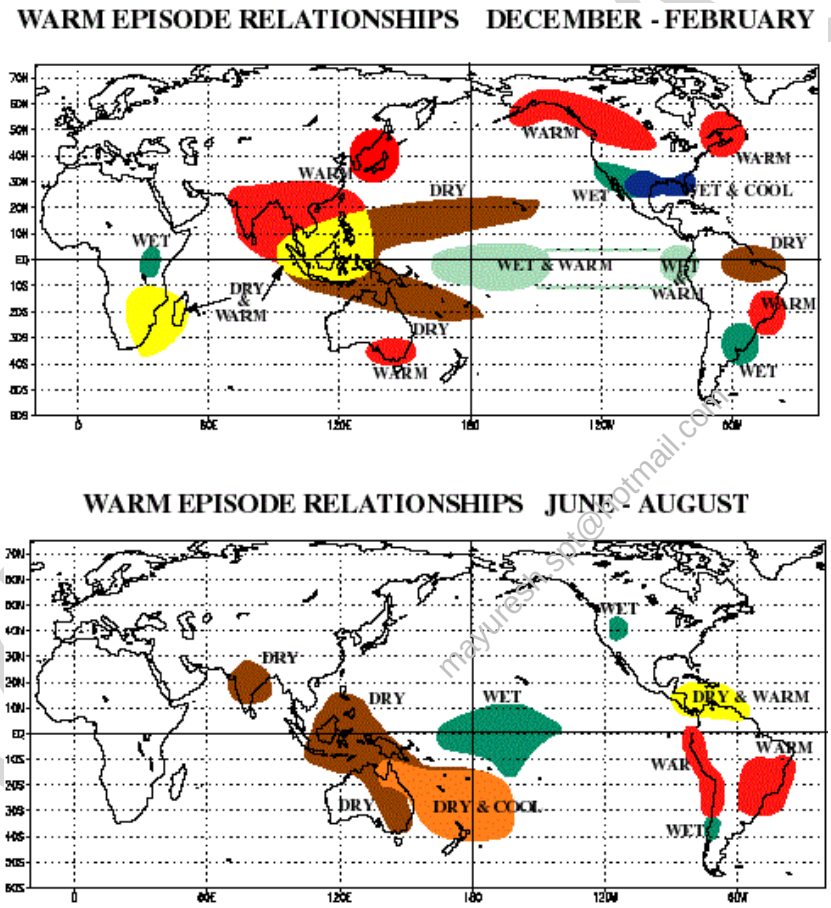


Figure 3 – global precipitation pattern during El Nino

[2] Thermocline – is a thin but distinct layer in a large body of fluid (e.g. water, such as an ocean or lake, or air, such as an atmosphere) in which temperature changes more rapidly with depth than it does in the layers above or below.

1.2. La Niña

La Niña (Spanish: meaning "The Girl Child") is a counterpart of El Niño. During La Niña, the cold pool in the eastern tropical Pacific intensifies and the trade winds strengthen. During a period of La Niña, the sea surface temperature (SST) across the equatorial Eastern Central Pacific Ocean will be lower than normal by 3–5 °C.

Effects of LA NIÑA

- **Africa** - La Niña results in wetter-than-normal conditions in Southern Africa from December to February, and drier-than-normal conditions over equatorial East Africa over the same period.
- **Asia** - During La Niña years, the formation of tropical cyclones, along with the subtropical ridge position, shifts westward across the western Pacific ocean, which increases the landfall threat to China. Generally, South Asian monsoon is good during La Nina events as it strengthens the Indian Ocean loop of walker cell.

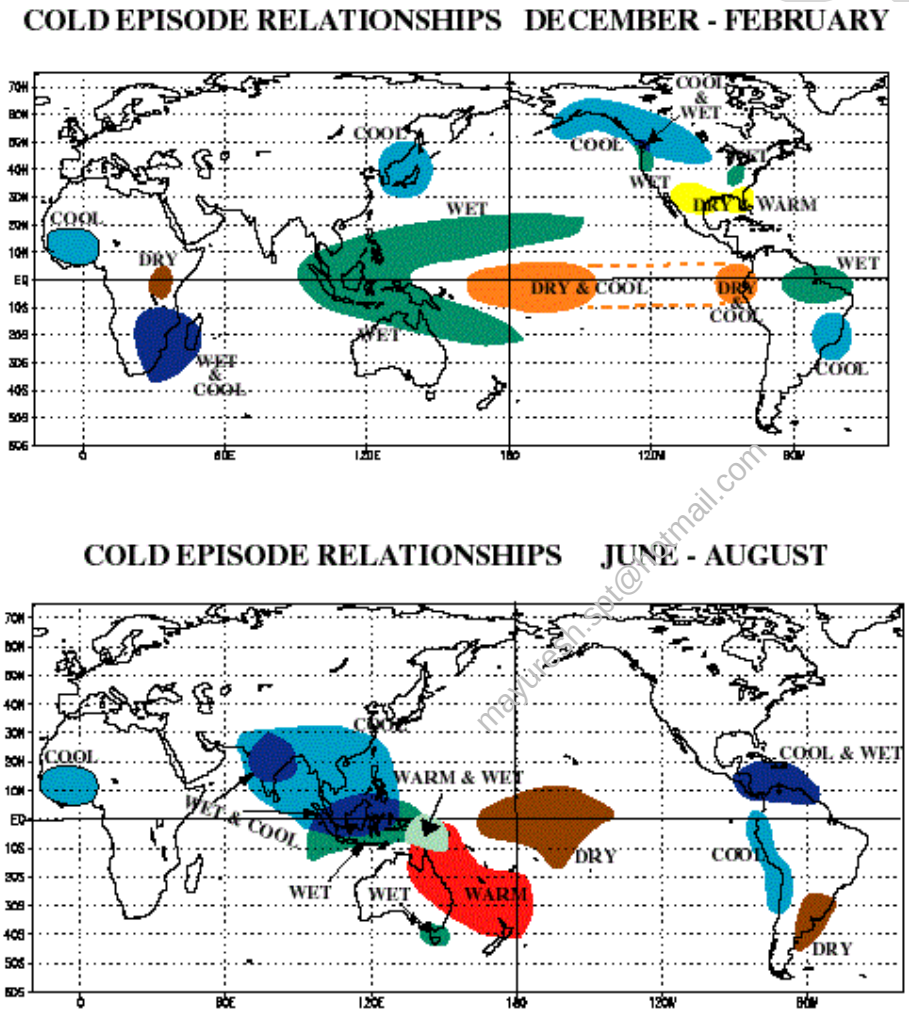


Figure 4 – global precipitation pattern during La Nina

- **South America** - During a time of La Niña, drought plagues the coastal regions of Peru and Chile.
- **North America** - La Niña causes mostly the opposite effects of El Niño, above-average precipitation across the Northern California, and the northern Rockies etc. There are above average hurricanes in the Atlantic and less in the Pacific.

1.3. Walker Circulation

The Walker Circulation refers to an east-west circulation of the atmosphere above the tropical Pacific, with air rising above warmer ocean regions (normally in the west), and descending over the cooler ocean areas (normally in the east). Its strength fluctuates with that of the Southern Oscillation. The characteristics of the Walker Circulation were largely determined by the coupling between the tropical atmosphere and oceans. Walker Circulation is closely tied to that of the Southern Oscillation and El Niño. The term Walker Circulation was first introduced in 1969 by Jacob Bjerknes. After Bjerknes, there have been reports of similar east–west circulation cells spanning different longitudinal sectors along the Equator. Compared to pacific cell, these cells cover smaller longitude ranges and tend to have weaker vertical motions (figure 5). The Indian Ocean cell is associated with the development of the South Asian monsoon. Generally, walker circulation is associated with only cells of Pacific Ocean.

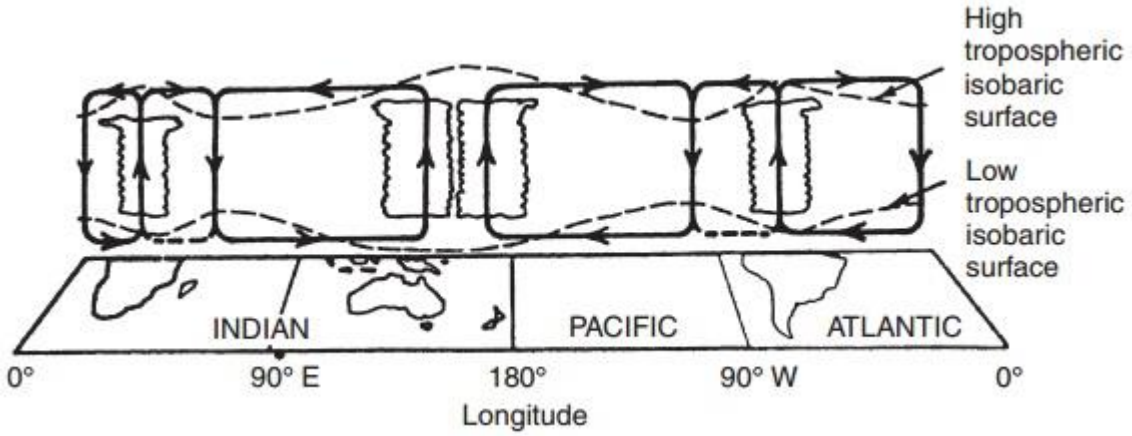


Figure 5 - east–west atmospheric circulation along the longitude–height plane over the Equator. The cell over the Pacific Ocean is referred to as the Walker Circulation.

The easterly trade winds are part of the low-level component of the Walker Circulation. Typically, the trade winds bring warm moist air towards the Indonesian region. Here, moving over normally very warm seas, moist air rises to high levels of the atmosphere. The air then travels eastward before sinking over the eastern Pacific Ocean. The rising air is associated with a region of low air pressure, towering cumulonimbus clouds and rain. High pressure and dry conditions accompany the sinking air. Sinking air completes the loop.

During **El Niño event,** the Walker Circulation and accompanying east–west circulations differ significantly from normal conditions (figure 6a). Rising motions prevailed at almost all longitudes. In particular, strong ascent in the mid-troposphere replaced descending air motion over the central and eastern Pacific, where the water was anomalously warm due to El Niño. The Walker Circulation is weakened and became less organized.

Walker Circulation may even reverse in the more intense episodes of El Niño. In this instance westerly winds are observed over parts of the equatorial western and central Pacific where normally easterly (trade) winds would be expected. Oceans around Australia cool, and slackened trade winds feed less moisture into the region.

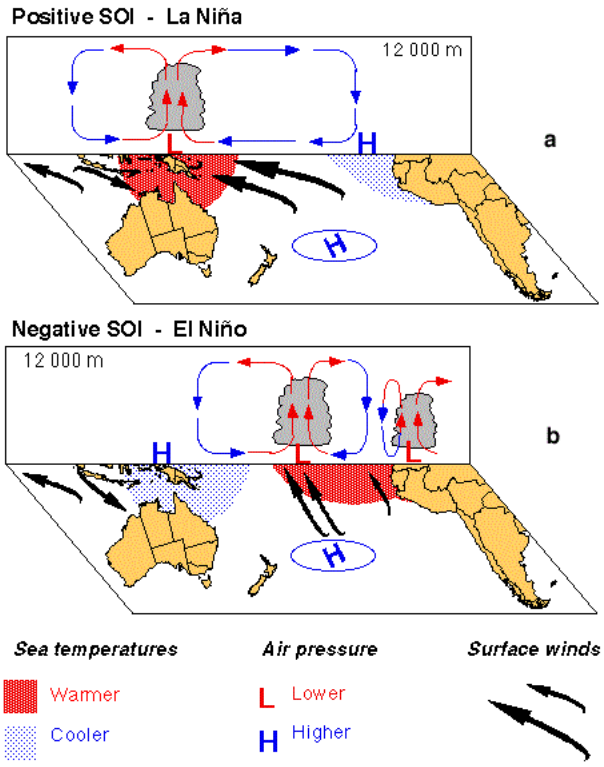


Figure 6 – Walker circulation during La Niña and El Niño

During La Niña, or reverse El Niño, the Walker Circulation is enhanced and became very pronounced, with well-defined rising and sinking branches (figure 6b). While the cells in Pacific and Atlantic Oceans intensify, the Indian Ocean cell weakens.

Impacts on world climate

The Walker Circulation regulates global exchange of momentum, heat, and water vapor within the tropics via massive overturning motions. In doing so, it plays an important role in the balance of atmospheric energy in the equatorial region and in determining the characteristics of weather and climate in the tropics.

The strongest atmospheric impacts associated with the fluctuations of the Walker Circulation are found over tropical and subtropical regions around the Pacific Rim. During an El Niño, the weakening Walker Circulation causes widespread drought in Indonesia/maritime continent, drought in northeastern Brazil, severe floods in Peru and Ecuador, and in south-eastern Brazil and northern Argentina. During a La Niña, the Walker Circulation intensifies and leads to rainfall anomalies with reverse sign compared to El Niño.

The Walker Circulation also represents the fundamental link between the changes in sea surface temperature in the eastern Pacific and the variability of the Asian–Australian monsoon. The mechanisms that are responsible for the interactions between the monsoon and El Niño Southern Oscillation have been attributed, in part, to the changes in the Walker Circulation. During El Niño, Walker Circulation is weakened and shifted eastward owing to reduced east–west sea surface temperature gradient across the Pacific Ocean. This suppresses broad-scale convection over the western Pacific and eastern Indian Ocean and leads to weaker South Asian monsoon.

Walker circulation interacts with the Hadley cell[3] in the form of an **inverse variation** between the two circulations. When the cold water belt along the Equator is well developed, the air above it will be too cold and heavy to join the ascending motion in the Hadley circulations. Instead, the equatorial air flows westward between the Hadley circulations of the two hemispheres to the warm west Pacific. These changes are the causes for severe weather and climate anomalies in the Asian–Pacific–American regions.

1.4. El Niño & La Niña Modoki

Like El Niño, El Niño **Modoki** (Japanese: meaning 'similar, but different') is a coupled ocean-atmosphere phenomenon in the tropical Pacific. El Niño is characterized by strong anomalous warming in the eastern equatorial Pacific. On the other hand, El Niño Modoki is associated with strong anomalous warming in the **central tropical Pacific** and cooling in the eastern and western tropical Pacific (figure 7b).

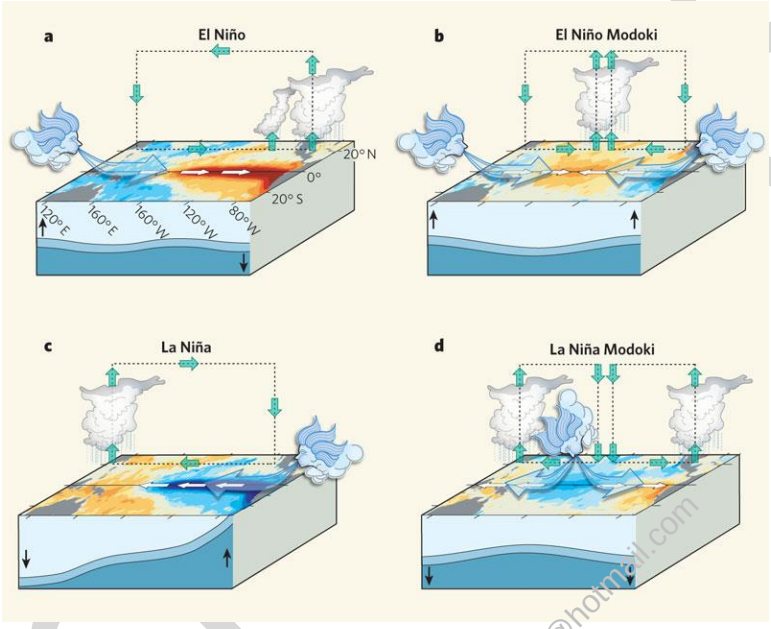


Figure 7 – El Nino Modoki and La Nina Modoki

La Nina Modoki is associated with low sea surface temperature (SST) in central tropical Pacific Ocean while eastern and western tropical pacific are warm relatively. It produces two walker cells with rising limbs at both ends of tropical pacific and descending limb of both cells fall at central equatorial pacific (figure 7d).

Together El Nino Modoki and La Nina Modoki forms **'ENSO Modoki'.** Several studies have shown that the ENSO Modoki has become more prominent in recent times, as compared to ENSO, and thereby changing the teleconnection pattern arising from the tropical Pacific. The ENSO Modoki has distinct teleconnections and affects many parts of the world. For example, the West Coast of United States of America is wet during El Nino but dry during El Nino Modoki. Recent studies show that teleconnections associated with ENSO Modoki influence the rainfall over India and South Africa.

El Nino results in anomalous two-cell Walker Circulation over the tropical Pacific, with a wet region in the central Pacific. During pre-monsoon and post-monsoon seasons in the North

[3] Hadley Cells are the low-latitude overturning circulations that have air rising at the equator and air sinking at roughly 30° latitude.

Indian Ocean, more cyclones form in the Bay of Bengal compared with the Arabian Sea. El Nino is found to suppress cyclone formation in the Arabian Sea. While in some years **more cyclones form in the Arabian Sea than usual. This is due to El Nino Modoki.** During El Nino Modoki, one of the descending limbs of the walker cell is over the Bay of Bengal which causes dry conditions not conducive for cyclone formation. On the other hand, there is large convergence over the Arabian Sea during an El Nino Modoki explaining the large number of cyclones in that region.

2. Urban Climate

The urban areas across the world experience a climate distinctive from the regional pattern. The process of urbanization changes the physical surroundings and induces alterations in the energy, moisture, and motion regime near the surface. The agglomeration of buildings interferes with the wind and atmospheric characteristics to a degree at least equal to that of a large forest. An urban area changes the air's composition, temperature and precipitation graphs etc.

Wind speed is lower in cities than in open areas due to obstructive nature of structure of cities. Actual effect varies with the street design, the season and the time of day. The wind tends to channel down streets parallel to the general direction of flow, especially in a city with canyon like streets (high rise buildings). While if street pattern is at right angle to the wind, strong lee effects may be experienced. During the day, city wind speeds are considerably less than surrounding areas, but at night, turbulence over the city makes contrasts less apparent. Rural-urban contrasts are most marked with strong winds, and the effects are therefore more evident in winter[4] than in summers.

Cities absorb much less **water** per area than rural areas, as much of city area is paved or built on. In some areas this creates a need for specific measures to reduce the risk of localised flooding during periods of heavy rainfall. Heavy construction activities in flood plains of rivers flowing through cities increase the period and intensity of flooding.

Cities tend to have **lower humidity** in contrast to rural or forested areas. Due to concrete surface, rapid surface run-off removes water. The lower density of vegetation and general absence of water bodies etc. also contribute for lower humidity and evaporation. On the other hand, it seems likely that under certain conditions, thermal and turbulences over cities may trigger off precipitation or thunderstorms. Many cities encounter more light rain and thunder than surrounding areas, resulting in a slight increase in total precipitation.

2.1. Urban Heat Island

The term "heat island" describes built up areas that are hotter than nearby surrounding areas. An **urban heat island (UHI)** is a metropolitan area that is significantly warmer than its surrounding rural areas due to human activities. The phenomenon was first investigated and described by Luke Howard in the 1810s. The **temperature difference usually is larger at night** than during the day, and is most apparent when winds are weak. The typical temperature difference is several degrees between the center of the city and surrounding fields. It can be as high as 10 °C.

[4] There is much greater variation in barometric pressure during the winter than during the summer. On average, high pressure systems are higher pressure and low pressure systems are lower pressure. This leads to a more rapid flow of air between the systems. This fluctuation is caused by much greater variation in temperature during the winter. While most summer days are roughly the same temperature, winter temperatures fluctuate dramatically.

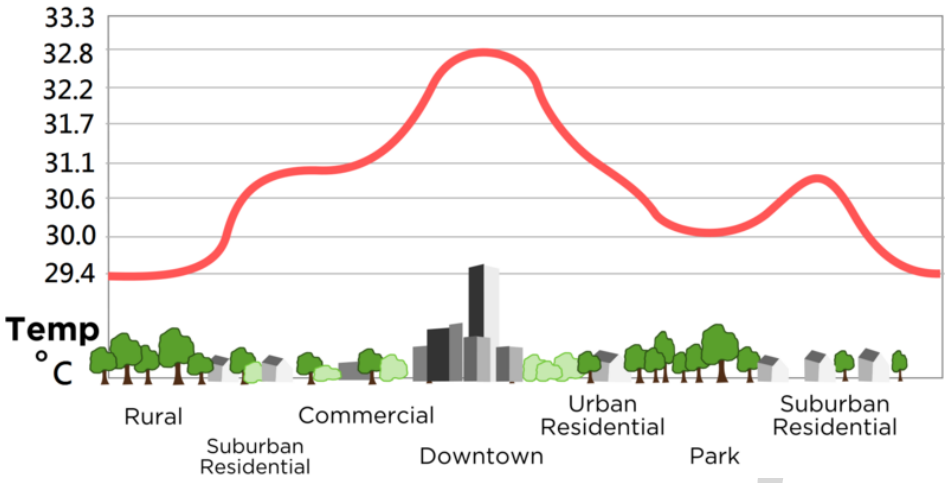


Figure 8 – Urban Heat Island Profile

There are **three main factors** responsible for this:

- The **direct production of heat** in city from fires, industry, home
- Heat conserving properties of the **bricks and fabric** of the city
- **Blanketing effect** by atmospheric **pollution** on outgoing radiation

Heat trapped in concrete buildings, pavements during day time is released very slowly in the form of long wave radiations, making cooling a slow process. With a decreased amount of vegetation, cities also lose the shade and cooling effect of trees, the low albedo of their leaves, and the removal of carbon dioxide. The tall buildings within many urban areas provide multiple surfaces for the reflection and absorption of sunlight, increasing the efficiency with which urban areas are heated. Tall buildings also inhibit cooling by convection and pollution from dissipating. Chemicals emitted by cars, industries affect sunshine in different ways, often trapping it and creating more heat. All these factors cause a change in the energy balance of the urban area.

As a population center grows, it tends to expand its area and increase its average temperature. For instance, Los Angeles has been very much affected by its urban heat island. The city has seen its average temperature rise approximately 0.5 °C every decade since the beginning of its super-urban growth since the World War II era. Other cities have seen increases of 0.1°-0.4°C each decade.

Each city's urban heat island varies based on the city structure and thus the **range of temperatures within the island varies** as well (figure 8). Parks and greenbelts reduce temperatures while the Central Business District (CBD), commercial areas, and even suburban housing tracts are areas of warmer temperatures. Every house, building, and road changes the microclimate around it, contributing to the urban heat islands of our cities.

Impact on urban dwellers

- The increased heat of our cities **increases discomfort** for everyone
- Homes require an increase in the amount of **energy used for cooling** purposes.
- The UHI **decreases air quality** by increasing the production of pollutants such as ozone, and decreases water quality as warmer waters flow into area streams and put stress on their ecosystems.
- Increased heat enhances photochemical reactions, which increases the particles in the air and thus contributes to the **formation of smog and clouds**. For instance, London receives approximately 270 fewer hours of sunlight than the surrounding countryside due to clouds and smog.

The heat island effect can be counteracted in several ways:

- Most prominent is to use light color or white or reflective materials in construction work – roof top, houses, road, and pavements – to increase the albedo. Dark/Black surfaces can be up to 21°C hotter than light surfaces and that excess heat is transferred to the building itself, creating an increased need for cooling. By switching to light colored roofs, buildings can use 40% less energy.
- Mitigation of the UHI effect can be accomplished through the use of **green roofs (figure 9).** The roof of a building is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane. Rooftop ponds are another form of green roofs which are used to treat grey-water. Apart from mitigating the UHI effect, Green roofs serve several purposes for a building, such as absorbing rainwater, providing insulation, creating a habitat for wildlife, and helping to lower urban air temperatures. Financially, it reduces energy usage, bring tax incentives provided by the government, increases life span of roof etc.

Figure 9 – green roof

- **Green Building** is constructed in a manner that is resource-efficient, environmentally sustainable. Sun light is used efficiently within the building. It lowers the overall energy usage of the building and thus, helps in reducing the effect of UHI.
- Another way is to increase the amount of **well-watered vegetation.** It is empirically tested that the cooling potential per area was highest for street with higher tree density. They increase evapotranspiration, which decreases the air temperature. Trees can reduce energy costs by 10-20%.

Typically heat island mitigation is part of a community's energy, air quality, water, or sustainability effort. Activities to reduce heat islands range from voluntary initiatives, such as cool pavement demonstration projects, to policy actions, such as requiring cool roofs via building codes. Most mitigation activities have multiple benefits, including cleaner air, improved human health and comfort, reduced energy costs, and lower greenhouse gas emissions.

2.2. Atmospheric Pollution Over Cities

Generally any substance that people introduce into the atmosphere that has damaging effects on living things and the environment is considered air pollution. A city atmosphere is affected by **soot, ash, gases, fumes, smoke and oxides of sulphur, carbon, nitrogen**. Carbon dioxide and other greenhouse gases such as Methane are the main pollutant that is warming Earth. Sulfur dioxide and closely related chemicals are known primarily as a cause of acid rain. These have effect of blanketing the radiation over a city, increasing the city's albedo. These also act as a condensation nuclei. Under normal conditions, much of this polluted part is diffused upwards

by turbulence and removed by stronger winds at height. However, high rise buildings of cities act as obstruction in free movement of these particles. The greatest concentrations of smoke occur with low wind speeds, temperature inversion and high relative humidities.

It requires multifold strategies with the active participation of civil society and individual city people. On a larger scale, governments are taking measures to curb the air pollution through legislation, tax benefits and other schemes. Civil society can play its part by spreading environmental awareness among people and helping people in urban forestry etc.

2.3. Urban Climate and Global Climate Change

The changes in urban Climate are strongly linked to global climate change. As centres for socio-economic activities, cities produce large amounts of Green House Gases, most notably CO_2 as a consequence of human activities such as transport, development (e.g. concrete production), and waste related to heating and cooling requirements etc. cities are the top consumer of energy produced largely through fossil fuels.

Many cities are vulnerable to the projected consequences of climate change (sea level rise, changes in temperature, precipitation, storm frequency) as most develop on or near coast-lines, nearly all produce distinct urban heat islands and atmospheric pollution.

3. Microclimate

A microclimate is the distinctive **climate of a small-scale area, such as a garden, park, valley or part of a city**. The weather variables in a microclimate, such as temperature, rainfall, wind or humidity, may be subtly different to the conditions prevailing over the area as a whole and from those that might be reasonably expected under certain types of pressure or cloud cover. Indeed, it is the mixture of many, slightly different microclimates that actually makes up the climate for a town, city or wood.

Microclimate can be caused by several **factors** such as

- Near water bodies
- Heat retaining capacity of urban areas
- Slope of mountains
- Absence of vegetation such as in central business districts
- Large presence of vegetation such in protected areas
- Soil type

There is a distinctive microclimate for every type of environment on the Earth's surface:

Upland regions

Upland areas have a specific type of climate that is notably different from the surrounding lower levels. **Temperature usually falls with height** at a rate of between 5 and 10 °C per 1,000 metres, depending on the humidity of the air. This means that even quite modest upland regions can be significantly colder on average.

Occasionally, a **temperature inversion**[5] can make air warmer in upland regions, but such conditions rarely last for long. With higher hills and mountains, the average temperatures can be so much lower that winters are longer and summers much shorter. Higher ground also tends

[5] Temperature inversion – It is a deviation from the normal change of an atmospheric temperature with altitude i.e., an increase in temperature with height, or to the layer ("inversion layer") within which such an increase occurs.

to be windier, which makes for harsher winter weather. **Katabatic wind**[6] also creates cold conditions in the valley. The effect of this is that plants and animals are often different from those at low levels.

Coastal regions

The coastal climate is influenced by both the land and sea between which the coast forms a boundary. The thermal properties of water are such that the **sea maintains a relatively constant day to day temperature compared with the land.** The sea also takes a long time to heat up during the summer months and, conversely, a long time to cool down during the winter. Coastal microclimates display different characteristics depending on where they occur on the earth's surface. In the tropics, sea temperatures change little and the coastal climate depends on the effects caused by the daytime heating and night-time cooling of the land. In temperate latitudes, the coastal climate owes more to the influence of the sea than of the land and coasts are usually milder than inland during the winter and cooler in the summer. Around the poles, sea temperatures remain low due to the presence of ice, and the position of the coast itself can change as ice thaws and the sea re-freezes.

Forest regions

Tropical rainforests cover only about 6% of Earth's land surface, but it is believed they have a significant effect on the transfer of water vapour to the atmosphere. This is due to a process known as **evapotranspiration** from the leaves of the forest trees. Woodland areas can be cooler and less windy than surrounding grassland areas, with the trees acting as a windbreak and the incoming solar radiation being 'filtered'.

Urban regions

These are perhaps the most complex of all microclimates. **Temperature is higher relative to surroundings** (see 'Urban Heat Island' topic for details). The distribution of rainfall over a town or city is very much influenced by topography with the largest values occurring over the more hilly regions and lowest values in more low—lying areas. The nature of rainfall varies during the year. In summer, rainfall is often of a showery nature, falling over short periods, and is normally more intense than in winter.

4. Applied Climatology

Weather and climate are important factors in determining our day to day and longer term activities and life styles. The ways in which the climatic elements affect every form of economic and social activity are now receiving increasing attention from climatologists. 'It is since second world war that new consciousness arose about the potentialities of climatology as an active subject with immense practical utility for planning almost all human requirements ranging from the development of water resources to the eradication of diseases.

4.1. Climate and Natural Vegetation

Natural vegetation is an indicator of the climate. But they are **interrelated as one influences the other to a great extent**. The knowledge of optimum climatic conditions in different stages of the growth of forest trees is essential for those engaged in the task of afforestation for timber, watershed management. In silvicultural[7] practices the interrelationship between forests and

[6] Katabatic wind - a wind that carries high density air from a higher elevation down a slope under the force of gravity.

[7] Silviculture is the practice of controlling the establishment, growth, composition, health, and quality of

climate must be taken into account. Microclimate of forest is taken into account for getting higher yields.

4.2. Climate and Agriculture

Food is the first and foremost need of humans. As a matter of fact, climate and vegetation are complementary to each other. Weather components – temperature, precipitation, humidity, wind etc. – play the most prominent role in the crop production. For instance, crops like coffee, bananas and sugar cane are very sensitive to frosts. Coconuts and pineapples need temperature above 21°C for their best growth. In hilly areas, the citrus and other sensitive crops are planted on the slopes exposed to the sun avoiding the valleys which are subject to winter frosts at night.

4.3. Climate and Animal Husbandry

Meat and Milk products are obtained by animals which are dependent on pastures and feed crops. Pasture land and crops are highly influenced by climatic factors. Of all the climatic elements affecting the animal husbandry temperature factor is indeed the most important. If the temperature is very high, milk produced from animals is less. It is required to maintain the temperature otherwise continuous high temperature reduces yield of flesh and fat from animals. Precipitation has direct effect on animals. Availability of grass in the pastures is much reduced because of snowfall. Animals feel discomfort in extreme relative humidity conditions.

In animal husbandry, natural or **artificial shelters** are built to keep the animals safe from the negative effect of climate. By heating or air conditioning, temperature is controlled in animal shelters.

4.4. Climate and Housing

It is the climate which determines the house types. **Igloo** in polar region (the house of Eskimos), and **open houses** in tropical areas are the glaring examples. In terms of building or architectural climatology, the micro-climatic conditions are influenced by a number of factors such as local relief, nearby buildings, landscaping, existing water bodies and industrial wastes. Climate is an important input in **green buildings which tries to maximize usage of sunshine, winds** etc.

In tropical countries, double roofs to ensure free movement of air reduce the flow of absorbed solar heat into a building. The type of roofs designed for houses in different climatic conditions take care of precipitation or snowfall.

4.5. Air Pollution and Health

Medical climatology studies the relationship between human health and climate or weather. Some of the **local winds** like the loo, cold wave etc are said to be the causes of irritability, depression, dizziness and hypertension. **High concentration of pollens** in air (such as in Bangalore) causes breathing problems to some people. For instance, local Bangalore government put ban on planting flowering saplings in its parks for certain period of the year to reduce the concentration of pollens in air.

All the cities are discharging huge quantity of pollutants into the atmosphere. These pollutants convert into acids through chemical reactions and fall as '**acid rain**' with rainwater. Study of the atmospheric percentage of these chemical helps in regulating the industries. For instance, vehicular traffic and industry is banned in surrounding of Taj Mahal, Agra. Acid rain is also harmful for plant and marine life.

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forests to meet diverse needs and values.

Certain diseases are, indeed, associated with certain climates or with a particular season. Cold season controls the insects' population by forcing hibernation. That's the reason **tropical diseases** such as Dengue and Malaria etc. are prevalent in tropical and subtropical regions. There are certain diseases which are closely associated with seasons. Pneumonia, influenza, measles etc can be cited as examples here. Such close association of diseases with season or climate helps in issuing warnings to people or taking other measures by the government to reduce the impact of same. Municipal bodies in cities of South Asia ensure that water is not logged in parts of cities during monsoon seasons to avoid Malaria and other vector born diseases.

4.6. Climate and Economy

Climate research benefits the following industries:

- Insurance
- Tourism
- Construction
- Energy
- Transport
- Sport
- Retail Food
- Retail Clothing

The **insurance** industry offers financial protection against climate-related damage. This includes direct impacts from damage due to flood, frost, wind etc. Climate research can help reduce the costs to insurers by quantifying the probability of extreme events, providing year-ahead forecasts and identifying vulnerable regions. There is a peak time of **tourists** to a particular place. This peak time is directly related to the climate of that particular place. For instance, hilly cold areas' peak time coincide with summer time.

Wind is a potential renewable source of **energy** in every country. Wind atlas of different region and at different altitude is a crucial input to decide the location and height of wind turbines. Similarly, hydro-electricity plants are established in areas which have continuous supply of water either through glacial or rain.

Transport sectors such as air, shipping etc. are directly impacted by the climate or weather. High altitude ports are frozen during winter season which makes them inaccessible for such period. Atmospheric disturbances, extreme weather conditions such as fog, cold waves etc. interrupts the flights' schedule. Roads are specially designed for areas which faces extreme weather conditions.

4.7. Climatic Adaptation

Humans and many other mammals have unusually efficient **internal temperature regulating systems** that automatically maintain stable core body temperatures in cold winters and warm summers. In addition, people have developed cultural patterns and technologies that help them adjust to extremes of temperature and humidity. Less massive individuals are more often found in warm climates near the equator, while those with greater bulk, or mass, are found further from the equator in colder regions. This is due to the fact that big animals generally have larger body masses which result in more heat being produced. People living in cold climates prefer drinking alcohol as it increases blood flow to the body extremities, thereby providing a feeling of warmth. With the help of technology, researches are able to stay throughout the year in extremely cold Antarctica and Arctic regions. People are able to live in extremely hot climate of tropical region by using air conditioners.

Student Notes:

5. UPSC Previous Years' Mains Questions

1. Bring out the causes for the formation of heat islands in the urban habitat of the world. (100 words) (UPSC 2013/5 marks)

2. Bring out the significance of the various activities of the Indian Meteorological Department. (UPSC 2009/15 Marks)

6. UPSC Previous Years' Prelim Questions

1. La Nina is suspected to have caused recent floods in Australia. How is La Nina different from El Nino? **(2011)**

1. La Nina is characterised by unusually cold ocean temperature in equatorial Indian Ocean whereas El Nino is characterised by unusually warm ocean temperature in the equatorial Pacific Ocean.
2. El Nino has adverse effect on south-west monsoon of India, but La Nina has no effect on monsoon climate.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

2. A new type of El Nino called El Nino Modoki appeared in the news. In this context, consider the following statements: **(2010)**

1. Normal El Nino forms in the Central Pacific ocean whereas El Nino Modoki forms in Eastern Pacific ocean. Normal El Nino results in diminished hurricanes in the Atlantic ocean but El Nino Modoki results in a greater number of hurricanes with greater frequency.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

3. For short-term climatic predictions, which one of the following events, detected in the last decade, is associated with occasional weak monsoon rains in the Indian sub-continent? **(2002)**

(a) La Nina (b) Movement of Jet Streams
(c) El Nino and Southern Oscillation (d) Greenhouse effect on global level

Student Notes:

DIFFERENT TYPES OF IRRIGATION AND IRRIGATION SYSTEMS

Contents

Getting an irrigation system is easy, but getting the most efficient irrigation system for your needs can be quite a bit harder.

1. Irrigation and Benefits of Irrigation

The process of supplying water to crops by artificial means such as canals, tube wells, tanks etc. is known as irrigation. It is used to assist in the growing of agricultural crops, maintenance of landscapes, and revegetation of disturbed soils in dry areas and during periods of inadequate rainfall. In contrast, agriculture that relies only on direct rainfall is referred to as rain-fed or dryland farming.

Mankind is getting benefits of irrigation system since ancient time. Archaeological investigation has identified evidence of irrigation where the natural rainfall was insufficient to support crops. For example, **Perennial irrigation** was practiced in Mesopotamian plains, **Terrace irrigation** in Syria, Basin irrigation in Egypt etc. With the advent of diesel and electric motors in 20th century, humans increased the area under irrigation by pumping more and more ground water and extending the canals etc.

In greater part of India, agriculture is rain-fed. In the incidence of failure of monsoon, the crop fails. The behavior of Indian monsoon is highly erratic. Excess rainfall may cause floods, but scanty rainfall may reduce the crop yield substantially, and in acute cases the crop may be a complete failure.

India has very large population and it is estimated that India needs more than 450 million tonnes of grain to meet the demand of growing population. Climate change will result into more instances of erratic climatic conditions and thus, crops are more prone to high variability in rain. The present productivity of irrigated land is about 2.5 tonnes/hectare and less than 0.5 tonnes/hectare for rainfed lands. In this context, there is an urgent need to implement and plan irrigation strategies.

India possesses 4% of the total average annual run off in the rivers of the world. The per capita water availability of natural run off is at least 1100 cubic meters/yr. The amount of water that can actually be to put to beneficial use is much less due to severe limitations imposed by physiographic, topographic, interstate issues and the present technology to harness water resources economically.

Benefits of irrigation

- **Increase in crop yield**: the production of almost all types of crops can be increased by providing the right amount of later at the right time, depending on its shape of growth. Such a controlled supply of water is possible only through irrigation.
- **Protection from famine:** the availability of irrigation facilities in any region ensures protection against failure of crops or famine due to drought. In regions without irrigation, farmers have to depend only on rains for growing crops and since the rains may not provide enough rainfall required for crop growing every year, the farmers are always faced with a risk.
- **New areas under cultivation:** irrigation brings new areas under cultivation and increases the net area under irrigated cultivation.
- **Cultivation of superior crops:** with assured supply of water for irrigation, farmers may think of cultivating superior variety of crops or even other crops which yield high return. Production of these crops in rain-fed areas is not possible because even with the slight unavailability of timely water, these crops would die and all the money invested would be wasted.
- **Elimination of mixed cropping**: in rain-fed areas, farmers have a tendency to cultivate more than one type of crop in the same field such that even if one dies without the required

amount of water, at least he would get the yield of the other. However, this reduces the overall production of the field. With assured water by irrigation, the farmer would go for only a single variety of crop in one field at anytime, which would increase the yield.

- **Economic development**: with assured irrigation, the farmers get higher returns by way of crop production throughout the year, the government in turn, benefits from the tax collected from the farmers in base of the irrigation facilities extended.
- **Hydro power generation**: usually, in canal system of irrigation, there are drops or differences in elevation of canal bed level at certain places. Although the drop may not be very high, this difference in elevation can be used successfully to generate electricity. Such small hydro electric generation projects, using bulb-turbines have been established in many canals, like Ganga canal, Sarada canal, Yamuna canal etc.
- **Domestic and industrial water supply**: some water from the irrigation canals may be utilized for domestic and industrial water supply for nearby areas. Compared to the irrigation water need, the water requirement for domestic and industrial uses is rather small and does not affect the total flow much. For example, the town of Siliguri in the Darjeeling district of West Bengal, supplies its residents with the water from Teesta Mahananda link canal.

2. Classification of Irrigation Schemes

Due to difference in topology, water availability, land availability, feasibility of technology etc., different irrigation technologies exist in the world. Irrigation system is classified under various schemes as discussed below:

2.1. Based on Sources

Depending on the availability of surface and underground water, slope of land, nature of the soil and the types of crops grown in a region, a number of sources of irrigation are utilized. The main sources of irrigation used in different parts of the country are (figure 1):

- Wells and tube-wells
- Canals
- tanks
- other sources – springs, kuhls, dhenkli, dongs and bokka

2.1.1. Well and Tube-Wells

This type of irrigation is practiced since ancient time. It accounts for 62 per cent of the total irrigated area of the country. It is the easiest source of irrigation. It can be installed in a short duration of time. It is however expensive and diminishes the underground water-table, if exploited in unsustainable manner. The largest area under tube-well irrigation is in Uttar Pradesh followed by Rajasthan, Punjab, Madhya Pradesh, Gujarat, and Bihar.

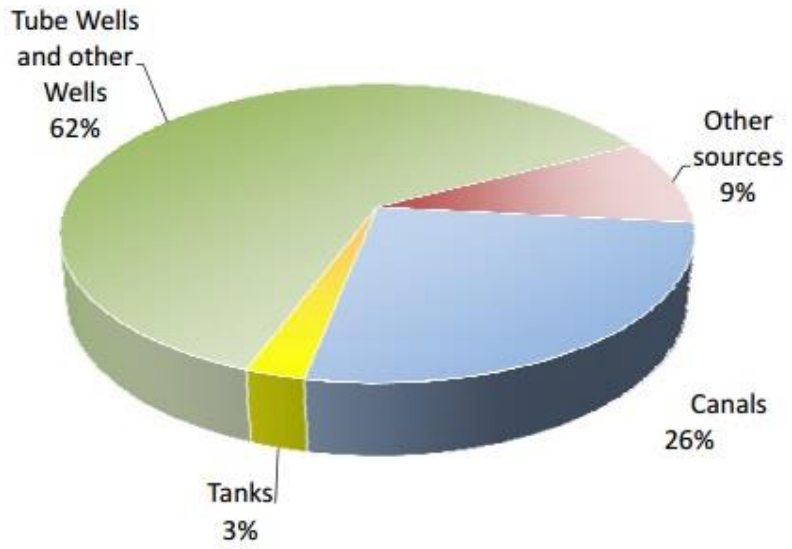


Figure 1: Net Area under irrigation by sources (2009-10)

2.1.2. Canal

Canal used to be the main source of irrigation in 1950-51, irrigating almost 50 per cent of the total irrigated area of India. In 1960s, there was a tremendous increase in the tube-well irrigated area promoted by the government. Consequently, the percentage of canal irrigated area declined to less than 40 per cent and in 2009-10, it is only 26 per cent.

Canals are an effective in low and leveled relief, productive plain areas where perennial source of surface drainage is available. These conditions are ideally found in the Northern plains of India, Kashmir and Manipur valleys and the Eastern Coastal plains (figure 2). High density of canals is found in Uttar Pradesh with Ganga canal system, Punjab, Haryana and Western Rajasthan with Indira Gandhi Canal. In Peninsular region, Damodar, Mahanadi, Godavari, Krishna, Narmada rivers etc. rivers have important canal system. Uttar Pradesh has the first rank in canal irrigation followed by Andhra Pradesh.

2.1.3. Tank

An **irrigation tank** or **tank** is an artificial reservoir of any size. It can also have a natural or man-made spring included as part of a structure. In some parts of the country, especially in the peninsular India tank is an important source of irrigation. About 3 per cent of the total irrigated area is under tank irrigation.

According to the third minor irrigation census carried out in 2000-01, there are about 5.56 lakh tanks in the country, with the most occurring in the following states:

- West Bengal: 21.2 per cent of all the tanks in the country
- Andhra Pradesh: 13.6 per cent
- Maharashtra: 12.5 per cent
- Chhattisgarh: 7.7 per cent
- Madhya Pradesh: 7.2 per cent
- Tamil Nadu: 7.0 per cent
- Karnataka: 5.0 per cent

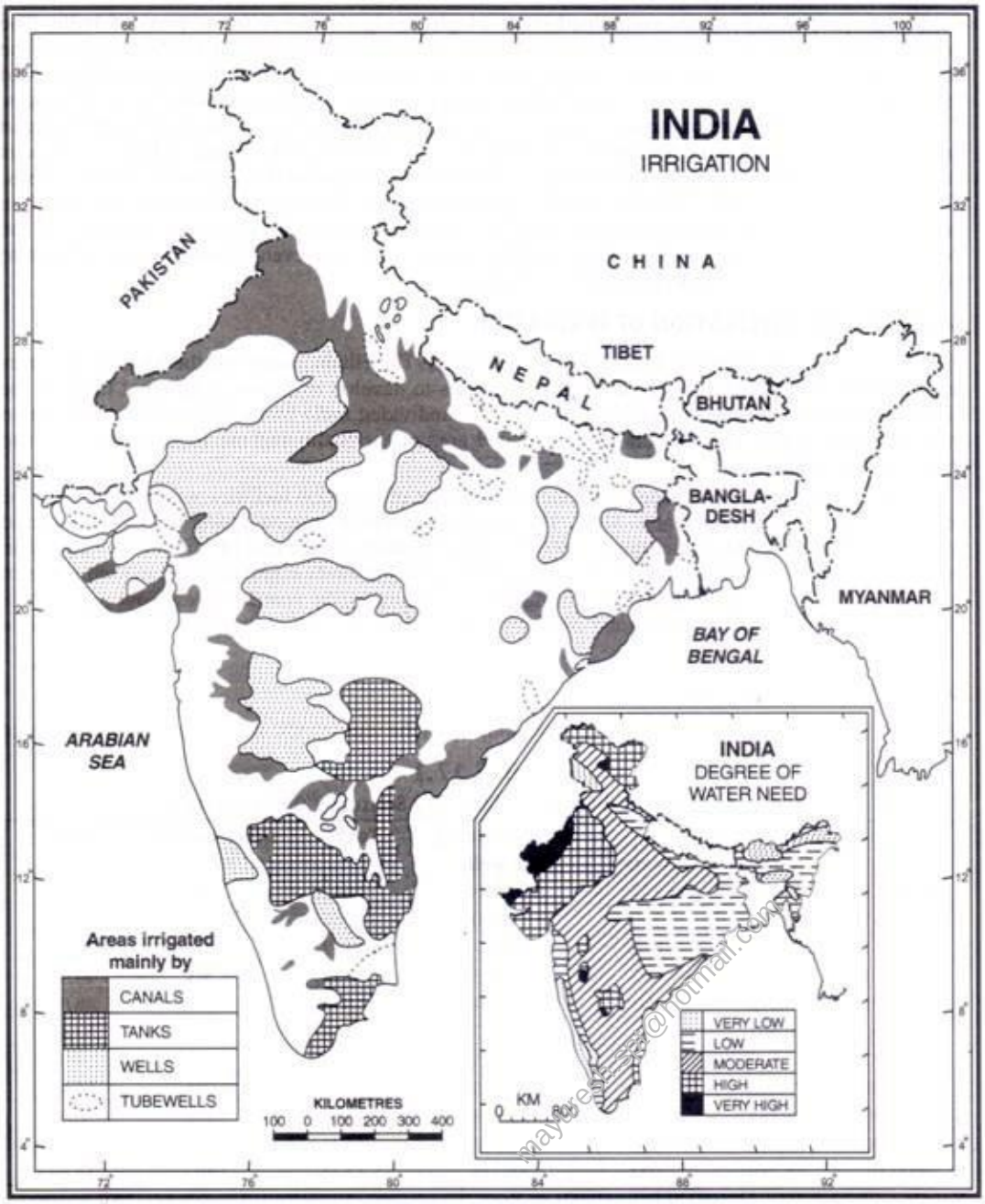


Figure 2: India – Source of irrigation

Many of the tanks, however, dry up during the summer season when more irrigation is required. Due to non-use of these 15 percent tanks nearly 1 M-ha of Irrigation potential is lost. Another, around 2 M-ha of potential is lost due to under utilisation of tanks in use. Loss of potential due to non use is more pronounced in Meghalaya, Rajasthan and Arunachal Pradesh (above 30%), whereas loss of potential due to under utilisation is more than 50 percent in case of Gujarat, Nagaland, Rajasthan, A&N Island and Dadar and Nagar Haveli.

2.2. Based on Magnitude

Irrigation Projects in India are classified into three categories on the basis of Culturable command area (CCA) [1] as:

- **Major** - Projects which have a **CCA of more than 10,000** hector are termed as Major Projects.

- **Medium** - Irrigation Projects which have a **CCA of less than 10,000 hector but more than 2,000** hector are termed as Medium projects
- **Minor Irrigation** - those Irrigation Projects which have a **CCA of 2,000 hector or less** are known as Minor projects.

The ultimate irrigation potential of the country from major and medium irrigation projects has been assessed as about 64 M-ha. For the country as a whole, 66% of it has been created. The average rate of creation of irrigation potential through Major and Medium projects from 1951 to 1997 has been found to be of the order of 0.51 Million hectare per year. During the year 1997 to 2005, the rate for creation has been found to be 0.92 Million hectare per year. This increase in pace is probably due to fruition of projects started much earlier, which have been expedited due to increased support through AIBP(Accelerated Irrigation Benefit Programme).

Minor irrigation projects have both surface and ground water as their source, while Major and Medium projects mostly exploit surface water resources. Ground water minor irrigation is primarily done through individual and cooperative effort of farmers with the help of institutional finance and their own savings. Surface water minor irrigation schemes are generally funded from the public sector only. The ultimate irrigation potential from minor irrigation schemes have been assessed as 75.84 million ha of which partly would be ground water based (58.46 million ha) and covers about two thirds. By the end of the ninth plan, the total potential created by minor irrigation was 60.41 million ha.

Minor irrigation schemes contribute a major share in the growing irrigation across the country accounting for about 65% of the total irrigation potential utilized. The Minor irrigation scheme has been categorized broadly into five major types, namely:

1. Dugwell
2. Shallow tubewell
3. Deep tubewell
4. Surface flow schemes
5. Surface lift schemes

2.2.1. Major and Medium vis-à-vis Minor Irrigation Projects

While formulating strategies for irrigation development the water resources planner should realize the benefits of each type of project based on the local conditions. For example, it may not always be possible to benefit remote areas using major/medium projects. At these places minor irrigation schemes would be most suitable. Further, land holding may be divided in such a way that minor irrigation becomes inevitable. However, major and medium projects wherever possible is to be constructed to reduce the overall cost of development of irrigation potential.

2.3. Based on Technique of Distribution of Water

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. It is often called **flood irrigation** when the irrigation results in flooding or near flooding of the cultivated land. Surface irrigation can be subdivided into:
    - **Basin irrigation** has historically been used in small areas having level surfaces that are surrounded by earth banks (figure 3). The water is applied rapidly to the entire basin and is allowed to infiltrate. Basins may be linked sequentially so that drainage from one basin is diverted into the next once the desired soil water deficit is satisfied.

- **Furrow irrigation** is conducted by creating small parallel channels along the field length in the direction of predominant slope (figure 4). Water is applied to the top end of each furrow and flows down the field under the influence of gravity.
- **Border strip**, otherwise known as border check or bay irrigation could be considered as a hybrid of level basin and furrow irrigation. The field is divided into a number of bays or strips; each bay is separated by raised earth check banks (borders). The bays are typically longer and narrower compared to basin irrigation and are orientated to align lengthwise with the slope of the field.

Figure 3: Basin irrigation

Figure 4: Furrow irrigation using siphon tubes

- **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. It is also known as **low-flow irrigation system/low volume irrigation/micro-irrigation**. **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 (figure 5). 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. The field water efficiency of drip irrigation is 80 to 90 percent. In modern agriculture, drip irrigation is often combined with plastic mulch, further reducing evaporation, and is also the **means of delivery of fertilizer**. This is known as **fertigation**.

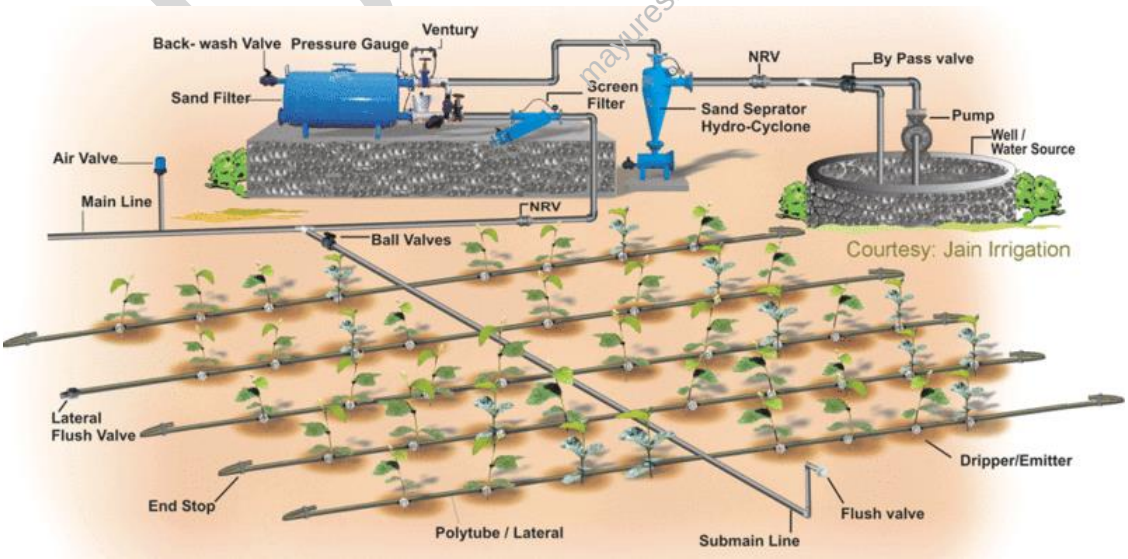


Figure 5: Drip Irrigation system

- **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 (figure 6). 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** (figure 7) may irrigate areas such as small farms, sports fields, parks, pastures, and cemeteries unattended. The field water efficiency of sprinkler irrigation is 60 to 70%.

Figure 6: Sprinkler irrigation

Figure 7: Travelling Sprinkler irrigation

- **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. Three basic types of sub-irrigation are: **ebb-and-flow, trough, and flooded floor**.

There are various **challenges** to adopt these localized forms of irrigation. Few of them are listed below:

- **Expense**: initial cost can be more than overhead systems.
- **Waste**: the sun can affect the tubes used for drip irrigation, shortening their usable life.
- **Clogging**: if the water is not properly filtered and the equipment not properly maintained, it can result in clogging.
- **Waste of water, time and harvest,** if not installed properly. These systems require careful study of all the relevant factors like land topography, soil, water, crop and agro-climatic conditions, and suitability of drip irrigation system and its components.

2.4. Based on the Way the Water is Applied

The classification of the irrigation systems can also be based on the way the water is applied to the agricultural land as:

- **Flow irrigation system**: where the irrigation water is conveyed by growing to the irrigated land. This may again be classified into the following.

- **Direct irrigation**: Where the irrigation water is obtained directly from the river, without any intermediate storage. This type of irrigation is possible by constructing a weir or a barrage across a river to raise the level of the river water and thus divert some portion of the river flow through an adjacent canal, where the flow takes place by gravity.
- **Reservoir/tank/storage irrigation**: The irrigation water is obtained from a river, where storage has been created by construction an obstruction across the river, like a dam. This ensures that even when there is no inflow into the river from the catchment, there is enough stored water which can continue to irrigate fields through a system of canals.

- **Lift irrigation system**: Where the irrigation water is available at a level lower than that of the land to be irrigated and hence the water is lifted up by pumps or by other mechanical devices for lifting water and conveyed to the agricultural land through channels flowing under gravity. For instance, a large portion of Indira Gandhi canal in Rajasthan is fed by lift irrigation system.

2.5. On the Basis of Duration of the Applied

Classification of irrigation systems may also be made on the basis of duration of the applied water, like:

- **Inundation/flooding type irrigation system:** In which large quantities of water flowing in a river during floods is allowed to inundate the land to be cultivated, thereby **saturating the soil**. The **excess water is then drained off** and the land is used for cultivation. This type of irrigation uses the flood water of rivers and therefore is limited to a certain time of the year. It is also common in the areas near river deltas, where the slope of the river and land is small. Unfortunately, many of the rivers, which were earlier used for flood inundation along their banks, have been embanked in the past century and thus this practice of irrigation has dwindled.
- **Perennial irrigation system**: In which irrigation water is supplied according to the crop water requirement at regular intervals, throughout the life cycle of the crop. The water for such irrigation may be obtained from rivers or from walls. Hence, the source may be either surface or ground water and the application of water may be by flow or lift irrigation systems.

2.6. Choice of Irrigation Method

As we have discussed above, there are various ways to provide water to crops. However, choosing right kind of method is a challenge. It must suit the particular crop, soil and of course, depends on availability of water. For example, following is a short list of available methods corresponding to the kind of crop.

Method	Suitable for crops
Border Strip method	Wheat, Leafy vegetables, Fodders
Furrow method	Cotton, Sugarcane, Potatoes
Basin method	Orchard trees

Table 1: Irrigation method for different crops

Other methods like sprinkler and drip irrigation systems are adapted where water is scarce and priority for its conservation is more than the consideration for cost. Although most advanced countries are adopting these measures, they have not picked up as much in India mainly due to financial constraints. However, as time passes and land and water resources get scarce, it would be essential to adopt these practices in India, too.

3. Efficiency

Irrigation efficiency is defined as the ratio between the water stored in the soil depth inhabited with active plant roots to the water applied by the irrigation system. Thus, water applied by the

irrigation system and not being made available to be taken up by plant roots is wasted and reduces irrigation efficiency. The major **causes** for reduced irrigation efficiency **are drainage of excess irrigation water** to soil layers deeper than the depth of active roots. **Leakage of irrigation water to deep soil layers** could result in pollution of the water table. Over-irrigation and under-irrigation, both are injurious to the crop. Thus, the timings of irrigation and the quantity of water supplied are decisive for the satisfactory performance of the crop. In the case of wheat for example, appropriate timing and spacing of irrigation raise the yield as much as 50 per cent with less use of water.

The cases of irrigation efficiency of 100 percent are practically none existent even in the most modern irrigation systems. Major difficulties in obtaining high irrigation efficiency stems from the inability to obtain an accurate estimate of the quantity of water needed to recharge the soil root zone depth and the lack of valid, real time information concerning the actual soil depth of active roots.

Conservative estimates suggest that even under optimal management practices the average irrigation efficiency is estimated to be 70 percent. Thus, the average water loss under sprinkler and drip irrigation is 30 percent but could drop to values of over 50 percent under furrow and flood irrigation. Efficiency of drip irrigation can reached to 90 per cent with best efforts. Water losses of irrigation water under urban and landscape irrigation could easily reach 50 percent of the applied water.

India's national water mission aims to increase water use efficiency by 20 per cent. Agriculture contributes for more than 80 per cent of water usage in the country. Therefore, a large focus of the mission is on the improving efficiency of various irrigation projects such as Major & minor irrigation schemes, CAP&WM (Command Area programmme & Water Management), and AIBP (Accelerated Irrigation Benefits Programme) etc.

4. Irrigation and National Water Policy

India had adapted a national water policy in the year 1987 which was revised in 2002. The policy document lays down the fact that planning and development of water resources should be governed by the national perspective. Certain aspects of policy related to irrigation are quoted below:

- Irrigation planning either in an individual project or in a watershed as a whole should take into account the irrigability of land, cost-effective irrigation options possible from all available sources of water and appropriate irrigation techniques for optimizing water use efficiency. Irrigation intensity should be such as to extend the benefits of irrigation to as large a number of farm families as possible, keeping in view the need to maximize production.
- There should be a **close integration of water use and land use policies.**
- Water allocation in an irrigation system should be done with due regard to equity and social justice. Disparities in the availability of water between head-reach and tail end farms and between large and small farms should be obviated by adoption of a rotational water distribution system and supply on a volumetric basis subject to certain ceilings and rational pricing.
- Concerted efforts should be made to ensure that the **irrigation potential created is fully utilised**. For this purpose, the command area development approach should be adopted in all irrigation projects.
- Irrigation being the largest consumer of fresh water, the **aim should be to get optimal productivity per unit of water**. Scientific management farm practices and sprinkler and drip system of irrigation should be adopted wherever feasible.
- **Reclamation of water-logged/saline affected land** by scientific and cost effective methods should form a part of command area development programme.

5. Command Area Development and Water Management (CADWM)

The planned development of irrigation sector started in a big way since the First Five Year Plan (1951–56). New projects were taken up in the Second Five Year Plan, the Third Five Year Plan, and the Annual Plans 1966–69. During the Fourth Five Year Plan emphasis was shifted to the completion of ongoing schemes.

The widening gap between potential creation and utilization was felt in the Fifth Plan (1974– 78) and accordingly Command Area Development programme (CADP) was launched as a Centrally-sponsored scheme in 1974-75. The CADP is an integrated area development approach towards the command areas of major and medium irrigation projects in the country. The programme is aimed at bridging the gap between created irrigation potential and its utilization in the command area.

The CAD programme was initially introduced in the Indira Gandhi Canal Command Area in 1974. Up to March 1998 the total number of projects taken up for command area development increased to 217 with cultivable command area (CCA) of 21.78 million hectares and spreading over 23 states and 2 union territories.

This programme was restructured and renamed as Command Area Development and Water Management (CADWM) Programme since April 1, 2004. The scheme is now being implemented as a State sector scheme during the XI Five Year Plan (2008-09 to 2011-12). During the XII Plan, the Scheme is to be implemented *pari-passu* with Accelerated Irrigation Benefits Programme (AIBP). The total proposed outlay for the XII Plan (Central share) is Rs.15,000 crore to cover about 7.6 Mha.

The Programme involves execution of on- farm development works like construction of Field channels and Fields drains, land leveling and shaping and conjunctive use of surface and ground-water. Warabandi or the rotational system of water distribution is undertaken with a view to ensuring equitable and timely supply of water to the farmers. Attention is also given to diversification of crore pattern so that water is put to optimum use and productivity of land increased. During such diversion Frication emphasis would be given to the production of oil seeds, pulses etc to eliminate as far as possible their shortage.

Under the CAD programme, the Ministry of Water Resources is also introducing and promoting participatory irrigation management (discussed below) in the CAD Projects by creating awareness and providing financial assistance to farmers' associations. Reclamation of waterlogged areas in irrigated commands is also an important component of the Programme.

An area of about 20.149 Mha has been covered under the programme since inception up to end of March, 2012.

6. Participatory Irrigation Management (PIM)

Any irrigation project cannot be successful unless it is linked to the stakeholders, that is, the farmers themselves. In fact, people's participation in renovation and maintenance of field channels was the established practice during the pre-independence days. However, the bureaucracy encroached on this function in the post-independence period and a realization has dawned that without the participation of farmers, the full potential of an irrigation scheme may not be realized.

The concept of involvement of farmers in management of the irrigation system has been accepted as a policy of the Government of India and has been included in the National Water Policy adopted in 1987. It stated that

"*Efforts should be made to involve farmers progressively in various aspects of management of irrigation systems, particularly in water distribution and collection of water rates. Assistance of voluntary agencies should be enlisted in educating the farmers in efficient water-use and water management.*"

Policy guidelines were framed for farmers' participation in the areas under the Centrally Sponsored Command Area Development Programme. One of the objectives of PIM is to create a sense of ownership of water resources and the irrigation system among the users, so as to promote economy in water use and preservation of the system.

At operational level, Water **Users' Association (WUA), Distributary Committee and Project Committees** have been formed. With the help of a model act by central government, various states have enacted laws for PIM. Total area covered under various WUA in all states together is approximately 15 million hectare in 2010.

7. Accelerated Irrigation Benefits Programme (AIBP)

The government of India launched Accelerated Irrigation Benefits Program (AIBP) in 1996-97. This program was launched to give loan assistance to the states to help them a few major irrigation projects which were in advanced stage of completion. The advanced stage of construction would imply that

- At least 50% of latest approved estimated project cost already incurred and
- At least 50% of physical progress of essential works of the project has taken place; and
- The proposal of the State for inclusion of project under AIBP must be supported by a credible construction schedule indicating the works already executed and works to be executed along with their costs.

In this program major, medium and Extension, Renovation & Modernization (ERM) irrigation projects which were having investment clearance of Planning Commission and were in advanced stage of construction and can be completed in the next four financial year and also were not receiving any other form of financial assistance were considered for inclusion in the programme.

The State Governments have been provided an amount of Rs.43425.6331 crore as CLA/Grant under AIBP since inception of this programme till 1.12.2010 for 283 major/medium irrigation projects and 11655 Surface minor irrigation schemes. After commencement of this Programme 129 major/medium projects and 7969 Surface major/medium irrigation Schemes have so far been reported completed. An additional irrigation potential of 59.39 lakh hectare has been created up to March 2009.

8. Repair, Renovation and Restoration of Water Bodies Scheme

In India, tanks/ponds and lakes have traditionally played an important role in conserving water for meeting various needs of the communities. Minor irrigation sources (tanks etc.) have 6.27 million ha. of irrigation potential. Around 15-20 per cent sources are not in use for one reason or the other, as a result of which one million ha of irrigation potential has been lost. Another, around 2 M-ha of potential is lost due to under utilisation of tanks in use.

The Government of India sanctioned a Pilot Scheme for "**National Project for Repair, Renovation & Restoration (RRR) of Water Bodies directly linked to Agriculture**" in January, 2005. Financial share of centre and state is in ration of 3:1. The objectives of the Scheme were to restore and augment storage capacities of water bodies, and also to recover and extend their lost irrigation potential. In its pilot phase, irrigation potential for 1.73 lakh hectare was realized.

With the success of pilot scheme, scheme has been extended for twelfth five year plan. It is envisaged to take up RRR works in 10,000 water bodies with a Central Assistance of Rs. 6235 crore. Out of 10000 water bodies, 9000 water bodies are proposed to be in rural areas and balance 1000 water bodies will be in urban areas. The proposal of water bodies where the Integrated Water Management Programme (IWMP) is implemented would be considered to be included under the scheme RRR of water bodies. At gram panchayat level, water users' associations (WUA) are responsible for detail project report and implementation. There are corresponding bodies at district, state levels and national level also.

Main **objectives** of the scheme

- Comprehensive improvement and restoration water bodies, thereby increasing tank storage capacity.
- Ground Water Recharge.
- Increased availability of drinking water.
- Improvement in agriculture/horticulture productivity.
- Improvement of catchment areas of tank commands.
- Environmental benefits through improved water use efficiency; by promotion of conjunctive use of surface and ground water.
- Community participation and self-supporting system for sustainable management for each water body.
- Capacity Building of communities, in better water management.

9. Virtual Water

The concept of "**virtual water**" was introduced by Prof. Allan in the early 1990s and refers to the water that is required for the production of agricultural commodities, or in other words the water "embedded" in agricultural products. For instance, it takes 1,600 cubic meters of water on average to produce one metric tonne of wheat. The water is said to be virtual because once the wheat is grown, the real water used to grow it is no longer actually contained in the wheat. The concept of virtual water helps us realize how much water is needed to produce different goods and services. In semi-arid and arid areas, knowing the virtual water value of a good or service can be useful towards determining how best to use the scarce water available.

Virtual water trade refers to the idea that when goods and services are exchanged, so is virtual water. When a country imports one tonne of wheat instead of producing it domestically, it is saving about 1,300 cubic meters of real indigenous water. If this country is water-scarce, the water that is 'saved' can be used towards other ends. If the exporting country is water-scarce, however, it has exported 1,300 cubic meters of virtual water since the real water used to grow the wheat will no longer be available for other purposes. Water-scarce countries like Israel discourage the export of oranges (relatively heavy water guzzlers) precisely to prevent large quantities of water being exported to different parts of the world.

Limitation of the Virtual water measures

- Relies on an assumption that **all sources of water**, whether in the form of rainfall or provided through an irrigation system, **are of equal value**.
- Implicitly assumes that water that would be released by reducing a high water use activity would necessarily be available for use in a less water-intensive activity. For example, the implicit assumption is that water used in rangeland beef production would be available to be used to produce an alternative, less water-intensive activity. As a practical matter this may not be the case, nor might the alternatives be economic.
- Fails as an indicator of environmental harm nor does it provides any indication of whether water resources are being used within sustainable extraction limits. The use of virtual water

estimates therefore offer no guidance for policy makers seeking to ensure that environmental objectives are being met.

- Importing food could pose the risk of further political dependence. The notion of "Self Sufficiency" is pride among people of many nations.

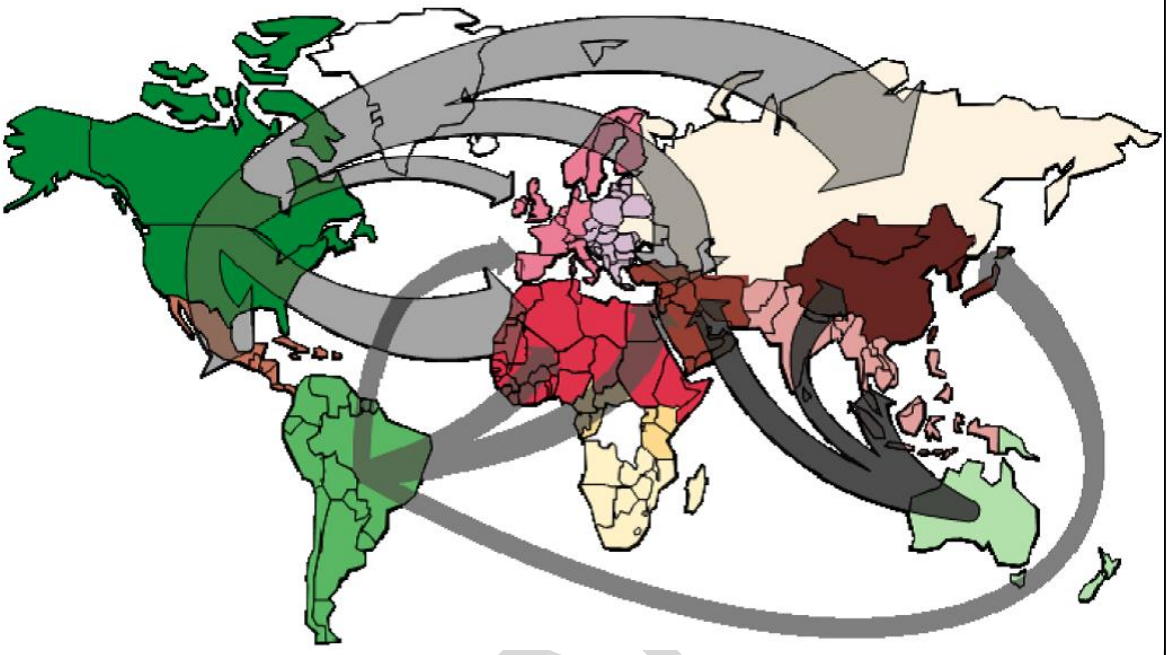


Figure 8: Virtual water flows by the region

In sum, virtual water trade allows a new, amplified perspective on water problems: In the framework of recent developments from a supply-oriented to a demand-oriented management of water resources it opens up new fields of governance and facilitates a differentiation and balancing of different perspectives, basic conditions and interests. Analytically the concept enables one to distinguish between global, regional and local levels and their linkages. This means, that water resource problems have to be solved in ***problemsheds*** if they cannot be successfully addressed in the local or regional watershed. Virtual water trade can thus overcome the hydro-centricity of a narrow watershed view.

References:

Culturable command area (CCA): *The gross command area contains unfertile barren land, alkaline soil, local ponds, villages and other areas as habitation. These areas are called unculturable areas. The remaining area on which crops can be grown satisfactorily is known as cultivable command area (CCA). Culturable command area can further be divided into 2 categories*

- *Culturable cultivated area: It is the area in which crop is grown at a particular time or crop season.*
- *Culturable uncultivated area: It is the area in which crop is not sown in a particular season.*

MISCELLANEOUS TOPICS LIKE EL NINO, LA NINA, ENSO, URBAN CLIMATE, APPLIED CLIMATOLOGY, HEAT ISLAND ETC.

Contents

1. Land Resources and Agriculture

Land is an important natural resource, which serves variety of functions. Different types of lands are suited to different uses. Human beings thus, use land as a resource for production as well as residence and recreation. Though, land seems to be in vast amount but its usage pattern and category makes it a limited resource.. There are two main factors determining land-use:

1. ***Physical Factors**:* These factors are like topography, soils, climate etc.
2. ***Human Factors**:* Growth of human population, duration of land control, technology, land rights, social, economic and cultural factors are some of the human factors.

1.1. Land Use Categories

In India, land-use records are maintained by land revenue department. The land use categories add up to *reporting area,* which refers to the total area reported by the land revenue department. At a surprising note, it is often different from the *geographical area* which is the total area as measured by the Survey of India and remains fixed as per the international boundaries.

Survey of India

Survey of India, The National Survey and Mapping Organization of the country under the Department of Science & Technology, is the OLDEST SCIENTIFIC DEPARTMENT OF THE GOVT. OF INDIA. It was set up in 1767 to help consolidate the territories of the British East India Company. In its assigned role as the National Principal Mapping Agency, Survey of India bears a special responsibility to ensure that the country's domain is explored and mapped suitably to provide base maps for expeditious and integrated development and ensure that all resources contribute their full measure to the progress, prosperity and security of India.

Besides being grouped under ''Scientific Surveys'' in Government of India Business Rule 1971, it has also been called upon extensively to deploy its expertise in the field of geodetic and geophysical surveys, study of seismicity and seismotectonics, glaciology, participation in Indian Scientific Expedition to Antarctica and projects related to digital cartography and digital photogrammetry, etc., to provide basic data to keep pace with Science and Technology Development.

Botanical Survey of India (BSI), Zoological Survey of India (ZSI) and Archaeological Survey of India (ASI) are some other important surveying agencies of government of India.

The land-use categories as maintained in the Land Revenue Records[1] are as follows:

(i) Forests: According to Survey of India report, *forest area* is one that is **notified by the department** as land under forests, **irrespective of whether it has any tree *cover* or not**. The land under ***forest cover*** is the land **exceeding one hectare** area having a minimum of 10 per cent tree *cover irrespective* of any other land-use. Thus, the area under actual forest cover may be different from area classified as forest. Hence, there may be an increase in this category without any increase in the actual forest cover.

(ii) Land put to Non-agricultural Uses: This includes the part of the geographic area that is put to non-agricultural uses like settlements, **both rural and urban**, infrastructure development like roads, railway lines, canals, industries, shops and other similar uses.

[1] As per the records of Land Revenue Department

(iii) Barren and Wastelands: The land classified as a wasteland such as barren hilly terrains, desert lands, ravines, etc. are normally can not be brought under cultivation with the available technology. They remain non suitable for agriculture and generally remain fallow.

(iv) Area under Permanent Pastures and Grazing Lands: The above type land is generally owned by the village 'Panchayat' or the Government (Forest & Revenue Department). Only a small proportion of this land is privately owned. These lands are not used for cultivation. The land owned by the village panchayat comes under 'Common Property Resources'. The benefits of this land accrue to the members of the community as a whole.

(v) Area under Miscellaneous Tree Crops and Groves: These areas are not included in net sown area. The land under orchards and fruit trees is included in this category. Most of this land is privately owned by the people.

(vi) Culturable Waste-Land: Any land which is left **fallow** (uncultivated) for more than **five years** is categorised as a culturable wasteland. This land may be marshy, saline land having degraded soil on account of soil erosion or under dense bushes. Such land can be brought under cultivation after improving it through reclamation practices.

(vii) Current Fallow: The land which has been left without cultivation for **one or less than one agricultural year** is known as current fallow. The practise adopted for giving rest to the culturable land is called fallowing. The land recoups the lost fertility through natural processes in the time duration.

(viii) Fallow other than Current Fallow: These are also the cultivable land which are left uncultivated for **more than a year**. The duration for which the land has been left uncultivated should be less than five years. Most of this land is either of poor quality or the cost of cultivation of such land is very high. If the land is left uncultivated for more than five years, it would be categorised as culturable wasteland.

(ix) Net Area Sown:

Net area sown represents the **area sown with crops at least once in any of the crop season** of the year counting area sown more than once in the same year, only once[2]. Net sown area is of crucial importance for India because it is the land actually under cultivation of crops and India has the highest percentage of Net Sown Area.

1.2. Land-use Changes in India

Land-use in a region, to a large extent, is influenced by the **nature of economic activities** carried out in that region. However, while economic activities change over time, land, like many other natural resources, is fixed in terms of its area. The pattern of land use depends on the economy of the region. With the **increase in size of the economy**, due to increasing population, change in income level, and updated technology, the pressure on the land increases many folds. Hence, marginal land also comes under usage. Also, with the **change in composition of economy**, brisk rate of growth of secondary and tertiary sector, there is gradual shift of land from agricultural usage to non-agricultural usage. But, it has been observed that though the share of agricultural land decreases with time, the pressure on land does not decrease. It is so

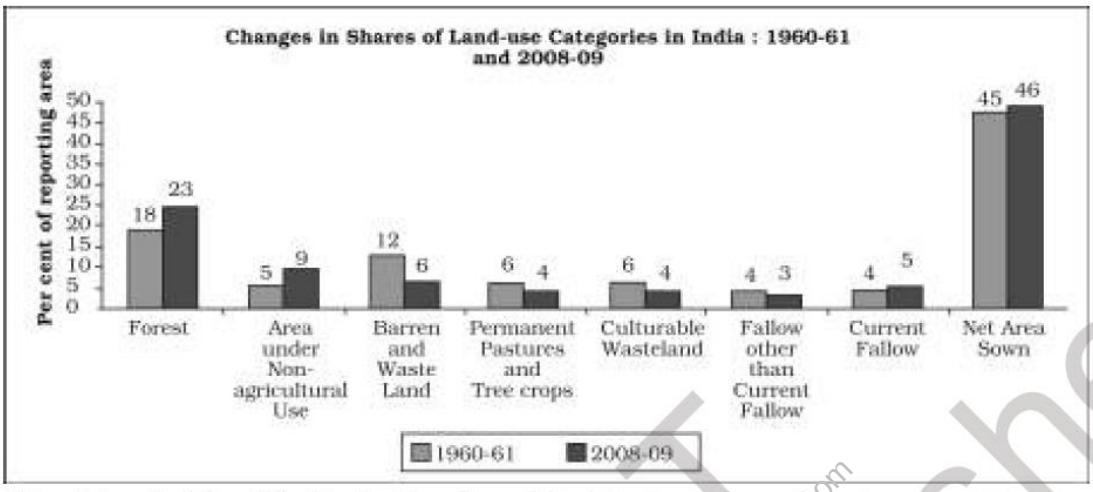
[2] Gross Cropped Area: This represents the total area sown once and/or more than once in a particular year, i.e. the area is counted as many times as there are sowings in a year. This total area is also known as total cropped area or total area sown.

because the number of people that the agricultural sector has to feed is increasing day by day.

India has undergone major changes within the economy over the past four or five decades, and this has influenced the land-use changes in the country. It has been observed that share of area under forest, area under non-agricultural uses and current fallow lands have shown an increase.

The *rate of increase* is the highest in case of area under non-agricultural uses. This is due to the changing structure of Indian economy, which is increasingly depending on the contribution from industrial and service sectors. Thus, the area under non-agricultural uses is increasing at the expense of wastelands and agricultural land.

Barren and wasteland, culturable wasteland, area under pastures and tree crops and net area sown have shown a decline in the areas. With the pressure on land increasing, wastelands and culturable wastelands have declined. Also, putting more area under the non-agriculture usage has caused a decline in net sown areas.



Note : Categories (iv) and (v) of Section I have been clubbed together in the graph.

1.2.1. Intensity of cropping

(To be covered)

1.2.2. Common Property Resources

Land, according to its ownership can broadly be classified under two broad heads – *private land and common property resources (CPRs)*. While the former is owned by an individual or a group of individuals, the latter is owned by the state meant for the use of the community. CPRs can be defined as community's natural resource, where every member has the right of access and usage with specified obligations, without anybody having property rights over them. Community forests, pasture lands, village water bodies and other public spaces are examples of the common property resources. CPRs provide fodder for the livestock and fuel for the households along with other minor forest products like fruits, nuts, fibre, medicinal plants, etc. In rural areas, such land is of particular relevance for the livelihood of the landless and marginal farmers, other weaker sections and women.

1.3. Agricultural Land Use in India

The term 'agriculture' has been derived from two Latin words ager meaning land and culture meaning cultivation. Agriculture thus means cultivation of land. Agriculture also includes horticulture, animal husbandry, forestry, fishing, etc. Agriculture, unlike other secondary and tertiary sectors, depends directly on the on the land use patterns in the country. Quality and fertility of land has a direct bearing on the productivity of agriculture. Besides in rural areas,

aside from its value as a productive factor, land ownership has a social value and serves as a security for credit, natural hazards or life contingencies, and also adds to the social status. It has been observed that over the years, there has been a marginal decline in the available total stock of cultivable land as a percentage to total reporting area. The scope for bringing in additional land under net sown area in India is limited. There is, thus, an urgent need to evolve and adopt land-saving technologies. It can be achieved either by increasing the yield of any particular crop per unit area of land or by increasing the total output per unit area of land from all crops grown over one agricultural year by increasing land-use intensity. A high value of cropping intensity[3] is desirable for improving the agricultural output in India.

1.4. Salient Features of Indian Agriculture

Indian agriculture has very wide variations throughout the length and breadth of the country. With growth of technology, more area has been brought under cultivation. Increase in irrigation facilities, coupled with use of fertilizers and pesticides and use of high yield variety of seeds has improved the productivity in the country. Despite the variations, there are some salient features which characterize Indian agriculture. They are:

1. **Subsistence agriculture[4]:** In general, the Indian agriculture is subsistence in nature. Farmers generally have a small piece of land and crop production is mostly for family use with surplus sold to market.
2. **Pressure of population:** Agriculture has to provide food for the rapidly increasing population and also employment to a large section of landless labourers. Hence, there is large pressure on agriculture. Besides, the increasing trend of urbanization is diverting the agricultural land to non-agricultural uses.
3. **Importance of animals:** In India, many of the agricultural operations such as ploughing, irrigation, threshing and transporting of the agricultural products are done by the animals. Animals form a major part of farmer's life in India. Complete mechanization of the Indian agricultural system is still a distant goal.
4. **Dependent upon monsoons:** The Indian farmer depends mainly on the monsoons, which are uncertain, unreliable and irregular. Only about 35 per cent of the total cropped area is under perennial irrigation and the rest depends on the monsoons. Thus, the dependency on monsoon makes life of Indian farmers highly vulnerable.
5. **Small land holdings**: The national average size of the land holdings is only 1.7 hectares. It is uneconomical to cultivate small farms and thus is a great hindrance to the progress of agriculture. Most of the farmers in our country are not owners of the land they cultivate.
6. **Variety of crops:** Due to highly suitable environmental conditions, the Indian farmers are able to grow a large variety of tropical and temperate crops. It includes food crops and commercial crops. The food crops score over all other crops for land under agriculture.
7. **Predominance of food crops:** The production of food crops is the first priority of the farmers, as they have to provide enough food for the rapidly increasing population of our country. About two-thirds of the total land under agriculture is devoted to food crops in India.
8. **Less importance to fodder crops:** India has the largest population of livestock in the world. Still the fodder crops are not given due consideration in the cropping pattern. Thus, we have very poor quality of domestic animals, when compared internationally.

[3] Cropping Intensity is defined as the ratio of Gross Cultivated Area (GCA) to Net Sown Area (NSA). It is generally expressed in percentage.

[4] Subsistence agriculture is self-sufficiency farming in which the farmers focus on growing enough food to feed themselves and their families.

1.5. Cropping Season in India

There are three distinct cropping seasons in India, namely Kharif, Rabi and Zaid.

1.5.1. The Kharif Season

largely coincides with Southwest Monsoon in the months of June – September. Major crops cultivated in Northern states include Rice, Cotton, Bajra, Maize, Jowar, and Tur. In southern states, major crops are Rice, Maize, Ragi, Jowar, and Groundnut.

1.5.2. The Rabi Season

begins with the onset of winter in October-November and ends in March-April. The major crops cultivated in northern states include Wheat, Gram, Rapeseeds and Mustard, Barley. In the southern states, major crops include Rice, Maize, Ragi, Groundnut, and Jowar.

1.5.3. The Zaid Season

is a short duration summer cropping season beginning after harvesting of Rabi crops. The cultivation of watermelons, cucumbers, vegetables and fodder crops during this season is done on irrigated lands. However, this type of distinction in the cropping season does not exist in southern parts of the country.

Cropping Season	Duration	Season	Major Crops
Kharif	June-July to Oct.-Nov	Rainy season	Rice, maize, jowar, bajra, cotton, sesamum, groundnut and pulses like mung, urad etc.
Rabi	Oct.-Nov. to March-April	Winter season	Wheat, barley, gram and oilseeds like linseed, rape and mustard, etc.
Zaid	March-April to May-June	Summer season	Vegetables, fruits like watermelon and cucumber and rice, maize etc.

1.6. Type of Farming (On Basis of Moisture for crops)

On the basis of main source of moisture for crops, the farming can be classified as ***irrigated farming*** and ***rainfed farming*** (*barani). Irrigated farming* can be further sub-divided into protective farming or productive farming. ***Protective irrigation farming*** is to protect the crops from adverse effects of soil moisture deficiency i.e. irrigation acts as a supplementary source of water over and above the rainfall. Whereas ***productive irrigation farming*** is meant to provide sufficient soil moisture in the cropping season to achieve high productivity. In such irrigation the water input per unit area of cultivated land is higher than protective irrigation.

Rainfed farming is further classified on the basis of adequacy of soil moisture during cropping season into *dryland* and *wetland* farming. . In ***wetland farming***, the rainfall is in excess of soil moisture requirement of plants during rainy season. These areas grow various water intensive crops such as rice, jute and sugarcane. The ***dryland farming*** is largely confined to the regions having annual rainfall less than 75 cm. These regions grow hardy and drought resistant crops such as *Ragi*, *Bajra*, M*oong*, Gram and G*uar* (fodder crops) and practise various measures of soil moisture conservation and rain water harvesting.

Chief Features **of Dryland Farming** are:

1. The techniques of rainwater harvesting are practised.It helps to reduce the gap of dryness between two rainfall periods.
2. Excess rainfall than needed is allowed to seep underground. It helps in water

conservation.

3. Soil and water are the two main resources of dryland farming.
4. On account of long periods of aridity soil erosion sets in.
5. On account of destruction of humus in the top layer the soils become unproductive and infertile.
6. Only very poor farmers practice dryland farming. These persons account of lack of funds, are unable to access irrigation and invest in soil fertility.
7. To supplement income animal husbandry is practised.
8. On account of pressure of population grazing lands are is becoming less and less.

Steps taken

1.7. Type of Farming (On Basis of Changing Geographical Environment or Historical Background)

Various type of farming patterns have developed in India due to highly variable environmental conditions. Based on changing geographical environment and historical background, we can further classify farming into following categories:

1.7.1. Shifting Agriculture

Shifting agriculture is also known as slash and burn cultivation. It is mostly practised in backward forest areas with heavy rainfall. Covered patchesof ground are cleared by cutting and burning trees and forests. The cleared land is then cultivated for two or three years in a primitive manner. When soil becomes leached and unproductive, the farmers shift to other part of the forest and follow the same pattern. There are certain disadvantages of shifting agriculture. We find that productivity is high in the first year but slowly the productivity decreases with every passing year. With the cutting of forests, soil gets easily degraded and blown away by wind and rain. The recovery period of the soil is long and it takes time to recover to the original state. Shifting cultivation is practised on a small scale in the forested areas of north eastern states, Orissa, Madhya Pradesh, Andhra Pradesh and parts of Kerala. It is known by different mimes such as Jhum in Assam, Podu in Orissa and Andhra Pradesh, Bewar in Madhya Pradesh and Ponam in Kerala.

1.7.2. Subsistence Agriculture

It is practised mainly for consumption purpose and maintenance of one's family. The farmer produces a variety of crops, and the total production is just enough to meet the requirements of the family. The farms are small and the yield is low. All types of manures, such as household waste, animal droppings, green manures, night soil and a little of chemical fertilizers are used. This type of agriculture is generally practised in the tribal areas of Assam and in the Himalayan region.

1.7.3. Intensive Agriculture

It is practised in regions with highly dense populated land with limited cultivable area. The farmer tries to get the maximum possible output from the small piece of land. More than one crop is cultivated in a year. Intensive agriculture is widely practised in the irrigated areas of the northern plains and the coastal plains of India.

1.7.4. Extensive Agriculture

This type of agriculture is practised in areas with low population density and the cultivable land is abundant. The farmer specializes in one or two commercial crops. In India, extensive cultivation is widely practised in the Terai region of the Himalayas and the north-western states.

1.7.5. Plantation Agriculture

This type of agriculture was introduced by the Europeans in the tropical and the subtropical regions of the country. Large tracts of agricultural land are mostly owned by the companies. In India, the main crops produced on plantations are tea, coffee, spices, coconut and rubber. The success of plantation agriculture depends on accessibility, availability of labour and adequate means of transport. Scientific methods of farming are used with an aim of higher yield and superior product quality.

1.7.6. Commercial Agriculture

The main aim of commercial farming is **to produce crops as per the market demands**. It can be either intensive or extensive. To keep the cost of production low, most modern methods of cultivation are employed. It is generally practised in areas of sparse population. In India, commercial farming is not very common due to heavy pressure of population on land. Commercial agriculture has developed in Punjab, Haryana, Gujarat, Maharashtra, Uttar Pradesh, West Bengal, Assam.

1.7.7. Mixed Farming

In this type of farming, livestock is reared along with crop farming. Cattle rearing and rotation of crops are important part of mixed farming. It is practised in thickly populated areas. The yields are generally high. Efficient methods of cultivation, quick means of transport and ready markets are seen as promoters of mixed farming in the country.

1.8. Cropping Pattern[5]

Cropping pattern refers to the yearly sequence and spatial arrangement of crops and fallows on a given area. The farmer's decision on crops and cropping pattern depends on several factors – soil and climate, household needs, socio-economic issues, market infrastructure, post-harvest storage and processing facilities, labour availability, technological development, government policies etc. By and large, most of the Indian farmers go for cultivation of a number of crops on their farms and rotate a particular crop combination over a period of 3 -4 years. It results in multiplicity of cropping system which remains dynamic in time and space.

A large diversity of cropping system exist under rainfed and dryland areas with an over-riding practise of intercropping due to greater risk involved in cultivating large area under a particular crop, while in areas of assured irrigation only a few cropping system are followed, they have a considerable coverage across the region and contribute significantly to food grain production at national level.

Three major type of cropping system in India are- **(i) Sequential System-** In this system, we have sequential multiple cropping using short duration crops and intensive input management. **(ii) Intercropping System-** Growing of two or more crops simultaneously on the same field; Crop intensification is in both temporal and spatial dimensions. **(iii) Alley Cropping System –** Growing of annual crops with multipurpose perennial trees or shrubs. It is a way of increasing production potential under fragile environment.

[5] The crops of India are divided into mainly two types: (a) Food crops (b) Cash crops. A cash crop is an agricultural crop which is grown for sale to return a profit. It is typically purchased by parties separate from a farm. Rice, wheat, maize, millet, barley, mower are the examples of food grains. Jute, cotton, sugarcane, oil seeds and rubber are known as cash crops.

1.9. Food grains

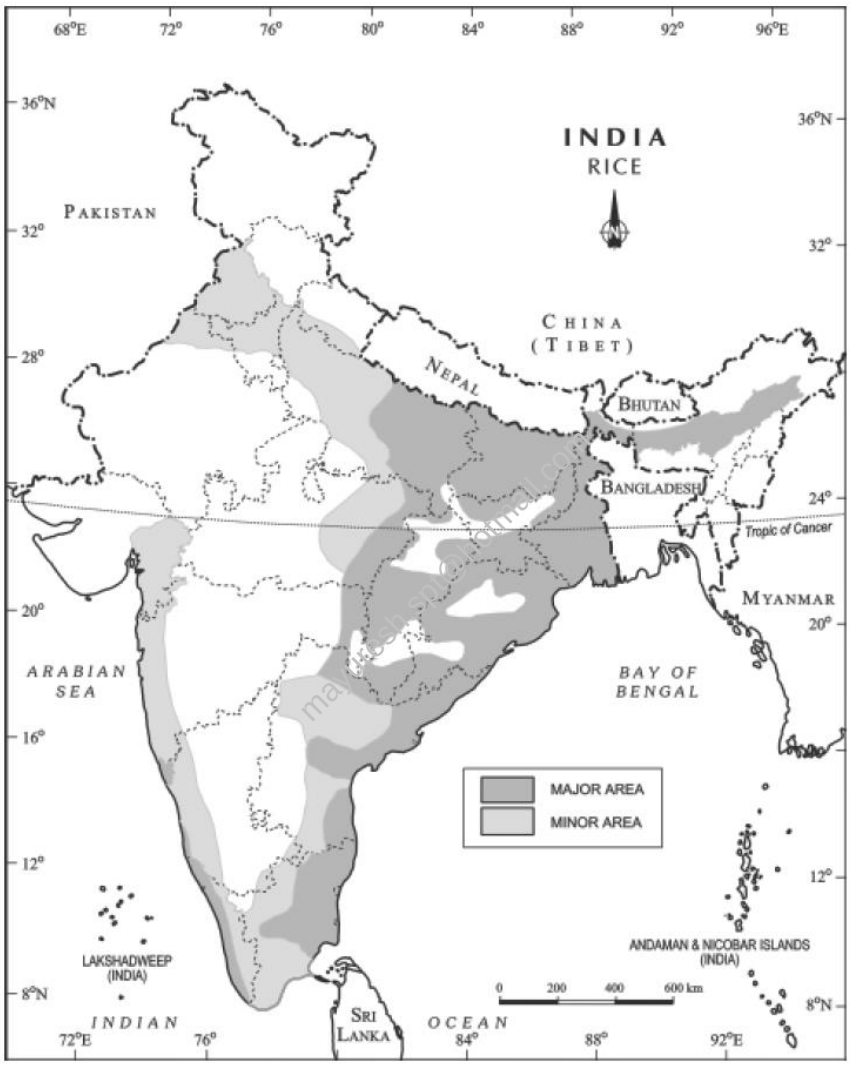
Food grains are the dominant crop in all parts of the country whether it is subsistence or commercial agricultural economy. On the basis of the structure of grain, the food grains can be classified as cereals and pulses.

1.9.1. Cereals

The cereals occupy about 54 per cent of total cropped area in India. The country produces about 11 per cent cereals of the world and ranks third in production after China and U.S.A. India produces a variety of cereals, which are classified as fine grains (rice, wheat) and coarse grains (Jowar, Bajra, maize, Ragi), etc.

1.9.1.1. Rice

Rice is the most important cereal crop in India. About 3,000 varieties are grown in different agro-climatic regions of the country. Rice being a tropical and sub-tropical plant requires a fairly high temperature of more than 22°C and amount of rainfall more than 100 cm. Irrigation is necessary in areas of lesser rainfall. *Clayey alluvial soil* in which water can remain standing is ideal for rice. A good crop of rice can be obtained only if the fields are kept filled with water. Cultivation of rice is *labour-intensive.*



India contributes 22 per cent of rice production in the world and ranks second after China. About one-fourth of the total cropped area in the country is under rice cultivation. West Bengal, Punjab, Uttar Pradesh, Andhra Pradesh and Tamil Nadu were five leading rice producing states in the country.

Golden Rice

Golden Rice is a new type of rice that contains beta carotene, a source of vitamin A. Golden Rice is being developed as a potential new food-based approach to improve vitamin A status. Vitamin A deficiency is a serious public health problem affecting millions of children and pregnant women globally.

1.9.1.2. Wheat

Wheat is the second most important cereal crop in India after rice. Indian production of wheat is second in the world after China[6]. It is primarily a crop of **temperate zone**. Wheat needs about **75 cm** of water and winter temperature of **10° to 15° C** and summer temperature of **21°C to 26°C** during ripening to produce a good crop. It requires a rainfall of **50 to 75 cm**. Excessive *rainfall* is harmful to wheat crop. Roots of the plant are destroyed in standing water. **Light loam** soil is ideal. Hence, its cultivation in India is done during winter i.e. ***rabi*** season. Cultivation of wheat is not labour-intensive. Uttar Pradesh, Punjab, Haryana, Rajasthan and Madhya Pradesh are five leading wheat producing states.

1.9.1.3. Jowar (Sorghum)

It is main food crop in **semi-arid areas** of central and southern India. Jowar is grown both as a **Kharif** and as a **rabi** crop. As a Kharif crop, it grows in areas having mean monthly average temperature of **26°C to 33°C**. It requires rainfall of about **30cm** during the growing season. Jowar can be grown in a **variety of soils** including loamy and sandy soils. The **clayey, regur and alluvium** are most suitable for Jowar cultivation. Maharashtra alone produces more than half of the total *Jowar* production of the country. Other leading producer states of *Jowar* are Karnataka, Madhya Pradesh and Andhra Pradesh. The grain also makes for an excellent poultry feed.

1.9.1.4. Bajra

Bajra is sown in **hot and dry** climatic conditions in north-western and western parts of the country. It is grown in areas with rainfall about **40-50 cm** and temperature of about **25°C -30°C**. It is a **hardy crop** which resists frequent dry spells and drought in this region. It is cultivated alone as well as part of mixed cropping. Leading producers of *Bajra* are the states of Maharashtra, Gujarat, Uttar Pradesh, Rajasthan and Haryana.

1.9.1.5. Maize

Maize is a **food as well as fodder crop** grown under **semi-arid** climatic conditions and over **inferior soils**. It requires **50-100cm** of rainfall and a temperature ranging from **21°C to 27°C**. Maize is sown **all over India except eastern and north-eastern regions.** The leading producers of maize are the states of Madhya Pradesh, Andhra Pradesh, Karnataka, Rajasthan and Uttar Pradesh. Yield level of maize is higher than other coarse cereals. It is high in southern states and declines towards central parts.

1.9.1.6. Pulses

Pulses are rich source of **protein** in India. India is a leading producer of pulses and accounts for about **one-fifth** of the total production of pulses in the world. The cultivation of pulses in the country is largely concentrated in the **dryland of Deccan and central plateaus and north-western parts of the country**. Gram and *tur* are the main pulses cultivated in India.

[6] http://faostat.fao.org/site/339/default.aspx

1.9.1.7. Gram

is cultivated in subtropical areas. It is mostly a rainfed crop cultivated during Rabi season in central, western and north-western parts of the country. Preferred temperature range is **20°C – 25°C** and rainfall in the range of **40-50cm**. Madhya Pradesh, Uttar Pradesh, Maharashtra, Andhra Pradesh and Rajasthan are the main producers of this pulse crop. **Tur** is the second important pulse crop in the country. It is also known as *red gram* or *pigeon pea*. It is cultivated over marginal lands and under rainfed conditions in the dry areas of central and southern states of the country. Maharashtra, Uttar Pradesh, Karnataka, Gujarat and Madhya Pradesh are the main producers of Tur.

1.9.2. Oilseeds

The oilseeds are produced for extracting edible oils. Dryland of Malwa plateau, Marathwada, Gujarat, Rajasthan, Telangana and Rayalseema region of Andhra Pradesh and Karnataka plateau are oilseeds growing regions of India. Groundnut, rapeseed and mustard, Soyabean and sunflower are the main oilseed crops grown in India.

1.9.2.1. Groundnut

Groundnut is largely a rainfed *Kharif* crop of dryland. Gujarat, Tamil Nadu, Andhra Pradesh, Karnataka and Maharashtra are the leading producers.

1.9.2.2. Rapeseed and Mustard

Rapeseed and mustard comprise several oilseeds as *rai, sarson, toria* and *taramira*. These are subtropical crops cultivated during rabi season in north-western and central parts of India. Rajasthan contributes about one-third production while other leading producers are Uttar Pradesh, Haryana, West Bengal and Madhya Pradesh. Yields of these crops are comparatively high in Haryana and Rajasthan.

1.9.2.3. Other Oilseeds

Soyabean and sunflower are other important oilseeds grown in India. Soyabean is mostly grown in Madhya Pradesh and Maharashtra. Sunflower cultivation is concentrated in Karnataka, Andhra Pradesh and adjoining areas of Maharashtra. It is a minor crop in northern parts of the country where its yield is high due to irrigation.

1.9.3. Cash Crops

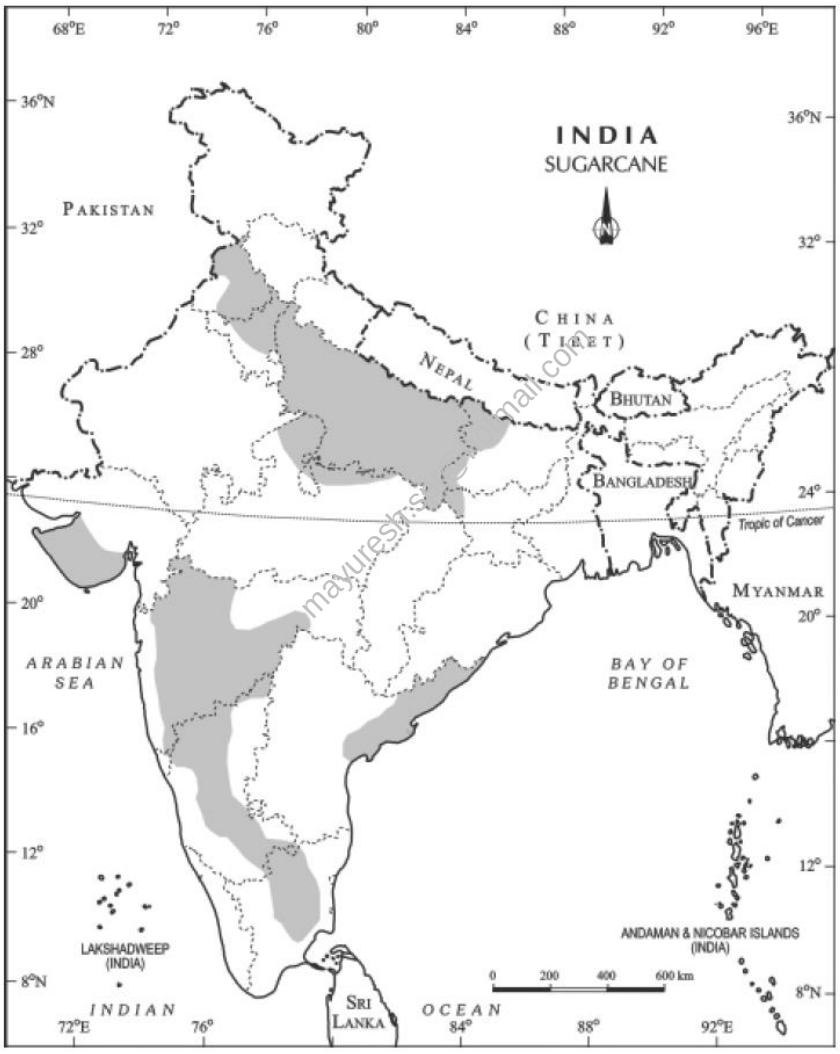
1.9.3.1. Cotton

Cotton is a tropical crop grown in ***Kharif*** season in **semi-arid** areas of the country. India grows both **short staple (Indian)** cotton as well as **long staple (American)** cotton called '***narma***' in north-western parts of the country. Cotton requires **clear sky during flowering stage**. Ideal temperature range is **21°C – 30°C** and rainfall in the range of **50 – 100cm**. There are three cotton growing areas, i.e. parts of Punjab, Haryana and northern Rajasthan in north-west, Gujarat and Maharashtra in the west and plateaus of Andhra Pradesh, Karnataka and Tamil Nadu in south. Leading producers of this crop are Maharashtra, Gujarat, Andhra Pradesh, Punjab and Haryana.

1.9.3.2. Jute

Jute is a cash crop in West Bengal and adjoining eastern parts of the country. West Bengal accounts for about **three-fourth** of the production in the country. Bihar and Assam are other jute growing areas. Ideal growing condition include temperature in range of **24°C – 35°C** and rainfall of **120- 150cm**.

1.9.3.3. Sugarcane



Sugarcane is a crop of **tropical** areas. Under **rainfed** conditions, it is cultivated in **sub-humid and humid climates**. It requires **hot and humid climate** with average temperature of **21°C-27°C** and **75-100 cm** rainfall. In Indo-Gangetic plain, its cultivation is largely concentrated in **Uttar Pradesh**. Sugarcane growing area in western India is spread over **Maharashtra and Gujarat**. In southern India, it is cultivated in irrigated tracts of Karnataka, Tamil Nadu and Andhra Pradesh. Uttar Pradesh produces about two-fifth of sugarcane of the country.

Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh are other leading producers of this crop.

1.9.3.4. Tea

Tea is a **plantation crop** used as beverage. It is grown over undulating topography of **hilly areas** and **well drained soils** in **humid and sub-humid tropics and sub-tropics**. The ideal temperature for growth is **20°C – 30°C** and rainfall around **150-300cm**. In India, tea plantation is done in Brahmaputra valley of Assam, sub-Himalayan region of West Bengal (Darjiling, Jalpaiguri and Cooch Bihar districts) and lower slopes of Nilgiris and Cardamom hills of Western Ghats.

1.9.3.5. Coffee

Coffee is a tropical plantation crop. There are three varieties of coffee i.e. ***arabica***, ***robusta*** and ***liberica***. Coffee is cultivated in the highlands of Western Ghats in Karnataka, Kerala and Tamil Nadu. The ideal temperature for growth is between **15°C and 28°C** and rainfall from **150 cm to 250cm.**

1.9.4. Tabular Representation of Various Crop Requirements in India

Crop	Climatic Conditions	Soil Requirements	Area of Cultivation
Rice	Temp: Higher than 22°C Rain: More than 100cm	Fertile clayey or loamy soil of the river valleys, flood plains, coastal plains and deltas capable of holding water	Lower and middle Ganga Plains, the east and west coastal plains, the Brahmaputra Valley and parts of the Deccan Plateau.
Wheat	Temp: Winter 10°C -15°C Summer 21°C-26°C Rain: 50-75 cm	Well-drained fertile silt and clayey loams	Punjab, Haryana, Uttar Pradesh, Rajasthan and Madhya Pradesh
Jowar	Temp: 26°C – 33°C Rain: About 30 cm	Clayey, regur and alluvium	Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, Rajasthan and Gujarat
Bajra	Temp: 25°C – 30 °C Rain: 40 -50 cm	Sandy loams, black and red soils	Maharashtra, Gujarat, Uttar Pradesh, Rajasthan and Haryana.
Maize	Temp: 21°C – 27°C Rain: 50 -100 cm	Deep fertile well drained soil rich in organic matter with good water holding capacity	Madhya Pradesh, Andhra Pradesh, Karnataka, Rajasthan and Uttar Pradesh
Ragi	Temp: 20°C – 30°C Rain: 50 -100 cm	Red, light black sandy loams	Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Bihar, Gujarat and Maharashtra
Gram	Temp: 20°C – 25°C Rain: 40 -50 cm	Well-drained fertile silt and clayey loams	Madhya Pradesh, Uttar Pradesh, Rajasthan, Haryana and Maharashtra
Tur (Arhar)	Temp: Winter 15°C -18°C Summer 30°C-35°C Rain: 50-70 cm	Sandy loam to clayey loam, Deep well drained soil	Uttar Pradesh, Madhya Pradesh, Maharashtra, Gujarat, Andhra Pradesh, Odisha, Karnataka and Tamil Nadu

Groundnut	Temp: 20°C – 30°C Rain: 50 -80 cm	Sandy loams and black soil	Andhra Pradesh, Tamil Nadu, Karnataka, Gujarat & Maharashtra.
Rapeseed & Mustard	Temp: 10°C – 20°C Rain: 50 -100 cm	Alluvial soil	Uttar Pradesh, Rajasthan, Punjab, Haryana, Madhya Pradesh and Chhattisgarh
Sesamum (Til)	Temp: 20°C – 25°C Rain: About 50 cm	Well-drained light loamy soils	Orissa, Rajasthan, Gujarat, Tamil Nadu, Maharashtra, West Bengal and Madhya Pradesh.
Sunflower	Temp: 15°C – 25°C Rain: About 50 cm	Well-drained loamy soil	Karnataka, Maharashtra, Andhra Pradesh, Haryana, Bihar and Uttar Pradesh
Soyabean	Temp: 15°C – 25°C Rain: 40-60 cm	Friable loamy soils can retain moisture.	Maharashtra, Uttar Pradesh, Uttarakhand, Madhya Pradesh, Gujarat and Chhattisgarh.
Linseed	Temp: 10°C – 20°C Rain: 50 -75 cm	Clay loams, deep black soils and alluvial soils	Madhya Pradesh, Uttar Pradesh, Bihar, Chhattisgarh and Maharashtra
Cotton	Temp: 21°C – 30°C Rain: 50 -100 cm	Black soil, Alluvial soil and Red soil	Punjab, Maharashtra, Gujarat and Haryana
Jute	Temp: 24°C – 35°C Rain: 120 -150 cm	Light sandy or clayey loam with annual water supply	West Bengal, Assam, Bihar and Orissa
Sugarcane	Temp: 21°C – 27°C Rain: 75 -100 cm	Deep, well-drained, rich loamy soil with moisture retaining capacity	Uttar Pradesh, Maharashtra, Tamil Nadu, Karnataka, Andhra Pradesh, Bihar and Punjab
Coconut	Temp: 20°C – 25°C Rain: Above150 cm	Loose porous or sandy along sea shores	Kerala, Tamil Nadu and Karnataka
Tea	Temp: 20°C – 30°C Rain: 150 -300 cm	Well-drained deep fertile sandy loams	Brahmaputra & Surma valleys of Assam, Darjeeling and Jalpaiguri districts of northern West Bengal and Nilgiris, Palnis and Annamalai hills in South India
Coffee	Temp: 15°C – 28°C Rain: 150 -250 cm	Well-drained loamy soils, rich in humus and minerals	Karnataka , Kerala and Tamil Nadu
Rubber	Temp: 25°C – 35°C Rain: Above 300cm	Deep, rich and well-drained loamy soil, at an elevation of about 400 metres	Kerala, Tamil Nadu, Karnataka and Andaman and Nicobar Islands

1.10. Agricultural Development in India

Agriculture continues to be an important sector of Indian economy. The importance of agricultural sector in India can be gauged from the fact that about **57 per cent of its land is devoted to crop cultivation**, whereas, in the world, the corresponding share is only about 12 per cent. Indian agricultural economy has been largely subsistence in nature. After

Student Notes:

Independence, the immediate goal of the Government was to increase food grains production by (i) switching over from cash crops to food crops; (ii) intensification of cropping over already cultivated land; and (iii) increasing cultivated area by bringing cultivable and fallow land under plough. Intensive Agricultural District Programme (IADP) and Intensive Agricultural Area Programme (IAAP) were launched in 1950s to improve production. New seed varieties of wheat (Mexico) and rice (Philippines) known as high yielding varieties (HYVs) were available for cultivation by mid-1960s and India took advantage by introducing package technology comprising HYVs, along with chemical fertilizers in irrigated areas of Punjab, Haryana, and Western Uttar Pradesh. This strategy of agricultural development increased the food production at very vast rate; this growth came to be known as ***Green Revol ution***. This strategy of agricultural development made the country self-reliant in food grain production. But green revolution was initially confined to irrigated areas only. This led to regional disparities in agricultural development in the country.

Agro-climatic planning was introduced in 1988 to induce regionally balanced agricultural development in the country. It also emphasised the need for diversification of agriculture and harnessing of resources for development of dairy farming, poultry, horticulture, livestock rearing and aquaculture. However, lack of development of rural infrastructure, withdrawal of subsidies and price support, and impediments in availing of the rural credits may lead to inter-regional and inter-personal disparities in rural areas. Improvement in technology, better yield crops, expansion in irrigation, improved fertilizers and use of pesticides has significantly improved the agricultural productivity in the country. Government initiated schemes like Rashtriya Krishi Vikas Yojana, Rainfed Farming Systems, National Horticulture mission etc along with National Mission on Oilseeds and Oil palms and Technology Mission on Oilseed, Pulses and Maize has led to improvement in agricultural produce in India.

1.10.1. Indian Council of Agricultural Research (ICAR)

The Indian Council of Agricultural Research (ICAR) is an autonomous organisation under the Department of Agricultural Research and Education (DARE), Ministry of Agriculture, Government of India. It was formerly known as Imperial Council of Agricultural Research and it was established on 16 July 1929. The Council is the apex body for co-ordinating, guiding and managing research and education in agriculture including horticulture, fisheries and animal sciences in the entire country. The ICAR has played a pioneering role in ushering Green Revolution and subsequent developments in agriculture in India through its research and technology development that has **enabled the country to increase the production of foodgrains by 4 times**, **horticultural crops by 6 times**, **fish by 9 times (marine 5 times and inland 17 times)**,**milk 6 times** and **eggs 27 times** since 1950-51, thus making a visible impact on the national food and nutritional security.

The mandates for the ICAR are to –

- To **plan, undertake, aid, promote** and co-ordinate **education, research and its application** in agriculture, agro forestry, animal husbandry, fisheries, home science and allied sciences.
- To act as a **clearing house** of research and general information relating to agriculture, animal husbandry, home science and allied sciences, and fisheries through its publications and information system; and instituting and promoting transfer of technology programmes.
- To provide, undertake and promote **consultancy services** in the fields of education, research, training and dissemination of information in agriculture, agro forestry, animal husbandry, fisheries, home science and allied sciences.
- To look into the problems relating to broader areas of **rural development** concerning agriculture, including postharvest technology by developing co-operative programmes with **other organizations** such as the Indian Council of Social Science Research, Council of Scientific and Industrial Research, Bhabha Atomic Research Centre and the universities
- To do other things considered necessary to attain the objectives of the Society.

1.11. Government Steps to Enhance Agricultural Inputs

Government has taken many steps to improve the yield of agriculture in the country. Various steps have been taken to promote efficient use of seeds, fertilizers, pesticides, micronutrients and irrigation. Each of these plays a role in determining yield level and in turn augmentation in level of production.

1.11.1. Seeds

Seeds are a critical input for agricultural crops. In India, farmers typically rely on farm-saved seeds, overuse of which leads to a low seed replacement rate and poor yield. An Indian Seed Programme for encouraging the development of new varieties and protecting the rights of farmers and plant breeders has been put in place with the participation of central and state governments, the Indian Council of Agricultural Research (ICAR), state agricultural universities, seed cooperatives, and private sectors. A central-sector Scheme for development and 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. A Sub-Mission on Seed and Planting Material under the **National Mission for Agricultural Extension and Technology** has been approved for the Twelfth Five Year Plan.

1.11.2. Mechanization and Technology

Tractors are the main power source for various farm operations. With adoption of appropriate mechanization of farm operations, we can increase production and farm productivity by 10-15

per cent. Steps are taken for setting up of custom-hiring centres/high-tech machinery banks so that small and marginal farmers can reap the benefits of farm mechanization. The government has initiated a Sub-Mission on Agriculture Mechanization in the Twelfth Five year Plan, with a focus on custom hiring.

1.11.3. Integrated Nutrient Management

Over 80% of India's Urea requirements are met from domestic production but we are largely dependent on foreign imports for meeting requirements of potassic (K) and phosphatic (P) fertilizers. Over-use of nitrogenous and limited use of P and K fertilizers are matters of great concern and need appropriate price incentives by reducing fertilizer subsidies so that sustainable practices are encouraged.

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. 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 fertilizer, depending upon its nutrient content. An additional subsidy is also provided to secondary and micro-nutrients. Under this scheme, manufacturers/marketers are allowed to fix the maximum retail price (MRP).

1.11.4. Irrigation

Although India has made considerable progress in developing irrigation infrastructure, irrigation efficiency is low for both surface and ground waters. In order to help the rainfed farmers improve productivity and profitability, in situ soil and water conservation practices are developed for different agro-climatic regions with special emphasis on effective rainwater management. The central government initiated the Accelerated Irrigation Benefit Programme (AIBP) in 1996-7 for extending assistance for the completion of incomplete irrigation schemes. Besides, the Command Area Development Programme has also been amalgamated with the AIBP to reduce the gap between irrigation potential that has created and that is utilized.

1.12. Major Schemes/Programmes for the Agricultural Sector

The central government has undertaken many schemes for enhancing productivity and exploring untapped potential of the agricultural sector. The central government supplements the efforts of state governments through centrally sponsored and central-sector schemes.

National Mission on Agricultural Extension and Technology (NMAET)

Agricultural productivity has a positive correlation with level of farm mechanization. For accelerated growth in farm mechanization in the current decade, there is a need to include the large community of small and marginal farmers into the fold of cost effective and remunerative mechanized farming, to help sustain desired agricultural growth and to enhance agricultural productivity.

Agricultural Technology, including the adoption/ promotion of critical inputs, and improved agronomic practices were being disseminated under 17 different schemes of the Department of Agriculture & Cooperation during the 11th Plan. The Modified Extension Reforms Scheme was introduced in 2010 with the objective of strengthening extension machinery and utilizing it for synergizing interventions under these schemes under the umbrella of the Agriculture Technology Management Agency (ATMA).

The NMAET has been envisaged as the next step towards this objective through the amalgamation of these schemes.

NMAET consists of 4 Sub Missions:

1. Sub Mission on Agricultural Extension (SMAE)
2. Sub-Mission on Seed and Planting Material (SMSP)
3. Sub Mission on Agricultural Mechanization (SMAM)
4. Sub Mission on Plant Protection and Plant Quarantine (SMPP)

The common threads running across all 4 Sub-Missions in NMAET are Extension and Technology. Therefore, while 4 separate Sub-Missions are being proposed for administrative convenience, these are inextricably linked to each other at the field level and most components thereof have to be disseminated among farmers and other stakeholders through a strong extension network.

The aim of the Mission is to restructure and strengthen agricultural extension to enable delivery of appropriate technology and improved agronomic practices to farmers. This is envisaged to be achieved by a judicious mix of extensive physical outreach and interactive methods of information dissemination, use of ICT, popularisation of modern and appropriate technologies, capacity building and institution strengthening to promote mechanisation, availability of quality seeds, plant protection etc. and encourage aggregation of Farmers into Interest Groups (FIGs) to form Farmer Producer Organisations (FPOs).

1.12.1. National Food Security Mission

With an aim to enhance the production of rice, wheat, and pulses by 10, 8, and 2 million tonnes respectively, government had launched NFSM-Rice, NFSM-Wheat and NFSM-Pulses in 2007-08. During 2012-13, a Special Plan to achieve 19+ million tonnes of pulses production during Kharif 2012 was launched by the government. The programme also aimed at area expansion and productivity enhancement; restoring soil fertility and productivity; creating employment opportunities; and enhancing farm-level economy to restore the confidence of farmers of targeted districts.

1.12.2. Rashtriya Krishi Vikas Yojana

The Rashtriya Krishi Vikas Yojana (RKVY) was launched in 2007-8 for incentivizing states to enhance public investment. It permits taking up national priorities as sub-schemes, allowing the states flexibility in project selection and implementation for increased public investment in agriculture by incorporating information on local requirements, geographical/climatic conditions, available natural resources/ technology and cropping patterns. It aims to significantly increase the productivity of agriculture and its allied sectors and eventually maximize the returns of farmers in agriculture and its allied sectors.

1.12.3. National Mission for Sustainable Agriculture

Climate change poses a major challenge to agricultural production and productivity.

National Mission for Sustainable Agriculture (NMSA), under the aegis of the National Action Plan on Climate Change (NAPCC), seeks to transform Indian agriculture into a climate resilient production system through suitable adaptation and mitigation measures in domains of both crops and animal husbandry. NMSA as a programmatic intervention focuses on promotion of location specific integrated/composite farming systems; resource conservation technologies; comprehensive soil health management; efficient on-farm water management and mainstreaming rainfed technologies.

NMSA identifies 10 key dimensions namely seed & culture water, pest, nutrient, farming practices, credit, insurance, market, information and livelihood diversification for promoting suitable agricultural practices that covers both adaption and mitigation measures through four functional areas, namely, Research and Development, Technologies, Products and Practices,

Infrastructure and Capacity building. During XII Five Year Plan, these dimensions have been embedded and mainstreamed into Missions/Programmes/Schemes of Ministry of Agriculture including NMSA through a process of restructuring of various schemes/missions implemented during XI Five Year Plan and convergence with other related programmes of Central/State Governments.

1.12.4. Bringing Green Revolution to Eastern India (BGREI)

Bringing Green Revolution to Eastern India, initiated in 2010-11, intends to address the constraints limiting the productivity of **'rice based cropping systems'**[7] in eastern India comprising **seven states, viz. Assam, Bihar, Chhattisgarh, Jharkhand, Odisha, Eastern Uttar Pradesh, and West Bengal**. The BGREI is a subscheme of the Rashtriya Krishi Vikas Yojna (RKVYJ). The following strategies are being adopted, in general, for maximising productivity and production of crops in the eastern region –

i. *In **situ*** **water harvesting/conservation** through adoption of cultural practices like bed furrow in deep black cotton uplands and flat sowing & ridging later in red soils.
ii. **Reclamation of soil salinity** through application of gypsum particularly in oilseed crops along with micro-nutrients like zinc, iron & sulphur in deficient soils.
iii. **Reclamation of acidic soils** through liming/paper mills sludge/application of organic manures/green manures to improve physical condition of the soil
iv. Promotion of **Integrated Nutrient Management** to ensure balanced use of fertilizers/organic manures/bio-fertilizers.
v. Adoption of **soil & water conservation practices** namely; summer ploughing, broad bed furrow, compartmental bunding, pre-monsoon sowing and rain water harvesting (Farm ponds) to check soil erosion and recycling runoff.
vi. **Enhancement of irrigation Water** Use Efficiency through adoption of micro-irrigation system (Sprinkler & Drip).
vii. **Promotion of high value crops** namely; sweet sorghum, maize, pulses and oilseeds in addition to hybrid rice in the region.

Outcome: Eastern region hitherto known as food deficit region, has with the help of the programme, turned food surplus region. The rice production from the region is estimated at 562.6 lakh tons an increase of 19.8% over last year against an all India increase of 7%. And the foodgrain production from the region is estimated at 1032 tons an increase of 11.9% against an all India increase of 2.2%.

The increased productivity/ production was optimized due to resource allocation and utilization. The significant increase in production of food grains in the region not only offset the decline in production in central and peninsular India but also contributed significantly to the highest ever production of food grains. The growth in food grains i.e. rice and wheat provides an opportunity to procure and create food grain reserves locally reducing the pressure on Punjab and Haryana, and cutting costs on transport and other logistics.

The focus will now be to consolidate the gains with continued emphasis during the 12th Plan. Further steps will be taken to improve the infrastructure for procurement and storage of the produce and to ensure a reasonable price for the farmers.

[7] Current focus is on rice and wheat only.

Evergreen Revolution

The architect of the country's green revolution, M.S. Swaminathan, gave a clarion call for taking up an 'evergreen revolution' that "increases productivity in perpetuity without causing any ecological harm and without using chemical inputs".

"I am against a second green revolution, but I am very much for an evergreen revolution," he said. Pointing out that a majority of food production comes from farmers with small holdings, he said it was essential to increase their income through higher productivity. But it should be done without harming ecological interests, he noted.

Swaminathan is an advocate of moving India to sustainable development, especially using environmentally sustainable agriculture, sustainable food security and the preservation of biodiversity, which he calls an "evergreen revolution."

1.12.5. Integrated Scheme Of Oilseeds, Pulses, Oilpalm & Maize (ISOPOM)

National Mission on Oilseeds and Oil Palm (NMOOP) envisages increase in production of vegetable oils sourced from oilseeds, oil palm and TBOs from 7.06 million tonnes (average of 2007-08 to 2011-12) to 9.51 million tonnes by the end of Twelfth Plan (2016-17). The Mission is proposed to be implemented through three Mini Missions with specific target as detailed below:

MM I on Oilseeds	Achieve production of 35.51 million tones and productivity of 1328 kg/ha of oilseeds from the present average production & productivity of 28.93 million **tonnes** and 1081 kg/ha during the 11th Plan period respectively.
MM II on Oil Palm	Bring additional 1.25 lakh hectare area under oil palm cultivation through area expansion approach in the States including utilization of wastelands with increase in productivity of fresh fruit brunches (FFBs) from 4927 kg per ha to 15000 kg per ha.
MM III on TBOs	Enhance seed collection of TBOs from 9 lakh **tonnes** to 14lakh tonnes and to augment elite planting materials for area expansion under waste land.

The strategy to implement the proposed Mission includes

- increasing Seed Replacement Ratio (SRR) with focus on Varietal Replacement;
- increasing irrigation coverage under oilseeds from 26% to 36%;
- diversification of area from low yielding cereals crops to oilseeds crops; inter-cropping of oilseeds with cereals/ pulses/ sugarcane;
- use of fallow land after paddy /potato cultivation;
- expansion of cultivation of Oil Palm and tree borne oilseeds in watersheds and wastelands;
- increasing availability of quality planting material enhancing procurement of oilseeds and collection; and
- processing of tree borne oilseeds.

Inter-cropping during gestation period of oil palm and tree borne oilseeds would provide economic return to the farmers when there is no production.

The scheme would be implemented in mission mode through active involvement of all the stakeholders. The Centre and States will bear costs in the ratio of 75:25. Fund flow would be

strictly monitored to ensure that benefit of the Mission reaches the targeted beneficiaries in time to achieve the results.

NEED FOR MISSION APPROACH

India is among major oilseed growers and edible oil importers. India's vegetable oil economy is world's fourth largest after USA, China and Brazil. The oilseed accounts for 13% of the gross cropped area, 3% of the Gross National Product and 10% value of all agricultural commodities.

The diverse agro-ecological conditions in the country are favourable for growing 9 annual oilseed crops, which include 7 edible oilseeds (groundnut, rapeseed & mustard, soybean, sunflower, sesame, safflower and niger) and two non-edible oilseeds (castor and linseed). Oilseeds cultivation is undertaken across the country in about 27 million hectares mainly on marginal lands, of which 72% in confined to rainfed farming.

During the last few years, the domestic consumption of edible oils has increased substantially and has touched the level of 18.90 million tonnes in 2011-12 and is likely to increase further. With per capita consumption of vegetable oils at the rate of 16 kg/year/person for a projected population of 1276 million, the total vegetable oils demand is likely to touch 20.4 million tonnes by 2017.

A substantial portion of our requirement of edible oil is met through import of palm oil from Indonesia and Malaysia. It is, therefore, necessary to exploit domestic resources to maximize production to ensure edible oil security for the country.

Oil palm is a comparatively new crop in India and is the highest vegetable oil yielding perennial crop. With quality planting materials, irrigation and proper management, there is potential of achieving 20-30 MT Fresh Fruit Bunches per ha after attaining age of 5 years. Therefore, there is an urgent need to intensify efforts for area expansion under oil palm to enhance palm oil production in the country. Tree-borne oilseeds (TBOs), like sal, mahua, simarouba, kokum, olive, karanja, jatropha, neem, jojoba, cheura, wild apricot, walnut, tung etc. are cultivated or grow wild in the country under different agro-climatic conditions. These TBOs are also good source of vegetable oil and therefore need to be supported for cultivation.

Background

In order to provide flexibility to the States in implementation based on regionally differentiated approach, to promote crop diversification and to provide focused approach to the programmes, the four erstwhile schemes of OPP, OPDP, NPDP and AMDP were merged into one Centrally Sponsored Integrated Scheme of Oilseeds, Pulses, Oil palm and Maize (ISOPOM) in 2004.

Now ISOPOM is replaced with National Mission on Oilseeds and Oil Palm (NMOOP) to be implemented during the 12th Plan Period as NFSM absorbed pulses and maize component from the ISOPOM scheme.

1.13. Problems of Indian Agriculture

The nature of problems faced by Indian agriculture varies according to agro-ecological and historical experiences of its different regions. Many of the problems are common to the nation and range from physical constraints to institutional hindrances.

1. **Dependence on erratic Monsoon** is one of the major problems in India. Irrigation covers only about 33 per cent of the cultivated area in India. Hence, the crop production in rest of the cultivated land directly depends on rainfall. Since, rainfall is very fluctuating; the areas are vulnerable to both droughts and floods. Drought is a common phenomenon in the low rainfall areas which may also experience occasional floods.

2. **Low Productivity** is another major concern. Per hectare output of most of the crops such as rice, wheat, cotton and oilseeds in India is much lower than that of other countries in the world. Because of the very high pressure on the land resources, the labour productivity in Indian agriculture is also very low in comparison to international level.
3. The farmers **use outdated techniques**. Most of the agricultural operations are carried out manually using simple and conventional tools. This hampers the production potential of the farmers.
4. **Constraints on financial resources** and indebtedness also make agriculture unmanageable for small and marginal farmers with very meagre or no savings. Crop failures and low returns from agriculture have forced them to fall in the trap of indebtedness.
5. **Lack of land reforms** has led to exploitation of Indian farmers for long time. There are no proper land records which make them susceptible to exploitation.
6. Besides, **small size farms and fragmentation of land holdings** also reduces the productivity and production of the farms. More than **60 per cent** of the ownership holdings have a size smaller than **one hectare (ha)**. Furthermore, about 40 per cent of the farmers have operational holding size smaller than 0.5 hectare (ha). The small size fragmented landholdings are uneconomic. A large number of farmers produce crops for self-consumption. These farmers do not have enough land resources to produce more than their requirement. Most of the small and marginal farmers grow food grains, which are meant for their own family consumption.
7. There is a massive **problem of under-employment** in the agricultural sector in India, particularly in the un-irrigated tracts. In these areas, there is a seasonal unemployment ranging from 4 to 8 months.
8. Another serious problem that arises out of faulty strategy of irrigation and agricultural development is **degradation of land resources**. Large tracts of fertile lands suffer **from soil erosion** due to wind, deforestation, overgrazing and occasional heavy rainfall. Soil's fertility should be conserved at any cost. This is serious because it may lead to depletion of soil fertility. The situation is particularly alarming in irrigated areas. A large tract of agricultural land has lost its fertility due to alkalisation and salinisation of soils and water logging.
9. Besides, **the marketing of agricultural products**, especially in rural India, is neither adequate nor standardised. Thus, many farmers have to sell their products at low prices through local traders and middle-men.

1.14. UPSC Questions Covered

1. "Small-holder farms need to be strengthened to achieve national food security." Do you agree with this assessment? Substantiate. (UPSC 2010/12 Marks)
2. Assess the contributions made by the Indian Council of Agricultural Research (ICAR) in agricultural development. (UPSC 2010/12 Marks)
3. Write about Organic Farming in 20 words. (UPSC 2008/2 Marks)
4. Agricultural Productivity in India remains low. Explain the reasons for this situation. (UPSC 2008/15 Marks)
5. Write note on Negative impacts of shifting cultivation. (UPSC 2005/2 Marks)
6. Write short notes on Jhum cultivation – process and consequences. (UPSC 2002/2 Marks)
7. Give an account of the tea plantations of Assam and West Bengal and state the economic significance of these plantations. (UPSC 2002/10 Marks)
8. What is dry farming? Discuss the relevance in augmenting the food supply in India. (UPSC 1999/15 Marks)
9. What is shifting cultivation? Describe its salient characteristics with reference to India? (UPSC 1996/15 Marks)
10. What is dryland agriculture? Discuss its importance to India? (UPSC 1994/15 Marks)

Student Notes:

11. Briefly explain the use of various chemical fertilizers in India agriculture. (UPSC 1992/15 Marks)
12. Mention the states where shifting cultivation is still practiced in India. (UPSC 1990/3 Marks)
13. What are the important wheat growing regions in India and why? Are we now growing enough wheat in India to meet our own demand for it? (UPSC 1985/20 Marks)
14. Government of India has given high priority to Oilseeds Development Programme. What strategy has been adopted to accelerate the efforts for increasing their production? Name important oilseeds cultivated in India with their distribution. (UPSC 1984/15 Marks)
15. Name the cotton growing areas of India. Describe the various factors which favour its cultivation in these areas. What part does cotton play in the present day economy of India? (UPCS 1983/15 Marks)
16. Discuss the geographical conditions favouring the cultivation of wheat or rice in India and describe the steps taken for improving its productivity. (UPCS 1982/30 Marks)
17. What is shifting cultivation? Where in India has this been resorted do? Consider its consequences and examine the steps taken by Government to prevent this practice. (UPCS 1981/20 Marks)
18. Which are the States in India that produce: (i) groundnut, (ii) tea, (iii) tobacco, and (iv) pepper? (UPCS 1980/20 Marks)
19. Can be agricultural development, we have achieved so far, be considered adequate? If so, why? If not, why not?

DISTRIBUTION OF KEY NATURAL RESOURCES ACROSS THE WORLD (INCLUDING SOUTH ASIA AND THE INDIAN SUB-CONTINENT

Contents

1. Introduction

Natural resources which satisfy the material and spiritual needs of humans are the free gifts of the nature. In other words, any material or energy derived from the nature that is used by humans called a **natural resource**. These resources include land, water, minerals, vegetation, wildlife etc. In fact every material has some utility for human beings but its utilisation is possible on the availability of appropriate technology.

Distribution of natural resource refers to the geographic occurrence or spatial arrangement of resources on earth. In other words, where resources are located. Any one place may be rich in the resources people desire and poor in others.

1.1. Uneven Distribution of Resources

Low latitudes (latitudes close to the equator) receive more of the sun's energy and much precipitation, while higher latitudes (latitudes closer to the poles) receive less of the sun's energy and too little precipitation. The temperate deciduous forest biome provides a more moderate climate, along with fertile soil, timber, and abundant wildlife. The plains offers flat landscapes and fertile soil for growing crops, while steep mountains and dry deserts are more challenging. Metallic minerals are most abundant in areas with strong tectonic activity, while fossil fuels are found in rocks formed by deposition (sedimentary rocks).

However, uneven distribution of natural resources have their own consequences on human settlement, economic activities, trade and even on conflict and war. Human settlement has been found near the natural resources in pre-historic time. Natural resources form the backbone of the economy of a nation. Without land, water, forest, mineral one cannot develop agriculture and industry. By utilising natural resources, humans created their own world of houses, buildings, means of transport and communication, industries etc.

2. Classification of Resources

Resources can be classified in several ways: one the bases of (i) renewability, (ii) origin and (iii) utility. The objective of classification would primarily decide how we put a resource under a particular category.

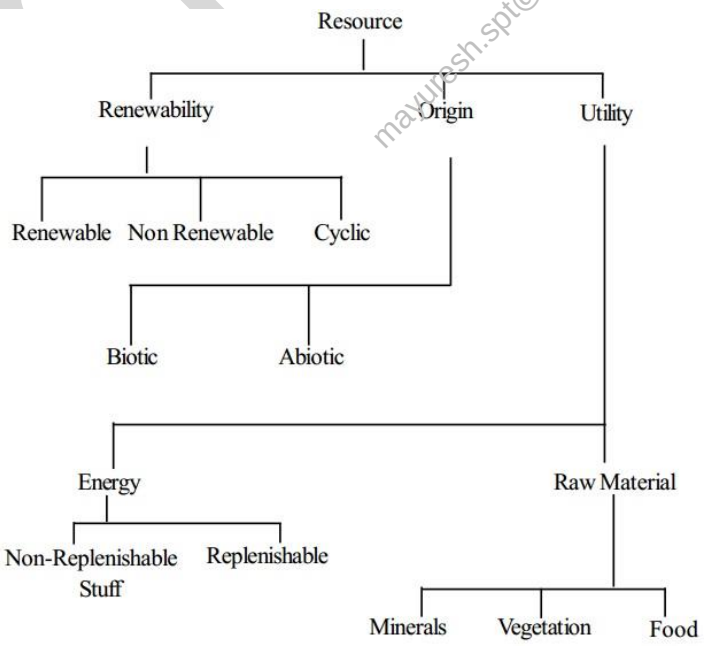


Figure 1: Classification of Resources

Student Notes:

3. Energy Resources

Energy is an essential input for economic development and improving the quality of life. It is required for generation of power, required by agriculture, industry, transport and other sectors of the economy. Energy may be classified into two categories, namely:

- **Conventional** – Coal, Petroleum, Natural gas and electricity
- **Non-conventional** – solar, wind, tidal, geothermal, and biogas energy

Other classification can be made between –

- **Non-renewable** resources – which when exhausted are exhausted forever such as coal etc.
- **Renewable** resources – which are inexhaustible such as wind energy, solar energy etc.

3.1. Coal

Coal is a one of the important minerals which is mainly used in the generation of thermal power and smelting of iron ore. It is the one of the most mined mineral from the earth. According to one estimate, proven coal reserves are 860, 938 million tonnes.

Of the three fossil fuels (Petroleum, natural gas and coal), coal has the most widely distributed reserves; coal is mined in over 100 countries, and on all continents except Antarctica. The largest proved reserves are found in the United States, Russia, China, Australia and India (figure 2). A proved recoverable reserve is the tonnage of coal that has been proved by drilling etc. and is economically and technically extractable. Coal is found majorly in forms of Lignite [1] and Anthracite. Distribution of coal across the world is shown in figure 3.

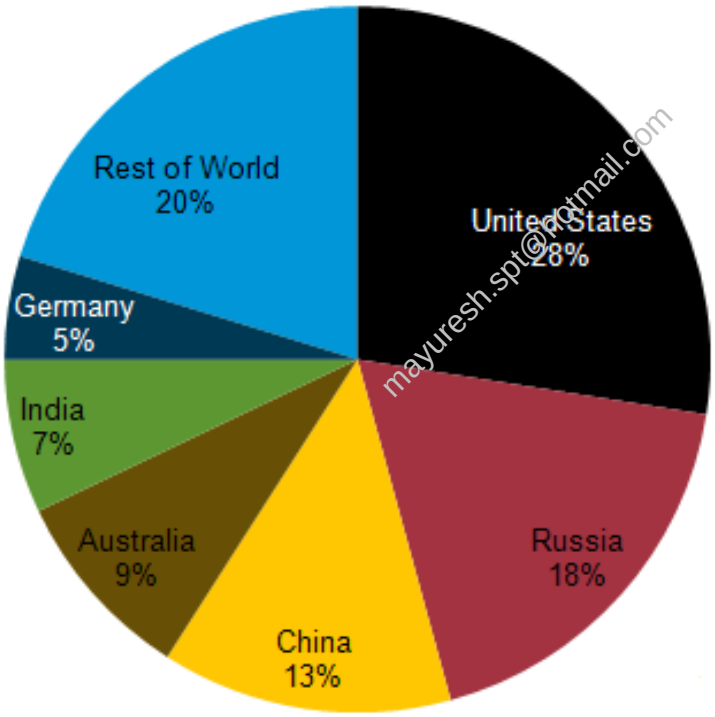
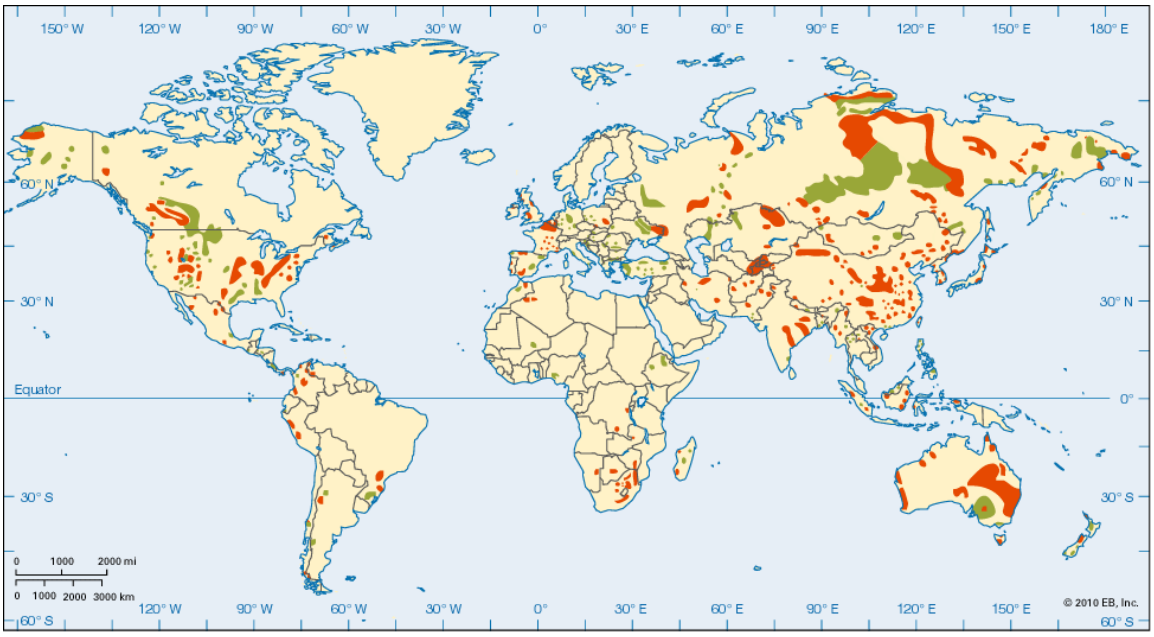


Figure 2: Global share of recoverable coal reserves

Student Notes:



Major Coal Deposits of the World

Anthracite and Bituminous Coal Lignite

Figure 3: coal deposits of the world

In terms of **production**, China is the top coal producer since 1983. In 2011 China produced 3,520 millions of tonnes (mt) of coal – 49.5% of 7,695 million tonnes world coal production. In 2011 other large producers were United States (993 mt), India (589 mt), European Union (576 mt) and Australia (416 mt). **Top coal exporting countries** are Australia with 27% and Indonesia with 26% of total world coal export in 2010. Japan is the largest **coal importer** with 17% of total world coal import seconded by China having share of 16% in 2010. Major coalfields of the world are listed in the table 1.

North America	• Pennsylvania anthracite field • Appalachian bituminous field • Eastern Illinois field – Illinois, Indiana and Kentucky • Western interior field – Iowa, Missouri, Oklahoma • Gulf province – Texas, Alabama and Arkansas • Rocky mountain province- Utah, Colorado, Wyoming, Montana, new Mexico • Canada – Prairies, British Columbia coalfields, Nova Scotia Coal fields
Europe	• Donetz coal basin (anthracite and high grade bituminous coal) • Moscow-Tula coalfields • Kuznetsk coal basin • Karaganda field • Silesia coal fields • Ruhr area of Germany • Other coal fields in Urals, Taimyr fields of the Arctic, deposits of the Caucasus mountains
Asia	• China – Shanxi, Fushun, Inner Mongolia, Kansu • Japan – Chikugo coalfield, Ishikari coalfield • India – Damodar valley, Raniganj, Bokaro, Jharia, Singareni. • Pakistan - Quetta, Kalabagh and Thar coalfields • Australia – Bowen Basin coalfield, Galilee Basin coalfield, South Maitland coalfield, Sydney Basin coalfield, and Latrobe valley coalfield

Africa	• Transvaal and Natal – Middleburg, Vereeniging and Witbank • Zimbabwe – Wankie • Zaire – Luena • Mozambique – Maniamba • Zambia – Nkandabwe and Mamba • Nigeria – Enugu
South America	• Brazil – Santa Catarine and Rio grande de sul • Chile – Concepcion • Columbia – Cauca valley coalfield • Mexico – Piedras Negras, Sabinas and Lampazos

Table 1 – Distribution of coal across continents

3.1.1. Coal in India

Coal is the most important and abundant fossil fuel in India. It accounts for 55% of the country's energy need. Hard coal deposit spread over 27 major coalfields, are mainly confined to eastern and south central parts of the country. A **cumulative total of 2,93,497 million tonnes** of geological resources of Coal upto depth of 1200 meters have so far been estimated in the country as on 1.4.2012.

The lignite reserves stand at a level of 41.96 billion tones as on 1.4.2012, of which 90% occur in the southern State of Tamil Nadu. Other states where lignite deposits have been located are Rajasthan, Gujarat, Kerala, Jammu & Kashmir, and union territory of Puducherry

The coal resources of India are available in **older Gondwana** (570 million years to 245 million years ago) formations of peninsular India and **younger tertiary** (60 to 15 million years ago) formations of north-eastern region. Formation-wise coal resources of India as on 1.4.2012 are given in table 2 below:

Formation	Proved (million tonnes)	Total (million tonnes)
Gondwana coals	117551.01	292004.51
Tertiary coals	593.81	1492.64
Total	118114.82	293497

Table 2: Estimations for different types of coal based on formation

The **Gondwana** coal belongs to the carboniferous period. It is found in the Damodar, Mahanadi, Godavari, and Narmada valleys. Raniganj, Jharia, Bokaro, Ramgarh, Giridih, Chandrapur, Karanpura, Tatapani, Talcher, Himgiri, Korba, Penchgati, Sarguja, Kamthi, Wardha valley, Singreni (A.P.) and Singrauli are some of the important coal mines of the Gondwana formations. **The Jharguda coal mine (Chhattisgarh) is the thickest coal seam** 132 meters of the Gondwana period, followed by the Kargali seam near Bokaro belong to the Gondwana period. The detail of state-wise geological resources of Gondwana coal is given below in table 3.

State	Proved (million tonnes)	Total (million tonnes)
Andhra Pradesh	9566.61	22154.86
Chhattisgarh	13987.85	50846.15
Jharkhand	40163.22	80356.2
Madhya Pradesh	9308.70	24376.26
Maharashtra	5667.48	10882.09
Odisha	25547.66	71447.41
Uttar Pradesh	884.04	1061.80
West Bengal	12425.44	30615.72
Total	117551.01	292004.51

Table 3: Gondwana coalfields

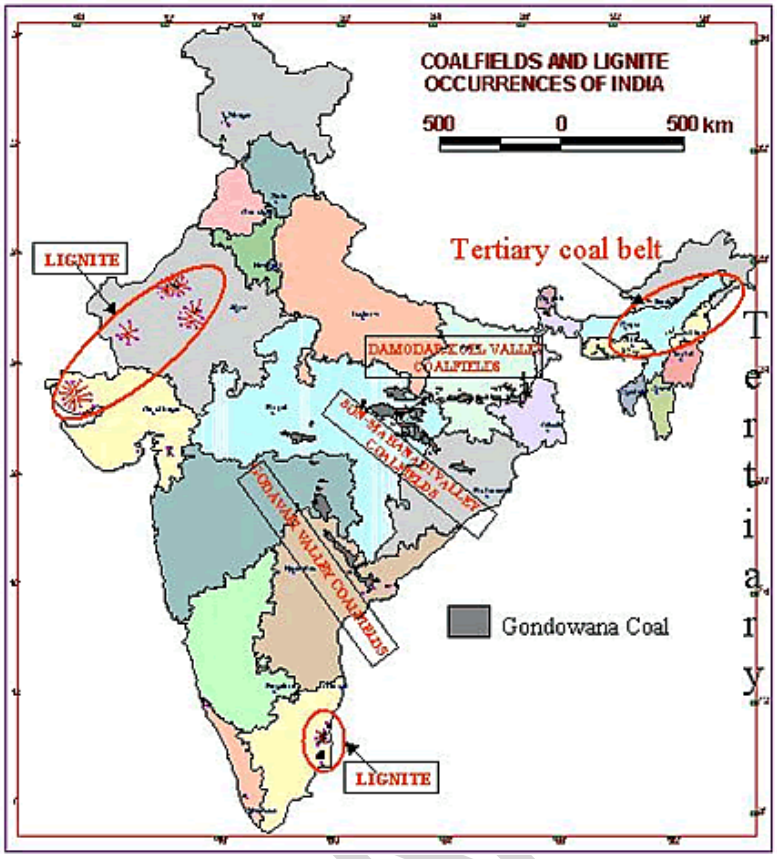


Figure 4: Major coalfields of India

Tertiary coal is found in the rocks of the Tertiary era. It is about 15 to 60 million years old. The Tertiary coal is also known as the 'brown coal'. The Tertiary coal contributes only about two per cent of the total coal production of the country. It is an inferior type of coal in which the carbon varies between 30 per cent in Gujarat and Rajasthan to 50 per cent in Assam. Lignite coal is found in Arunachal Pradesh and West Bengal (Darjeeling District). The **largest lignite deposits of the country are at Neyveli** in the state of Tamil Nadu. The detail of state-wise geological resources of tertiary coal is given below in table 4.

State	Proved (million tonnes)	Total (million tonnes)
Arunachal Pradesh	31.23	90.23
Assam	464.78	510.52
Meghalaya	89.04	576.48
Nagaland	8.76	315.41
Total	593.81	1492.64

Table 4: Tertiary coalfields

3.2. Petroleum

Petroleum is also called 'black gold' or 'liquid gold'. It is second to coal in terms of sources of energy. It is an essential source of energy for all internal combustion engines in automobiles, railways and aircraft. Crude petroleum occurs in sedimentary rocks of the tertiary period. It is formed when large quantities of dead organisms, usually zooplankton and algae, are buried underneath sedimentary rock and subjected to intense heat and pressure.

Petroleum (and natural gas) are born and accumulate in the sedimentary mantle of the Earth. Small amounts of these hydrocarbons are present throughout the mantle, but large

accumulations are encountered less frequently. About 600 sedimentary basins, characterized by oil and gas occurrence, are found on the Earth.

Unlike coal, Petroleum is not distributed evenly around the world. More than half of the world's proven oil reserves are located in the Middle East (figure 5). Following the Middle East are Canada and the United States, Latin America, Africa, and the region occupied by the former Soviet Union. Each of those regions contains less than 15 percent of the world's proven reserves [2].

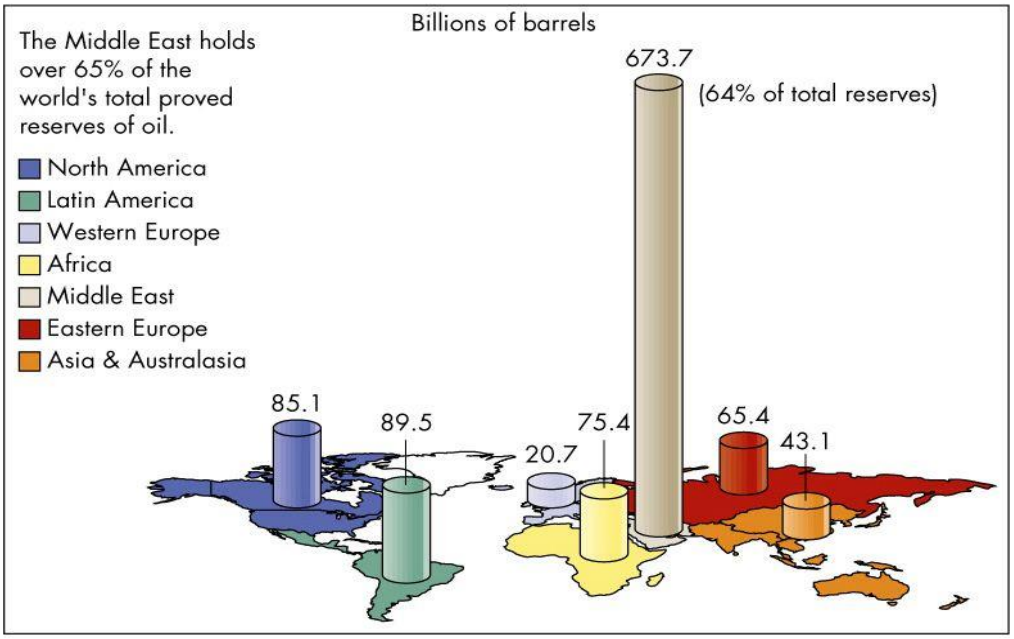


Figure 5: Worldwide Oil Distribution

Since exploration for oil began during the early 1860s, some 50,000 oil fields have been discovered. More than 90 percent of these fields are insignificant in their impact on world oil production. The two largest classes of fields are the **super-giants**, fields with 5 billion or more barrels of ultimately recoverable oil, and **world-class giants**, fields with 500 million to 5 billion barrels of ultimately recoverable oil. Fewer than 40 supergiant oil fields have been found worldwide. The Arabian-Iranian sedimentary basin in the Persian Gulf region contains two-thirds of these supergiant fields. The remaining super-giants are distributed as follows: two in the United States, two in Russia, two in Mexico, one in Libya, one in Algeria, one in Venezuela, and two in China.

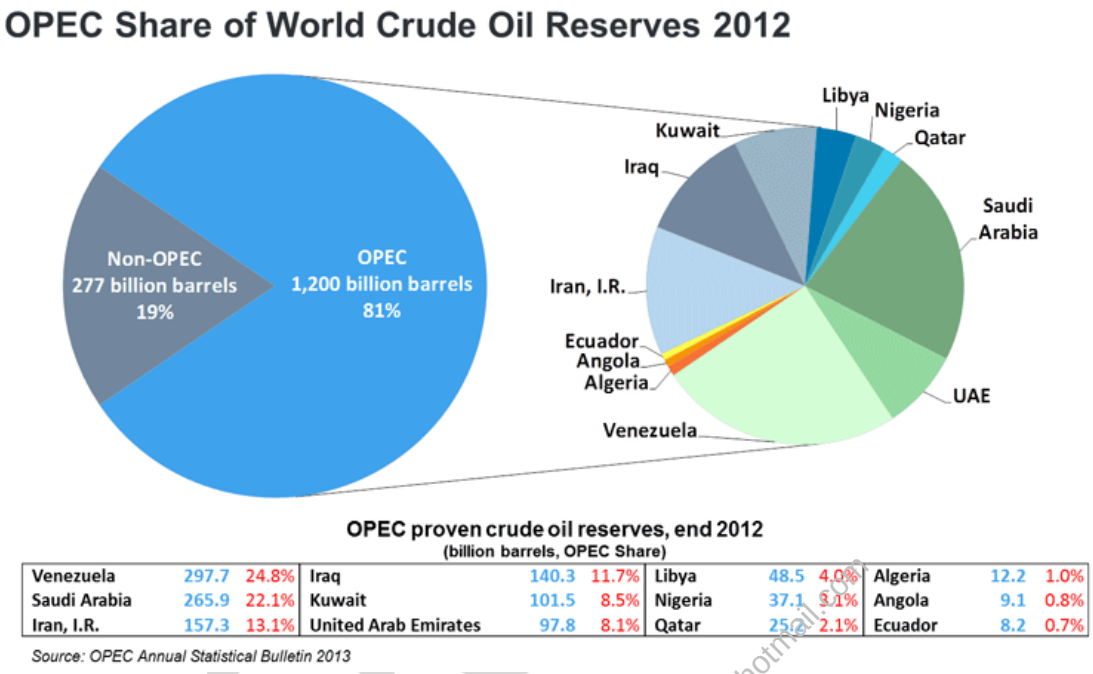
The nearly 280 world-class giant fields thus far discovered, plus the super-giants, account for about 80 percent of the world's known recoverable oil. There are, in addition, approximately 1,000 known **large oil fields** that initially contained between 50 million and 500 million barrels. These fields account for some 14 to 16 percent of the world's known oil. **Major oil fields** are listed below:

- Ghawar field – Saudi Arabia
- Burgan field – Kuwait
- Azeri-Chirag-Guneshli – Caspian Sea, Azerbaijan
- Ku-Maloob-Zaap – Mexico
- Zakum - UAE
- Ferdows field – Iran
- Sugar Loaf field – Brazil
- Bolivar Coastal field – Venezuela

World's five **largest offshore** oilfields:

- Safaniya oilfield – Persian Gulf, Saudi Arabia
- Upper Zakum oilfield – Persian Gulf, UAE
- Manifa oilfield – Persian Gulf, Saudi Arabia
- Kashgan oilfield – Caspian Sea, Kazakhstan
- Lula Oilfield - Brazil

According to current estimates, more than 81% of the world's proven oil reserves are located in OPEC Member Countries, with the bulk of OPEC oil reserves in the Middle East (figure 6). OPEC Member Countries have made significant additions to their oil reserves in recent years. As a result, OPEC's proven oil reserves currently stand at 1,200.83 billion barrels.



OPEC proven crude oil reserves, end 2012
(billion barrels, OPEC Share)

Venezuela	297.7	24.8%	Iraq	140.3	11.7%	Libya	48.5	4.0%	Algeria	12.2	1.0%
Saudi Arabia	265.9	22.1%	Kuwait	101.5	8.5%	Nigeria	37.1	3.1%	Angola	9.1	0.8%
Iran, I.R.	157.3	13.1%	United Arab Emirates	97.8	8.1%	Qatar	25.2	2.1%	Ecuador	8.2	0.7%

Source: OPEC Annual Statistical Bulletin 2013

Figure 6: Share of Organization of the Petroleum Exporting Countries (OPEC) in world crude oil reserves 2012

Classification of crude oil

Crude oil may be referred to as sweet if it contains relatively little sulfur (0.5%) or *sour* if it contains substantial amounts of sulfur. **Sweet crude** requires less energy to be extracted and once extracted, yields higher quality gasoline as well as larger quantities of it. Iraq is one of the leading producers of sweet crude. Major locations where sweet crude is found include the Appalachian Basin in Eastern North America, Western Texas, the Bakken Formation of North Dakota and Saskatchewan, the North Sea of Europe, North Africa, Australia, and the Far East including Indonesia.

Sour crude, on the other hand, has a high level of impurities in it, namely sulfur, which must first be removed before being processed into gas and other petroleum based products. Venezuela is a leading producer of sour crude oil. Sour crude is more common in the Gulf of Mexico, Mexico, South America, and Canada. Crude produced by OPEC Member Nations also tends to be relatively sour, with an average sulfur content of 1.77%.

According to IEA top 10 oil producer countries produced over 64 % of the world oil production in 2012. In 2012 total oil production was 4,142 Mt. The **top oil producers in 2012** were:

- Russia - 544 Mt (13 %)
- Saudi Arabia - 520 Mt (13 %)
- United States - 387 Mt (9 %)
- China - 206 Mt (5%)
- Iran - 186 Mt (4 %)
- Canada - 182 Mt (4 %)
- United Arab Emirates (UAE) - 163 Mt (4 %)
- Venezuela - 162 Mt (4 %)
- Kuwait - 152 Mt (4 %)
- Iraq - 148 Mt (4 %).

3.3. Natural Gas

Natural gas is a fossil fuel formed when layers of buried plants, gases, and animals are exposed to intense heat and pressure over thousands of years. The energy that the plants originally obtained from the sun is stored in the form of chemical bonds in natural gas. Natural gas, a nonrenewable energy resource, is found in deep underground rock formations or associated with other hydrocarbon reservoirs in coal beds and as methane clathrates. Petroleum is another resource and fossil fuel found in close proximity to, and with natural gas.

Like Petroleum, natural gas is not distributed evenly around the world. More than three-fourth of the world's proved natural gas reserves are located in top ten countries (figure 7). Following the Russia are Iran and Qatar, Turkmenistan, USA. Small gas fields are located in various parts of the world. [2]. Unconventional sources of natural gas are:

- Shale gas
- Coalbed methane (CBM)
- methane hydrates

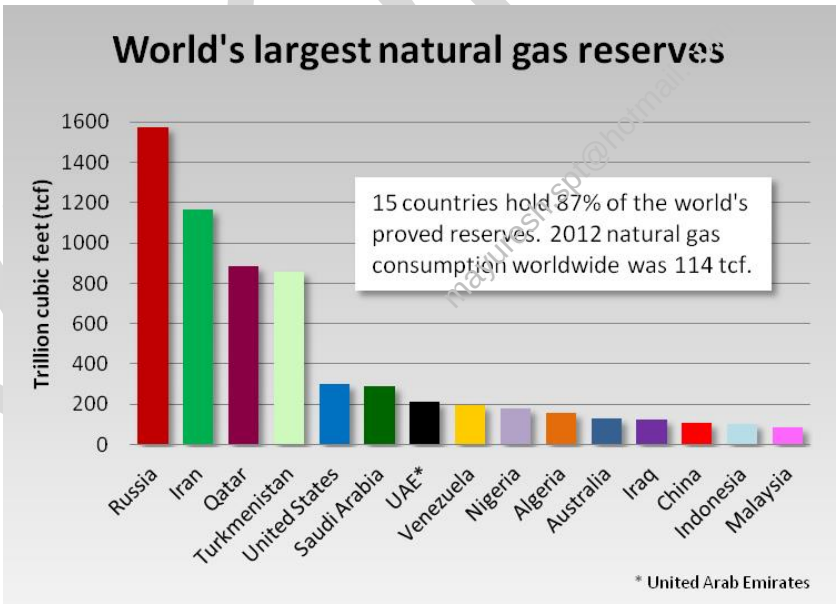


Figure 7: Countries with largest proved natural gas reserves

Some of the largest gas fields are listed below:

- South Pars/North Dome – Persian Gulf, Iran and Qatar
- Urengoy – Siberian Basin, Russia
- Yamburg – Arctic circle, Russia
- Hassi R'Mel – Algeria

- Shtokman – Barents Sea, Russia
- South Iolotan-Osman – Turkmenistan
- Zapolyarnoye – Russia
- Hugoton – USA
- Groningen – Netherlands
- Bovanenko – Russia

As measured by the International Energy Agency, the **top 10 natural gas producers in 2011** were (66.7% of total):

- Russia (20.0%)
- United States (19.2%)
- Canada (4.7%)
- Qatar (4.5%)
- Iran (4.4%)
- Norway (3.1%)
- China (3.0%)
- Saudi Arabia (2.7%)
- Indonesia (2.7%)
- Netherlands (2.4%)

3.3.1. Shalegas

Shale gas is a natural gas produced from shale, a type of sedimentary rock. Due to constant announcements of shale gas recoverable reserves, as well as drilling in Central Asia, South America and Africa, deepwater drilling, estimates are undergoing frequent updates, mostly increasing. Since 2000, some countries, notably the US and Canada, have seen large increases in proved gas reserves due to development of shale gas, but shale gas deposits in most countries are yet to be added to reserve calculations. Some analysts expect that shale gas will greatly expand worldwide energy supply. Figure 8 shows the major shale gas fields of the word. **China is estimated to have the world's largest** shale gas reserves followed by USA, Argentina, Mexico, South Africa, Australia, and Canada (table 5).

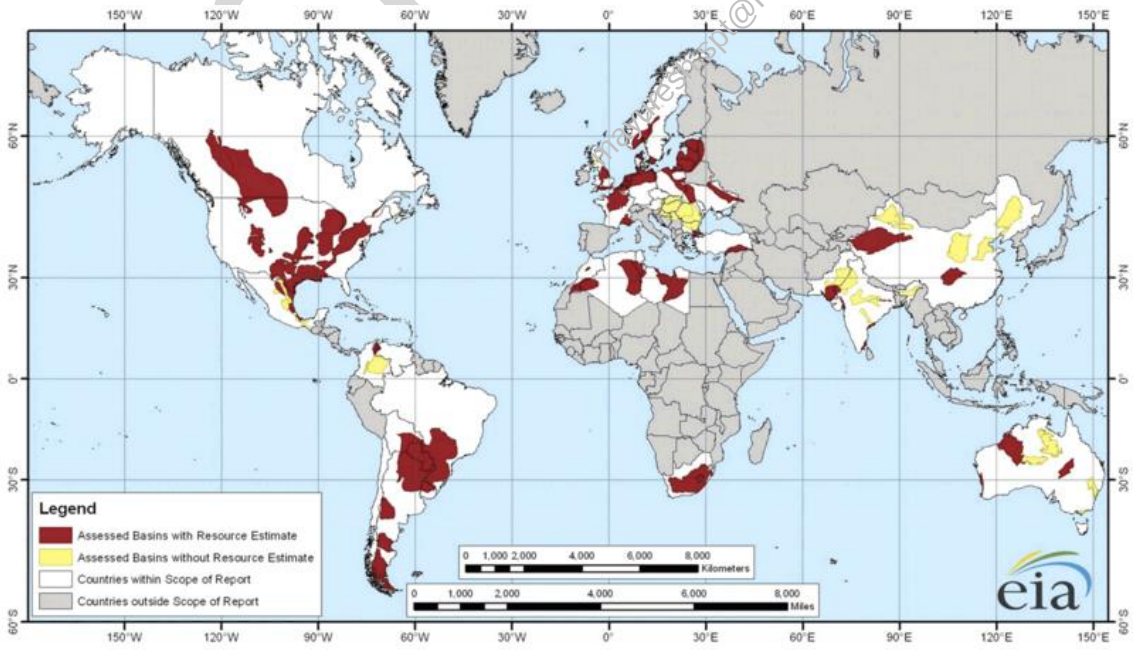


Figure 8: World Shale Gas

The United States and Canada are the major producers of commercially viable natural gas from shale formations in the world, even though about a dozen other countries have conducted exploratory test wells. China is the only nation outside of North America that has registered commercially viable production of shale gas, although the volumes contribute less than 1% of the total natural gas production in that country. In comparison, shale gas as a share of total natural gas production in 2012 was 39% in the United States and 15% in Canada.

Country	Estimated recoverable reserves (trillion cubic feet)	Proven gas reserves(trillion cubic feet)
China	1, 275	107
USA	862	272.5
Argentina	774	13.4
Mexico	681	12
South Africa	485	-
Australia	396	110
Canada	388	62
Libya	290	54.7
Algeria	231	159
Brazil	226	12.9

Table 5: List of top 10 countries by recoverable shale gas

3.3.2. Coalbed Methane (CBM)

CBM is generated by the conversion of plant material to coal through burial and heating. As "coalification" progresses, increasingly dense coal is formed. Coal serves as both the source rock and the reservoir rock. Coal is extremely porous but has low permeability (connected openings). Much of the methane generated by the coalification process escapes to the surface or migrates into adjacent reservoir or other rocks, but a significant volume remains trapped within the coal itself.

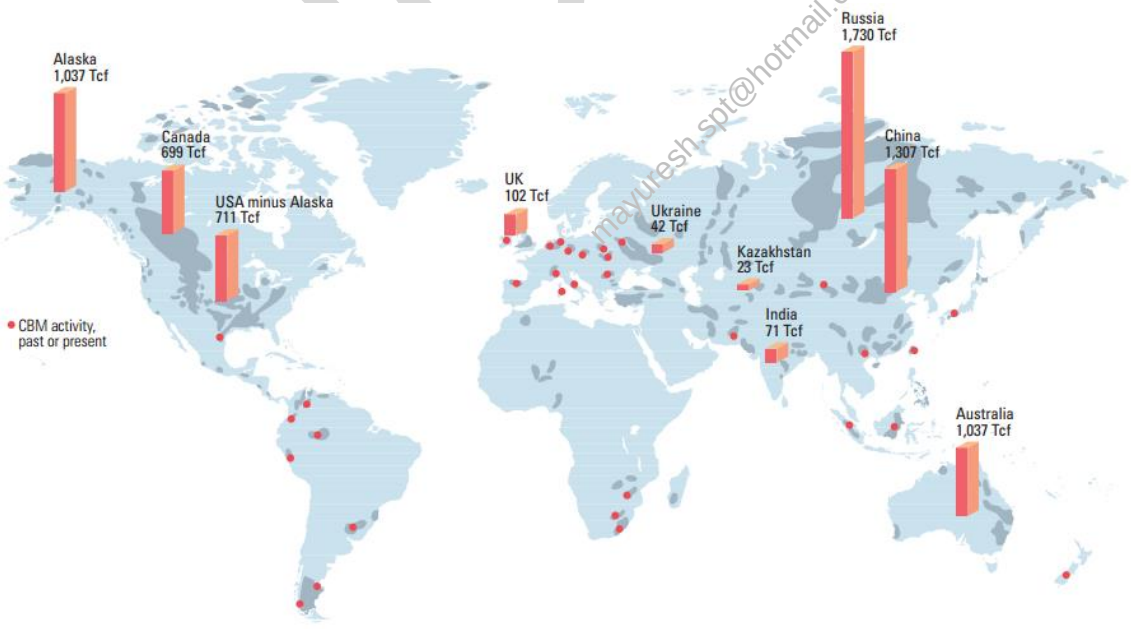


Figure 9: Major coalbed Methane reserves

CBM can be found almost anywhere there is coal. Figure 9 shows CBM resources by top countries. Deep coal seams beyond the reach of mining operations present opportunities for development of CBM. The largest proven recoverable coal reserves, according to the

latest published data, are in the USA (28.6%), followed by Russia (18.5%), China (13.5%), Australia (9.0%) and India (6.7%). Indonesia has highly prospective CBM potential, with an estimated 453 Tcf of in-place resources located mainly in Sumatra and Kalimantan provinces. Depending on the source, Russia's resource estimates range from 600 to 2,825 Tcf.

Global CBM production totals 5.8 Bcfd (billion cubif feet per day) from 15 basins in the USA, Canada, Australia, China, and India. The USA still dominates with nearly 5 Bcfd of production and about 20 Tcf produced to date, but production there is expected to fall going forward because of resource maturity and depletion. Australia may well displace the USA as the top-ranked producer, making a projected 6 Bcfd by 2020 once its LNG export plants are fully operational. CBM production in China (150 MMcfd) and India (10 MMcfd) is struggling due to more challenging geologic conditions and low well productivity.

3.4. India – Petroleum – Petroleum and Natural Gas

Oil exploration and production was systematically taken up after the Oil and Natural Gas Commission was set up in 1956. Till then, the **Digboi in Assam** was the only oil producing region but the scenario has changed after 1956. **Mumbai High** which lies 160 km off Mumbai was discovered in 1973 and production commenced in 1976. In recent years, new oil deposits have been found at the extreme western and eastern parts of the country.

State/region	Reserves in million metric tonnes
Gujarat	136.73
Assam (includes north eastern reserves)	178.07
Andhra Pradesh	7.42
Tamil Nadu	9.21
Western Offshore (includes Bombay High, Rajasthan)	396.41
Eastern Offshore	30.43
Total	758.27

Table 6: Reserves of Crude Oil in India (2013)

India has total reserves (proved & indicated) of 758 million metric tonnes of crude oil (table 6) and 1355 billion cubic meters of natural gas (table 7) as on 1.4.2013. Onshore and offshore crude oil constitutes 398 million metric tonnes and 360 million metric tonnes respectively. Geographical distribution of **crude oil** indicates that the maximum reserves are in the western offshore including Bombay High and Rajasthan (52%) followed by Assam (23%) whereas maximum reserves of **natural gas** are in the Eastern offshore including CBM in West Bengal (38%) followed by western offshore including Bombay High, Rajasthan, Madhya Pradesh and Jharkhand (36%). The increase in the estimated natural gas reserves is largely from CBM.

State/region	Reserves in billion cubic meters
Gujarat	77.53
Assam (includes north eastern reserves)	181.77
Andhra Pradesh	48.21
Tamil Nadu	45.83
Western Offshore (includes Bombay High, Rajasthan, Madhya Pradesh and Jharkhand)	488.20
Eastern Offshore (Includes CBM in West Bengal)	513.22
Total	1354.76

Table 7: Reserves of Natural Gas in India (2013)

The 15 basins out of a total 26 **sedimentary basins** (figure 10) in India have prognosticated hydrocarbon resources of about 206 Billion barrels of oil equivalent spread across **onland**, **offshore** and **deepwater** areas. Total area under these basins is 3 million sq. km. Over the last twelve years, there have been significant forward steps in exploring the hydrocarbon potential of the sedimentary basins of India. The unexplored area has come down to 15% which was 50% in 1995-96.

Figure 10: sedimentary Basin of India

Oil and natural gas have been found in exploratory wells in Krishna-Godavari and Kaveri basin on the east coast. Largest natural gas discovery has been made **in Krishna-Godavari deep waters**. Similarly, largest oil discovery after Bombay High has been made in the **Barmer oil fields** of Rajasthan. In **Assam**, Digboi, Naharkatiya and Moran are important oil producing areas. The **major oil fields** of **Gujarat** are Ankaleshwar, Kalol, Mehsana, Nawagam, Kosamba and Lunej. Exclusive reserves of natural gas are located along the eastern coast as well as Tripura, Rajasthan and off-shore wells in Gujarat and Maharashtra. Some of the major oil and gas discoveries in 21st century are shown in figure 11.

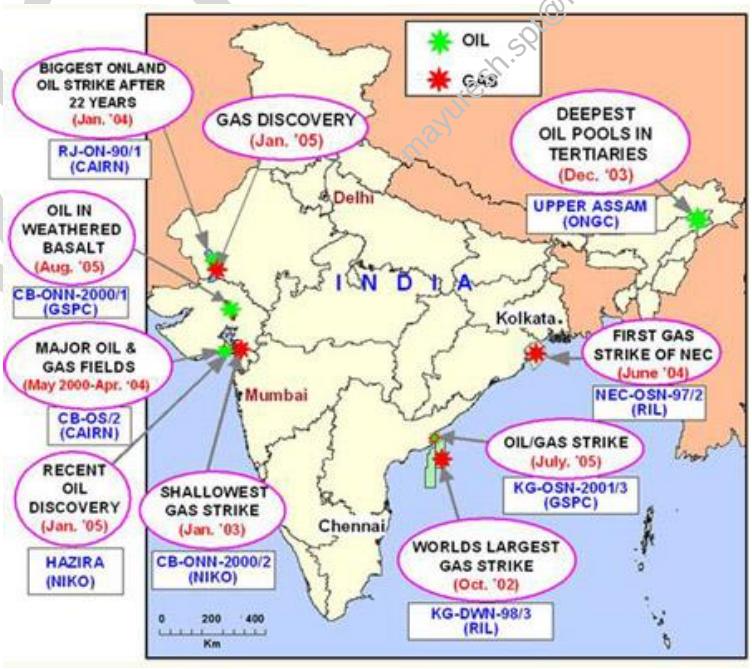


Figure 11: Major Oil and Gas discoveries after 2000

Coalbed Methane (CBM)

India has substantial coal reserves and most are suitable for **CBM** development. Deep coal deposits, not accessible by conventional mining operations, also offer CBM development opportunities. In 1997, India's government formulated a CBM policy and allotted a number of blocks for exploration. Commercial production of CBM began in 2007. The first CBM production started in 2007 from Raniganj in West Bengal. Government aims to offer up to 90% of total coal bearing area by the end of 2016-17 for exploration and production of CBM. The CBM reserves as per Directorate General of Hydrocarbons is tabulated here under:

State	Coalfields/block	Reserves in billion cubic metres
West Bengal	North Raniganj, Eastern Raniganj and Birbhum	109.87
Jharkhand	Jharia, East and West Bokaro, North Karanpura	174.93
Madhya Pradesh	Sohagpur, Satpura	114.11
Gujarat	Cambay Basin	311-549 (advance estimates)
Total		710 - 948

Table 8: CBM reserves of India

Shale gas

Shale gas has reduced America's dependence on oil imports, leading other countries to look for such reserves. India, too, has potential to reduce its dependence on imports by tapping the potential of shale gas. Six onshore basins — Cambay, Krishna-Godavari, Cauvery, Assam-Arakan, Ganga and Gondwana/Damodar—have been identified for shale exploration (figure 12). The Indian Government entered into a MoU with the United States Geological Survey (USGS) to conduct an assessment of the shale gas resources.

According to the US Energy Information Administration, India could be sitting on as much as 96 TCF of recoverable shale gas reserves, equivalent to about 26 years of its gas demand, compared with its 43.8 TCF of natural gas reserves at the end of 2012. Another estimate, by Schlumberger Company, has indicated a shale gas resource base of between 600 Tcf and 2,000 Tcf.

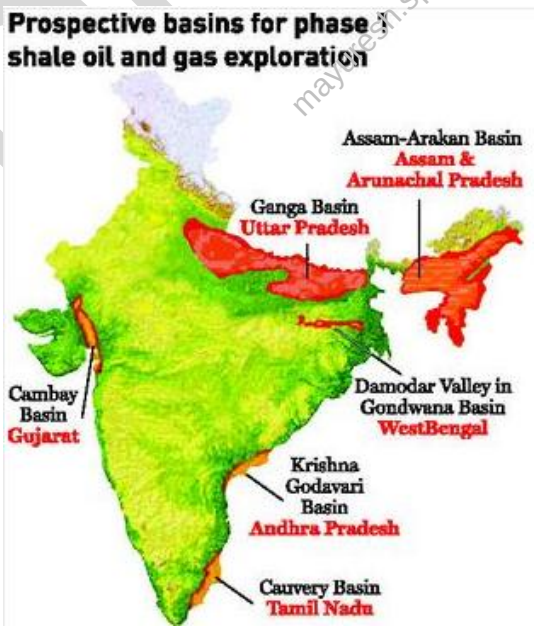


Figure 12: Shale oil and gas basins of India

Krishna Godavari basin, located in eastern India, is considered to hold the largest shale gas reserves in the country. The basin is estimated to have around 27 Tcf of technically recoverable gas. The **Cauvery** basin in Tamil Nadu state is estimated to have recoverable shale gas reserves of 7 Tcf. The **Cambay** basin in Gujarat is the largest basin in the country, spread across 51,800 sq km. As per the initial studies, around 20 Tcf of gas is estimated as technically recoverable reserves in the Cambay basin. ONGC had drilled the country's first shale gas well in Jambusar in the October in 2013 to exploit the natural gas trapped within the shale formations located in Cambay basin.

Methane Hydrate

Methane Hydrate is a cage-like lattice of ice inside of which are trapped molecules of methane, the chief constituent of natural gas. It is found in sea-bed that forms at low temperatures and high pressure. It is also found in onshore deposits in the permafrost of northern Canada and Russia. Heating the deposits or lowering the pressure will release gas from the solid. One litre of solid hydrate releases around 165 litres of gas.

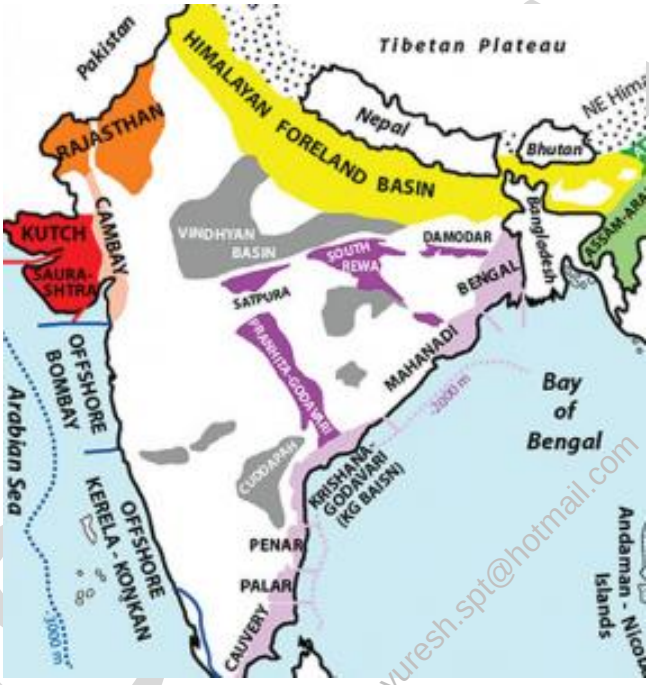


Figure 13: Potential Gas Hydrate reserves of India

India has some of the biggest methane hydrate reserves in the world. These are tentatively estimated at 1,890 trillion cubic metres. An Indo-US scientific joint venture in 2006 explored four areas: the Kerala-Konkan basin, the Krishna-Godavari basin, the Mahanadi basin and the seas off the Andaman Islands (figure 13). The deposits in the Krishna Godavari basin turned out to be among the richest and biggest in the world. The Andamans yielded the thickest-ever deposits 600 metres below the seabed in volcanic ash sediments.

3.5. Nuclear

Nuclear energy has emerged as a viable source in recent times. Important minerals used for the generation of nuclear energy are **uranium and thorium**. Uranium is a relatively common element in the crust of the Earth. It is a metal approximately as common as tin or zinc, and it is a constituent of most rocks and even of the sea. The table 14 gives some idea of our present knowledge of uranium resources. It can be seen that Australia has a substantial part (about 31 percent) of the world's uranium, Kazakhstan 12 percent, and Canada and Russia 9 percent each. Known uranium resources have increased almost threefold since 1975.

Recycled uranium and plutonium is another source for Uranium fuel, and currently saves 1500-2000 tU per year of primary supply, depending on whether just the plutonium or also the uranium is considered. In fact, plutonium is quickly recycled as MOX fuel, whereas the reprocessed uranium (RepU) is mostly stockpiled.

Re-enrichment of depleted uranium (DU, enrichment tails) is another secondary source. There is about 1.5 million tonnes of depleted uranium available, from both military and civil enrichment activity since the 1940s, most at tails assay of 0.25 - 0.35% U-235. Russian enrichment plants have treated 10-15,000 tonnes per year of DU producing a few thousand tonnes per year of natural uranium equivalent.

	tonnes U	percentage of world
Australia	1,661,000	31%
Kazakhstan	629,000	12%
Russia	487,200	9%
Canada	468,700	9%
Niger	421,000	8%
South Africa	279,100	5%
Brazil	276,700	5%
Namibia	261,000	5%
USA	207,400	4%
China	166,100	3%
Ukraine	119,600	2%
Uzbekistan	96,200	2%
Mongolia	55,700	1%
Jordan	33,800	1%
other	164,000	3%
World total	**5,327,200**	

Figure 14: Known Recoverable Resources of Uranium 2011

Global uranium mine production increased by over 25% between 2008 and 2010 because of significantly increased production in Kazakhstan, currently the world's leading producer. Global uranium production trend is shown in figure 15. Demand for uranium is expected to continue to rise for the foreseeable future. Although the Fukushima Daiichi nuclear accident has affected nuclear power projects and policies in some countries, nuclear power remains a key part of the global energy mix.

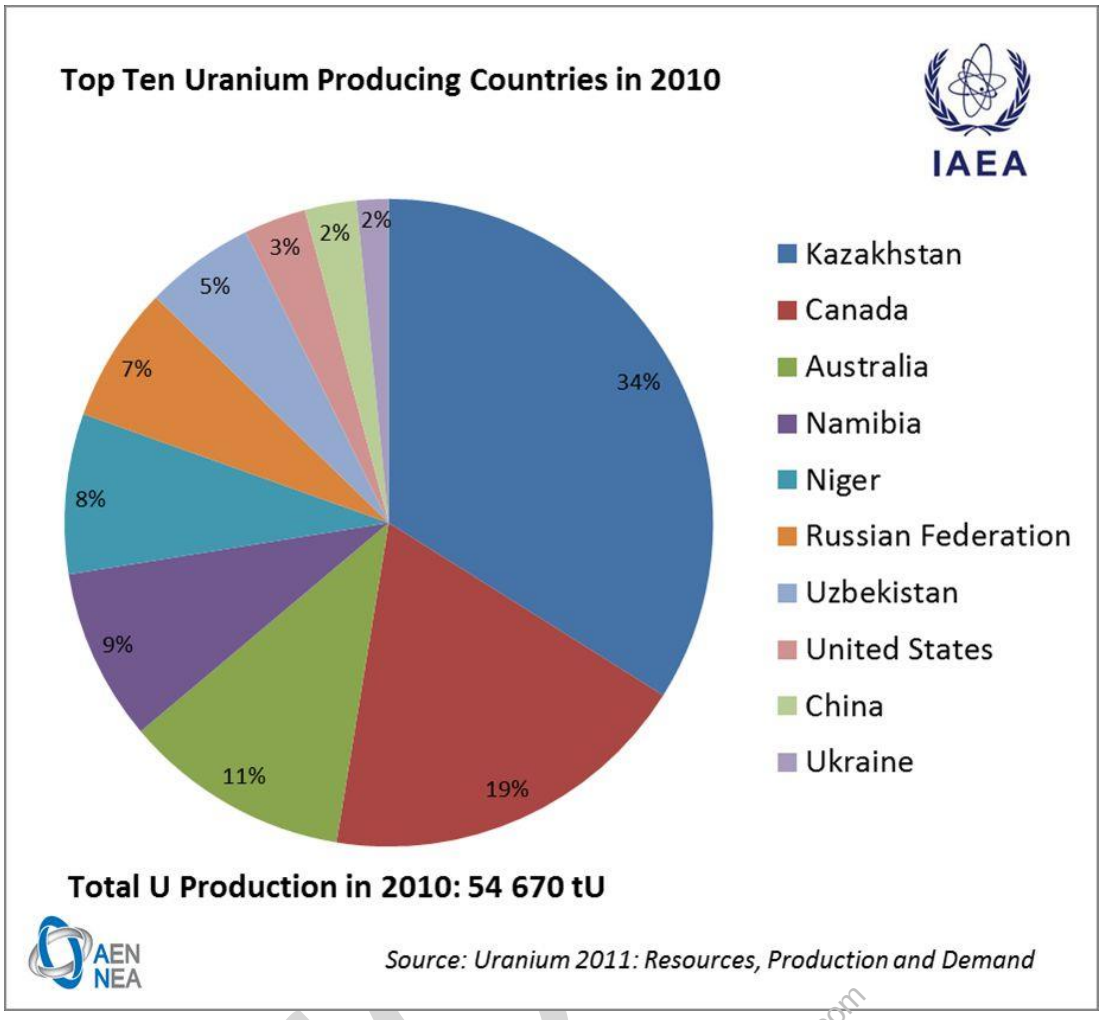


Figure 15: Top 10 Uranium producing countries (2010)

Current usage of Uranium is about 68,000 tU/yr. Thus, the world's present measured resources of uranium (5.3 Mt) in the cost category around present spot prices and used only in conventional reactors, are enough to last for about 80 years.

Thorium as a nuclear fuel

Today uranium is the only fuel supplied for nuclear reactors. However, thorium can also be utilised as a fuel for CANDU (CANada Deuterium Uranium) reactors or in reactors specially designed for this purpose. Neutron efficient reactors, such as CANDU, are capable of operating on a thorium fuel cycle, once they are started using a fissile material such as U-235 or Pu-239. Then the thorium (Th-232) atom captures a neutron in the reactor to become fissile uranium (U-233), which continues the reaction.

Thorium is about 3.5 times more common than uranium in the Earth's crust. Present knowledge of the distribution of thorium resources is poor because of the relatively low-key exploration efforts arising out of insignificant demand. World distribution of Thorium reserves is shown in figure 16. India and Australia are believed to possess about 300,000 tonnes each; i.e. each country possessing 25% of the world's thorium reserves.

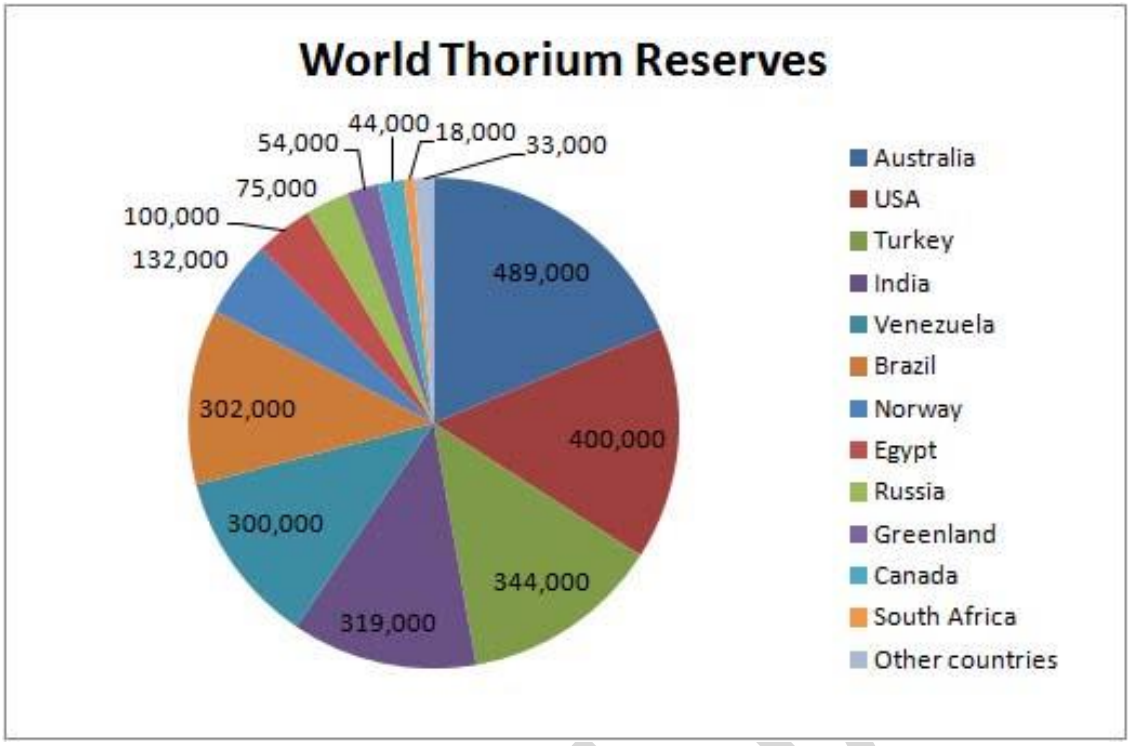


Figure 16: World Thorium reserves (in tonnes) (2005)

3.5.1. India

India has relatively modest reserves of uranium. India's uranium resources are modest, with 102,600 tonnes U (tU) as reasonably assured resources (RAR) and 37,200 tonnes as inferred resources in situ at January 2011. However, **department of atomic energy claims to have reserves of 1, 86, 653 tU in 2013.** Andhra Pradesh followed by Jharkhand and Meghalaya in that order is top state with largest uranium reserves.

With rise in number of reactors, India expects to import an increasing proportion of its uranium fuel needs. In 2013, India imported about 40% of her uranium requirements from France, Russia and Kazakhstan. India's Uranium mines are shown in figure 17. Ministry of Environment and Forest rejected the proposal of uranium mining in Mehgalaya keeping in view of the sentiments of the local people and a number of representations received from local civil society group. Following are the uranium mines in Jharkhand's Singhbhum zone:

- Jaduguda Mine
- Bhatin Mine
- Turamdih Mine
- Bagjata Mine
- Narwapahar Mine
- Banduhurang Mine
- Jaduguda Mill
- Turamdih Mill
- Mohuldih Mine

Major areas which are currently under survey and exploration to augment uranium reserves in India include:

- Tummalapalle-Rachakuntapalle, Kadappa district, Andhra Pradesh
- Koppunuru and adjoining areas, Guntur district, Andhra Pradesh

- Rohil and adjoining areas, Sikar district, Rajasthan
- Wahkut and Umthongkut areas of West Khasi Hills district, Meghalaya
- Gogi, Yadgir district, Karnataka
- Singridungri-Banadungri, East Singhbhum district, Jharkhand and
- Bangurdih, Seraikela-Kharsawan district, Jharkhand.

Figure 17: Uranium occurrence and production centres in India

Indian interest in thorium is motivated by their substantial reserves. Department of Atomic Energy has established the presence of 10.70 million tonnes of Monazite ore, found in beach and river sand in the country, which contains 9,63,000 tonnes of Thorium Oxide (ThO2) in 2009. India Monazite contains about 9-10% of ThO2 and about 8,46,477 tonnes of thorium Metal can be obtained from 9,63,000 tonnes. In 2013, total Monazite reserves are estimated to be 11.93 million tonnes. Following is the state wise distribution:

State	Monazite (million tonne)
Odisha	2.41
Andhra Pradesh	3.72
Tamil Nadu	2.46
Kerala	1.90
West Bengal	1.22
Jharkhand	0.22
Total	11.93

Thorium is mainly obtained from monazite and ilmenite in the beach sands along the coast of Kerala and Tamil Nadu (figure 18). World's richest monazite deposits occur in Palakkad and Kollam districts of Kerala, near Vishakhapatnam in Andhra Pradesh and Mahanadi river delta in Odisha.

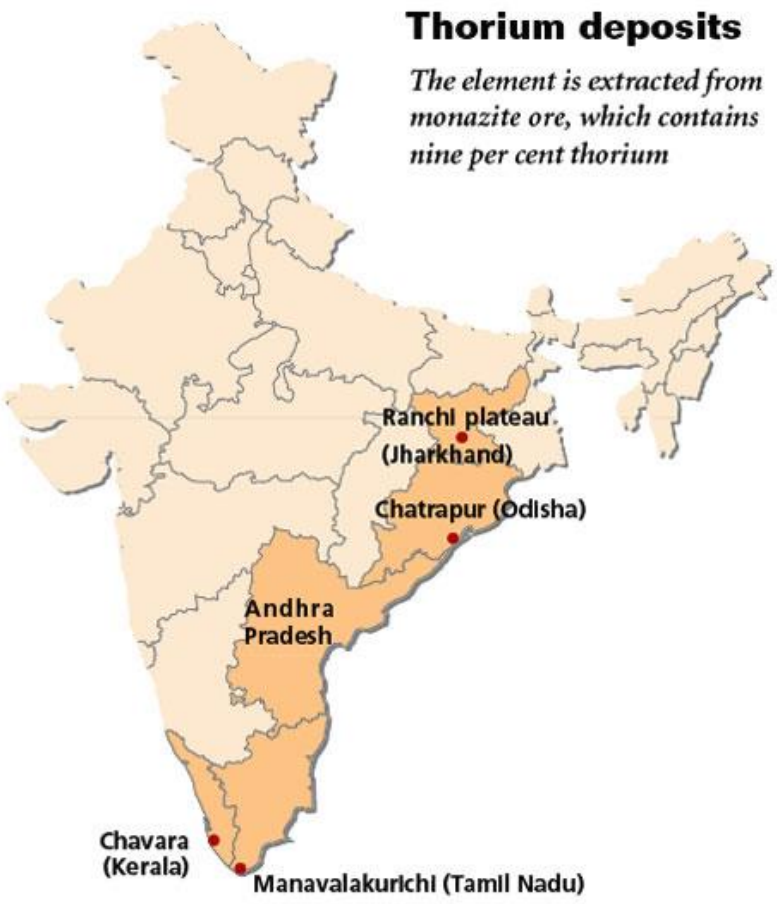


Figure 18: Thorium deposits, India

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[1] Types of coal

- **Lignite -** often referred to as **brown coal,** is a soft brown combustible sedimentary rock that is formed from naturally compressed peat. It is considered the lowest rank of coal due to its relatively low heat content. It has a carbon content of around 25-35%, a high inherent moisture content sometimes as high as 66%, and an ash content ranging from 6% to 19%. It is mined in Bulgaria, Kosovo, Greece, Germany, Poland, Serbia, Russia, Turkey, the United States, Canada, India, Australia and many other parts of Europe and it is used almost exclusively as a fuel for steam-electric power generation.
- **Bituminous coal** or **black coal** is a relatively soft coal containing a tarlike substance called bitumen. It is of higher quality than lignite coal but of poorer quality than anthracite. The carbon content of bituminous coal is around 60-80%; the rest is composed of water, air, hydrogen, and sulphur.
- **Anthracite** is a hard, compact variety of mineral coal that has a high luster. It has the highest carbon content, the fewest impurities, and the highest calorific content of all types of coal. The carbon content is between 92.1% and 98%. It is used mainly in power generation, in the metallurgy sector. Anthracite accounts for about 1% of global coal reserves,[4] and is mined in only a few countries around the world. China accounts for the majority of global production; other producers are Russia, Ukraine, North Korea, Vietnam, the UK, Australia and the US.

[2] Reserves are identified quantities of "in-place" minerals that are considered recoverable under current economic and technological conditions.

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Student Notes:

MINERAL RESOURCES & MANUFACTURING INDUSTRIES

Contents

Student Notes:

1. Mineral and Energy Resources

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. It has been estimated that nearly 100 minerals are known to be produced and worked in India. The country has fairly abundant reserves of coal, iron and mica, adequate supplies of manganese ore, titanium and aluminium, raw materials for refractory and limestone; but there is deficiency in ores of copper, lead and zinc. There are workable deposits of tin and nickel. India earns a lot of foreign exchange via export of a large variety of minerals such as iron ore, titanium, manganese, granite etc. while at the same time India has to depend upon imports to meet her requirements of some other mineral sources such as copper, silver, nickel, cobalt, zinc, lead, tin, mercury etc. The mineral resources in India are present in the peninsular part of the country. The vast alluvial plain tract of north India is devoid of minerals of economic use. The mineral resources provide the country with the necessary base for industrial development.

1.1. Types of Mineral Resources

On the basis of chemical and physical properties, minerals may be grouped under two main categories of metallic and non-metallic minerals.

Metallic minerals are the sources of metals. Metallic minerals can be further divided into two class- *ferrous minerals* (which have iron content) like iron, nickel, cobalt, tungsten, manganese etc. and *non-ferrous minerals* (which don't have iron content) like copper, bauxite, silver, gold etc.

Non-metallic minerals can be divided into **fuel minerals** (which are organic in origin) like coal, petroleum etc. and **other non-metallic minerals** like limestone, graphite etc. Minerals have certain characteristics. These are unevenly distributed over space. There is inverse relationship in quality and quantity of minerals i.e. good quality minerals are less in quantity as compared to low quality minerals. All minerals are exhaustible over time and it takes long to develop geologically and they cannot be replenished immediately at the time of need.

1.2. Distribution of Minerals in India

Most of the metallic minerals in India occur in the peninsular plateau region in the old crystalline rocks. Minerals are generally concentrated in three major belts in India. There are some sporadic occurrences here and there in isolated pockets. These belts are:

1.2.1. The North-Eastern Plateau Region

This belt covers Chota Nagpur (Jharkhand), Odisha Plateau, West Bengal and parts of Chhattisgarh. It is the richest mineral belt in India. It has variety of minerals viz. iron ore, coal, manganese, bauxite, mica. The Chota Nagpur plateau is also known as mineral heart land of India.

1.2.2. The Central Belt

This belt encompassing parts of Chhattisgarh, Madhya Pradesh, Andhra Pradesh and Maharashtra is the second largest mineral belt in the country. Large deposits of manganese, bauxite, limestone, marble, coal, mica, iron ore are available here.

1.2.3. The South-Western Plateau Region

This belt extends over Karnataka, Goa and contiguous Tamil Nadu uplands and Kerala. This belt is rich in ferrous metals and bauxite. It also contains high grade iron ore, manganese and limestone. This belt packs in coal deposits except Neyveli lignite. It does not have mica and copper deposits.

1.2.4. The North-Western Region

This belt extends along Aravali in Rajasthan and part of Gujarat and minerals are associated with Dharwar system of rocks. This belt has developed recently and is gradually becoming a productive region holding great promise for mining of the nonferrous metals. Copper, zinc has been major minerals. Rajasthan is rich in building stones i.e. sandstone, granite, marble. Gypsum and Fuller's earth deposits are also extensive. Dolomite and limestone provide raw materials for cement industry.

1.3. Ferrous Minerals

Ferrous minerals form an important part of mining activity in India and provide base to metallurgical industries in India. Our country is well-placed in respect of ferrous minerals both in reserves and production.

1.3.1 Iron Ore

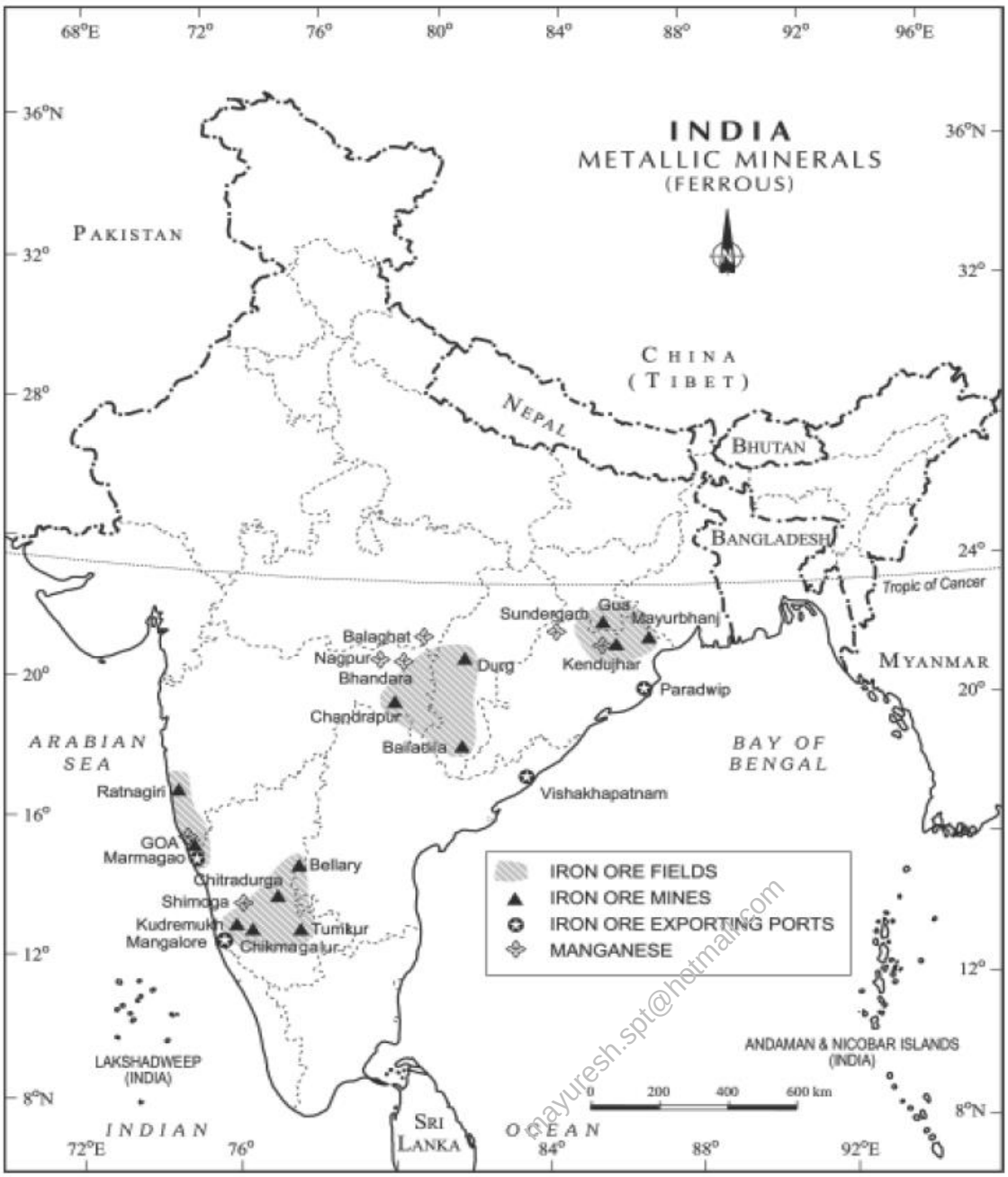
Iron is a metal of universal use. India has the largest reserve of iron ore in Asia. It is used for manufacturing articles from safety pins to ships. It is a durable and cheap metal which can be moulded in different forms and can be mixed with other metals to form alloys. Iron is not found in pure form. It is often mixed with lime, magnesium, phosphorous, silicon, etc. In India, we get four main types of iron ore, which are as under:

Haematite: It is also known as *red-ochre*, as it is reddish in colour. The iron contents in this type ranges from about 60 to 70 per cent. Most of the iron ore reserves in India belong to this type.

Magnetite: It is the best quality of iron ore and contains more than 70 per cent of the iron contents. The colour of the ore is dark brown to blackish and is known as *black ore.* It has magnetic properties.

Limonite: It is yellow or light brown in colour and the iron contents ranges from about 40 to 60 per cent. It is called hydrated iron oxide, when the iron ore in mixed with oxygen and water. Its mining is easier and cheaper.

Siderite: It is an inferior variety of iron ore and has many impurities. The iron contents ranges from about 20 to 40 per cent. It is also called *iron carbonate*.



About 95 per cent of total reserves of iron ore are located in the States of Odisha, Jharkhand, Chhattisgarh, Karnataka, Goa, Andhra Pradesh and Tamil Nadu. In ***Odisha***, iron ore occurs in a series of hill ranges in Sundergarh, Mayurbhanj and Jhar. The important mines are Gurumahisani, Sulaipet, Badampahar (Mayurbhaj), Kiruburu (Kendujhar) and Bonai (Sundergarh). In ***Jharkhand*** has some of the oldest iron ore mines and most of the iron and steel plants are located around them. Important mines such as Noamundi and Gua are located in Poorbi and Pashchimi Singhbhum districts. Dalli, and Rajhara in Durg are other important mines of iron ore. In ***Karnataka***, iron ore deposits occur in Sandur-Hospet area of Bellary district, Baba Budan hills and Kudremukh in Chikmagalur district and parts of Shimoga, Chitradurg and Tumkur districts. The districts of Chandrapur, Bhandara and Ratnagiri in ***Maharashtra***, Karimnagar, Warangal, Kurnool, Cuddapah and Anantapur districts of ***Andhra Pradesh***, Salem and Nilgiris districts of ***Tamil Nadu*** are other iron mining regions. ***Goa*** has also emerged as an important producer of iron ore.

India is the fifth largest exporter of iron in the world. Increasing demand of iron ore in domestic market has adversely affected the export performance of the sector. About half of the total production of iron ore is exported to Japan, South Korea, East European Countries and the Gulf region. Some iron ore is also exported to USA and China. The main ports handling the export are Marmagao, Vishakhapatnam, Paradip, Mangalore, Haldia and Chennai. Japan is the most important buyer of Indian iron ore.

1.3.2. Manganese

Manganese is a black hard iron like metal and is an important raw material for smelting of iron ore and also used for manufacturing ferrous alloys. It is also used for the manufacture of bleaching powder, insecticides, paints, glazed pottery, matches, batteries and china-clay. India

Student Notes:

has second largest ore reserves in the world after Zimbabwe. Manganese deposits are found in almost all geological formations; however, it is mainly associated with ***Dharwar system***. ***Odisha*** is the leading producer of Manganese. Major mines in Odisha are located in the central part of the iron ore belt of India, particularly in Bonai, Kendujhar, Sundergarh, Gangpur, Koraput, Kalahandi and Bolangir. ***Karnataka*** is another major producer and here the mines are located in Dharwar, Bellary, Belgaum, North Canara, Chikmagalur, Shimoga, Chitradurg and Tumkur. Maharashtra, Madhya Pradesh, Andhra Pradesh, Goa and Jharkhand are minor producers of manganese. India is the world's fifth largest producer of manganese ore as over four-fifth of the total produce of manganese is consumed within the country. Japan is the largest buyer of Indian manganese accounting for about two-third of the total export.

1.4. Non-Ferrous Minerals

India has limited reserves of non-ferrous minerals except bauxite. Copper, bauxite, gold, silver, tungsten, nickel, cobalt are major non-ferrous minerals.

1.4.1. Copper

Copper has been used for making utensils and coins since long. Also, Copper is an indispensable metal in the electrical industry for making wires, electric motors, transformers and generators. It is alloyable, malleable and ductile. It is a good conductor of electricity and it is used in making electrical wires, equipments and utensils. India has limited reserves of copper. The Copper deposits mainly occur in Singhbhum district in ***Jharkhand***, Balaghat district in ***Madhya Pradesh*** and Jhunjhunu and Alwar districts in ***Rajasthan***. Minor producers of Copper are Agnigundala in Guntur District (Andhra Pradesh), Chitradurg and Hasan districts (Karnataka) and South Arcot district (Tamil Nadu). Mining of copper is a costly and tedious affair as copper ores contain small percentage of metal. The production of copper ore in the country always fall short of our requirements and India has to import copper from other countries, mainly USA, Canada, Zimbabwe, Mexico.

1.4.2. Bauxite

Bauxite is an important ore and is used in making aluminium. Due to its lightness, strength, malleability, ductility, heat and electrical conductivity and resistance to atmospheric corrosion, aluminium has become one of the most useful metals in the present age. It is not specifically a mineral but a rock consisting mainly of hydrated aluminium oxides. Bauxite is found mainly in tertiary deposits and is associated with Laterite rocks occurring extensively either on the plateau or hill ranges of peninsular India and also in the coastal tracts of the country. India is self-sufficient in bauxite reserves. Kalahandi and Sambalpur in ***Odisha*** are the leading producers in the country. Jharkhand, Gujarat, Chhattisgarh, Madhya Pradesh and Maharashtra are other major producers. Bhavanagar, Jamnagar in Gujarat have the major deposits. Chhattisgarh has bauxite deposits in Amarkantak plateau while Katni-Jabalpur area and Balaghat in M.P. have important deposits of bauxite.

1.4.3. Lead

Lead is a widely used material mainly due to its malleability, softness, heaviness and bad conductivity of heat. Important use of lead is as a constituent in alloys such as type metal, bronze and anti-friction metal. It doesn't occur free in nature and occurs as a cubic sulphide known as *Galena*. Lead ores occur in India in the Himalayas, Tamil Nadu, Rajasthan, Andhra Pradesh and Jharkhand. ***Rajasthan*** is the leading producer of lead. Udaipur (Zawar, Rikhabdeo), Dungarpur (Ghughra and Mando) and Alwar are the main producing districts. About 75% of Indian requirements are met by imports mainly from Australia, Canada and Myanmar.

1.4.4. Zinc

Zinc is a mixed ore containing lead and zinc and is mainly used for alloying and manufacturing galvanized sheets. It is also used for dry batteries, white pigments, electrodes, textiles etc. Known reserves of zinc in India are very limited. More than 99% of zinc in India is produced in Zawar area in Udaipur district of ***Rajasthan***. Most of the industrial needs are met via imports from Zaire, Canada, Australia and Russia.

1.4.5. Gold

Gold is a valuable material which occurs in auriferous lodes and in sands of several rivers. It is known for making ornaments and usage as international currency. India's contribution to global

gold production is very small. There are three main gold fields in India namely, Kolar Gold Field, Hutti Gold field in Raichur district of ***Karnataka*** and Ramgiri Gold field in Anantpur district of ***Andhra Pradesh***. Kolar is the largest mine and one of the deepest mines in the world. *Alluvial gold* is obtained from the sands of the Subarnarekha River in Jharkhand. Such deposits are called placer deposits and the process of recovering gold from these sources is called *panning*.

1.4.6. Silver

Silver is a precious metal valued next only to gold in making ornaments due to its softness and attractive white colour. It is also used in manufacture of chemicals, electroplating, photography, for colouring glasses etc. The chief ore minerals of silver are agentine, stephanite, pyrargyrite and proustite. India has limited resources of silver ore and majority of production comes from Zawar mines in Udaipur district of ***Rajasthan***.

1.5. Non- Metallic Minerals

Among the non-metallic minerals produced in India, mica is the important one. The other minerals extracted for local consumption are limestone, dolomite and phosphate. They are used in a large variety of industries; the major industries being cement, fertilizers, electrical, etc.

1.5.1. Mica

Mica is mainly used in the electrical and electronic industries as it can be split into very thin sheets which are tough and flexible. It has also been used in India since ancient times as a medicinal item in Ayurveda and is known as ***Abhrak***. Three major types of mica found in India are- Muscovite, Phlogopite and Biotite. Rajasthan have the largest deposits of mica. Mica in India is produced in Hazaribagh plateau of ***Jharkhand***, Nellore district of ***Andhra Pradesh***, Bhilwara and Udaipur in ***Rajasthan*** followed by Tamil Nadu, Karnataka, West Bengal and Madhya Pradesh. India has near monopoly in the production of mica, producing about 60% of the world's total production.

1.5.2. Limestone

Limestone is associated with rocks either composed of calcium carbonate or a mixture of calcium carbonate and magnesium carbonate. It is used for large variety of purposes like cement industry, iron and steel industry, chemical industry etc. Of the total consumption,. 75 per cent is used in cement industry, 16 per cent in iron and steel industry, 4 per cent in chemical industry and the rest in paper, sugar, fertilizers, Ferro-manganese, glass and rubber industries. Limestone is produced in the states of Madhya Pradesh, Rajasthan, Andhra Pradesh, Gujarat, Chhattisgarh and Tamil Nadu. ***Madhya Pradesh*** is the largest producer of limestone in India where large deposits occur in the districts of Jabalpur, Satna, Betul, Rewa.

1.5.3. Dolomite

Limestone with more than 10% of magnesium is called dolomite, when percentage rises to about 45%, it is called true dolomite. Dolomite is chiefly used in metallurgical activities; as refractories; as blast furnace flux; as a source of magnesium salts and in fertilizer and salt industry. Odisha, Chhattisgarh, Andhra Pradesh, Jharkhand, Rajasthan and Karnataka are the major producers of Dolomite in India. Orissa is the largest producer of dolomite in the country with major deposits in Sundargarh, Sambhalpur and Koraput districts.

1.6. Atomic Minerals

Uranium and *thorium* are the main atomic minerals; Beryllium, Lithium and Zirconium are the other minerals. Uranium deposits occur in Singhbhum and Hazaribagh districts of ***Jharkhand***, Gaya district of ***Bihar***, and in the sedimentary rocks in Saharanpur district of Uttar Pradesh. But

the largest source of uranium comprise the monazite sands, both beach and alluvial. The largest concentration of monazite sand is on the Kerala coast. Some uranium is found in the copper mines of Udaipur in Rajasthan. India produces about 2% of world's uranium reserves. Thorium is also derived from monazite which contains 10% thorium. Other mineral carrying thorium is thorianite. Kerala, Bihar, Jharkhand, Tamil Nadu and Rajasthan are the main producers.

2. Energy Resources

Depending upon its source and utilization, energy can be divided into two major classifications viz. (i) Traditional or non-commercial, and (ii) Commercial Energy. Examples of non-commercial energy resources are firewood, charcoal, cow dung and agricultural wastes. The commercial sources of energy comprise coal, oil, natural gas, hydro-electricity, natural gas, nuclear power as well as wind and solar power.

Another important classification based on the nature of energy is conventional energy source

and non-conventional energy source. Coal, Petroleum, Natural Gas and electricity are the main sources of conventional energy while solar, wind, tidal, geothermal etc are example of non-conventional source of energy.

2.1. Conventional Energy Sources

The conventional sources are exhaustible resources. Major conventional sources of energy are discussed below:

2.1.1. Coal

Coal is a one of the important minerals which is mainly used in the generation of thermal power and smelting of iron ore. Coal occurs in rock sequences mainly of two geological ages, namely Gondwana and tertiary deposits. Most of the coal deposits are about 300 million years old.

About 65 per cent of the total coal production is consumed for generating electricity. It is also used as a basic fuel in many industries. Entire process of steel making is based on metallurgical coal. Cement industry consumes about five per cent of the total production. Coal is also an important source of naphtha and ammonia, which are widely used for making chemical fertilizers, tar, benzene, carbon black, etc. Soft coke is used as fuel in the kitchen.

Depending upon the percentage of carbon present, the coal can be *grouped in four types*, such as peat, lignite, bituminous and anthracite.

Peat- It represents the first stage of coal formation, i.e. from wood to coal, today; peat is being formed at many places. It has a high percentage of moisture and volatile matter. The carbon content in peat is less than 40 per cent. It burns like wood and gives more smoke and less heat. It leaves a large amount of ash after burning. Its low heating capacity reduces its value as an industrial fuel.

Lignite- It is generally regarded as the next stage of coal formation after peat. It is also known as the brown coal. Lignite is soft, but more compact than peat. The carbon contents vary from 40 per cent to 60 per cent. Lignite has large percentage of moisture and less amount of combustible matter. The increasing demand for coal has enhanced its use in thermal power stations and in some industries. In India, lignite is mostly found in Rajasthan, Tamil Nadu, Assam and Jammu and Kashmir states.

Bituminous -It is the hard and compact variety of coal. The carbon content varies from about 60 per cent to 80 per cent. Almost 80 per cent of the world's total output of coal is of the bituminous type. The moisture and the volatile contents are also less. Coke is mainly used in the iron and steel industry for smelting iron ore in blast furnaces. Bituminous coal is found in Jharkhand, Orissa, West-Bengal, Madhya Pradesh and Chhattisgarh.

Anthracite - It is the hardest and the best quality of coal. The carbon content varies from about 80 per cent to 90 per cent. Anthracite, practically, has no volatile matter. It does not ignite easily, but once lighted, it has the highest heating capacity. It burns for a long time and leaves very little ash behind. Only about 5 per cent of the world's total coal is anthracite. In India this type of coal is found only in Jammu and Kashmir and that too in very small quantity.

About 80 per cent of the coal deposits in India is of bituminous type and is of non-coking grade. The most important ***Gondwana coal fields*** of India are located in ***Damodar Valley***. They lie in ***Jharkhand-Bengal*** coal belt and the important coal fields in this region are Raniganj, Jharia, Bokaro, Giridih, Karanpura. The other river valleys associated with coal are Godavari, Mahanadi and Son. The most important coal mining centres are Singrauli in Madhya Pradesh (part of Singrauli coal field lies in Uttar Pradesh), Korba in Chhattisgarh, Talcher and Rampur in Odisha, Chanda–Wardha, Kamptee and Bander in Maharashtra and Singareni and Pandur in Andhra Pradesh.

Coal mining industry is facing a lot of problems in India. Some of the ***major problems*** are –

1. The distribution of coal is uneven; this involves high transport cost to carry heavy commodity like coal over long distance. Consequently, the coal consuming industries have to pay much higher prices.
2. Indian coal has high ash content and low calorific value. The ash content varies about 20-30 percent which significantly reduces the calorific value of the product.
3. A large percentage of the coal is taken out from underground mines where the productivity of the labour and machinery is quite low.
4. Besides the problem of pilferage and fire in mines, mining industry is also suffering from problems of environmental pollution.

2.1.2. Petroleum

Crude petroleum consists of hydrocarbons of liquid and gaseous states varying in chemical composition, colour and specific gravity. It is an essential source of energy for all internal combustion engines in automobiles, railways and aircraft. Its numerous by-products are processed in petrochemical industries such as fertiliser, synthetic rubber, synthetic fibre, medicines, Vaseline, lubricants, wax, soap and cosmetics.

The crude petroleum deposits are found only in the sedimentary rock basins of marine origin. But all sedimentary rocks do not contain mineral oil. Petroleum has an organic origin and is formed by the gradual decay and compression of various marine deposits. They remain buried for millions of years and the decomposition of the organic matter has led to the formation of mineral oil. According to latest estimates the total reserves of crude oil are about 500 crore tons on land and in off-shore regions. There are three main areas of potential petroleum reserves. These are:

1. The Terai zone running parallel to the Himalayas *from* Jammu and Kashmir to Assam;
2. River basins of Ganga, Satluj, etc. including deltaic tracts of Ganga, Mahanadi, Godavari, Krishna and Kaveri;
3. The continental shelf along the Western Coast, Gulf of Cambay, and the islands in the Arabian Sea and the Bay of Bengal. Oil and natural gas have been recently found in exploratory wells in Krishna-Godavari and Kaveri basin on the east coast.

India is not self-sufficient in respect of crude oil and has to import huge quantities from abroad. At present, India has to import about 55 per cent of its needs of petroleum and its products. The imports are mainly from the Middle East countries (Iraq, Iran, Kuwait, Saudi Arabia, Bahrain), Russia, Indonesia, Malaysia and Kazakhstan.

Pipelines are most convenient, efficient and economical mode of transporting liquids like petroleum, petroleum products, natural gas, water, milk etc. India has a pipeline network exceeding 7000 km in the country. **Advantages of Pipeline:** 1. Pipeline 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 low energy consumption. 4. It needs little maintenance. 5. They are safe, accident-free and environmental friendly**. Disadvantages of Pipelines:** 1. They are not flexible i.e. they can be used only for a few fixed points. 2. The capacity cannot be increased once laid down. 3. It is difficult to maintain security arrangements for the pipelines. 4. Underground pipelines cannot be easily repaired and detection of leakage is also difficult.

Important Pipelines in India:

1. Naharkatia- Nunmati – Barauni Pipeline
2. Mumbai High – Mumbai – Ankaleshwar – Kayoli Pipeline
3. Salaya- Koyali – Mathura Pipeline
4. Hajira – Bijapur – Jagdishpur (HBJ) Gas Pipeline
5. Jamnagar – Loni LPG Pipeline
6. Kandla – Bhatinda Pipeline

2.1.3. Natural Gas

Natural gas is obtained along with oil in all the oil fields. Whenever a well for oil is drilled, it is natural gas which is available before oil is struck. But exclusive reserves have been located along the eastern coast (Tamil Nadu, Odisha and Andhra Pradesh) as well as in Tripura, Rajasthan and off-shore wells in Gujarat and Maharashtra.

With fast expanding transport network, the consumption level is increasing day by day. Oil products constitute nearly 80% of the total commercial energy used in transport. As these energy sources are limited in quantity, so the need of the hour is to develop and implement energy conservation programme in transport sector. The Petroleum Conservation Research Association (PCRA) under the Ministry of Petroleum and Natural Gas has been taking various steps to increase awareness and promote conservation of petroleum products.

2.2. Non Conventional Energy Sources

With increasing demand for energy and with fast depleting conventional source of energy such as coal, petroleum and natural gas, the non-conventional sources of energy such as energy from sun, wind, bio-mass, tidal , geo-thermal energy are gaining importance. This energy is abundant, pollution-free, renewable and eco-friendly. Besides, it can be supplied evenly to urban, rural and even remote areas. The non-conventional energy sources are cost intensive at the initial stages but will provide more sustained, eco-friendly cheaper energy after the initial cost is taken care of.

2.2.1 Solar Energy

Sun rays tapped in photovoltaic cells can be converted into energy, known as solar energy. The two effective processes considered to be very effective to tap solar energy are ***photovoltaic*** and ***solar thermal technology***. Solar thermal technology has some relative advantages over all other non-renewable energy sources. It is cost competitive, environment friendly and easy to construct. It is generally used more in appliances like heaters, crop dryers, cookers, etc. The western part of India has greater potential for the development of solar energy in Gujarat and Rajasthan.

2.2.2. Wind Energy

Wind energy is absolutely pollution free, inexhaustible source of energy. The mechanism of energy conversion from blowing wind is simple. The kinetic energy of wind, through turbines is converted into electrical energy. The Ministry of non-conventional sources of energy is developing wind energy in India to lessen the burden of oil import bill. The country's potential of wind power generation exceeds 50,000 megawatts, of which one fourth can be easily harnessed. In Rajasthan, Gujarat, Maharashtra and Karnataka, favourable conditions for wind energy exist. Wind power plant at Lamba in Gujarat in Kachchh is the largest in Asia. Another, wind power plant is located at Tuticorin in Tamil Nadu.

2.2.3. Tidal and Wave Energy

Ocean currents are the store-house of infinite energy. For the past few centuries, persistent efforts were made to create a more efficient energy system from the ceaseless tidal waves and ocean current. India has great potential for the development of tidal energy as large tidal waves are known to occur along the west coast of India but so far these have not yet been utilised.

2.2.4. Geothermal Energy

There are vast possibilities of developing and exploiting geothermal energy in India. Lots of hot spring localities have been found in the country. Many potential sites have been identified in Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Jharkhand and Chhattisgarh. A geothermal energy plant has been commissioned at Manikaran in Himachal Pradesh.

2.2.5. Bio-energy

Bio-energy refers to energy derived from biological products which includes agricultural residues, municipal, industrial and other wastes. Bio energy is a potential source of energy conversion. It can be converted into electrical energy, heat energy or gas for cooking. It will also

process the waste and garbage and produce energy. The technique is based on the decomposition of organic matter in the absence of air to yield gas consisting of methane and carbon dioxide which can be used as a source of energy. This will improve economic life of rural areas in developing countries, reduce environmental pollution, enhance self-reliance and reduce pressure on fuel wood.

2.3. Conservation of Natural Resources

In order to promote sustainable development, we need to integrate economic development with environmental concerns. In method of conventional usage of natural resources, there has been large amount of wastage and many environmental problems. Hence, for sustainable development, there is an urgent need to conserve the resources. The alternative energy sources like solar power, wind, wave, geothermal energy are inexhaustible resource and should be developed to replace the exhaustible resources.

3. Manufacturing Industries

Manufacturing is the processing of primary products into more refined and more usable products. Many of the natural products cannot be used directly without processing. It is because of this reason that we manufacture cloth from cotton, sugar from sugarcane, paper from wood pulp etc. By doing so, we make the primary products more valuable and usable. Thus, *manufacturing means transformation of natural material endowments into commodities of utility by processing, assembling and repairing.*

3.1. Types of Industries

Industries are classified in a number of ways.

- On the *basis of* ***size, capital investment and labour force*** employed, industries are classified as large, medium, small scale, and cottage industries.
- On the ***basis of ownership***, industries are categorised as : (i) public sector, (ii) private sector, and (iii) joint and cooperative sector, Public sector enterprises are government/state controlled companies or corporations funded by governments. Industries of strategic and national importance are usually in the public sector.
- Industries are also classified on the ***basis of the use of their products*** such as: (i) basic goods industries, (ii) capital goods industries (iii) intermediate goods industries, and (iv) consumer goods industries.
- Another method of classifying industries is on the ***basis of raw materials*** used by them. Accordingly, these can be: (i) agriculture based industries, (ii) forest-based industries, (iii) mineral-based industries, and (iv) industrially processed raw material based industries.
- Another common classification of industries is ***based on the nature of the manufactured products***. Eight classes of industries, thus identified are: (1) Metallurgical Industries, (2) Mechanical Engineering Industries, (3) Chemical and Allied Industries, (4) Textile Industries, (5) Food Processing Industries, (6) Electricity Generation, (7) Electronics and (8) Communication Industries.

S.N.	Basis	Types of Industries	Chief Characterises	Examples
1	Source of Raw Material	(i)Agro-based industries	(i) Agricultural products used as raw materials (ii) Minerals used as raw materials (iii) Raw materials used from forests (iv) Finished products are used as raw materials for other industries.	(i) Cotton, textile, jute, sugar and paper industry (ii) Iron and steel, chemical and cement industry (iii) Matchsticks and Bidi industries (iv) Motor industries use

				manufactured iron and steel.
2	Ownership	(i) Public Sector (ii) Private Sector (iii) Mixed Sector (iv) Cooperative Sector (v) Multinational Companies	(i) Operated and controlled by government (ii) Operated and controlled by an individual or a group as a company; (iii) Established jointly by public and private sector; (iv)Industry established by a co-operative society of raw material producers (v)Foreign companies established their companies with Indian companies	(i) Bokaro Steel Plant, Chittaranjan Locomotive works; (ii) Tata Iron & Steel, Birla Cement; (iii)Maruti Udyog; (iv) Sugar Industry (Maharashtra), Amul (Gujarat); (v)BMW car manufacturer of Germany
3	Major Functions	(i) Basic Industry (ii) Consumer Goods Industry (iii) Capital Goods Industry (iv) Half Manufacturer Industry	(i) Their finished product is used as raw material for other industries (ii) Their finished produce is directly consumed; (iii)Such machines are made which can be used to produce other goods. (iv) Raw materials produced for other industries	(i) Iron & steel Industry (ii) Toothpaste, Soap, Sugar Industries (iii) Produce machines for sugar and cotton mills (iv) Plastic grains industries
4	Knowledge Based Industries	-	Application of special knowledge of manufacturing Hi-tech expertise, engineering and management, Fast growth rate	Software Industry
5	Manufactured Goods	(i) Metallurgical (ii) Mechanical Engineering (iii) Chemical and Related Activities (iv)Textiles (v) Fertiliser (vi) Electronics and Electricals	-	-

3.2. Location of Industries

Location of industries is influenced by several factors like access to raw materials power, market, capital, transport and labour, etc. Relative significance of these factors varies with time and place. The factors affecting the location of industry can be divided into two broad categories: a) Geographical Factors and b) Non- Geographical Factors.

3.2.1. Geographical Factors

Following are the important geographical factors influencing the location of industries.

Raw Materials: Location of industries is often governed by the location of raw materials. Industries using weight-losing raw materials are located in the regions where raw materials are located. For raw materials which lose weight in process of manufacture or which cannot bear high transport cost or cannot be transported over a long distance because of their perishable nature, industries are often located near the supply of raw materials. Examples of this type of industry are sugar mills, pulp industry, copper smelting and pig iron industries.

Power: Regular supply of power is a pre-requisite for the location of industries. Coal, mineral oil and hydro electricity are the three important conventional sources of power. Most of the industries tend to concentrate around the source of power. Certain industries, like aluminium and synthetic nitrogen manufacturing industries tend to be located near sources of power because they are power intensive and require huge quantum of electricity.

Labour: Availability of cheap labour is a prerequisite for many industries which are labour intensive in nature. Labour supply should be available in large numbers and also they should have skill or technical expertise as needed. Light consumer goods and agro-based industries need plentiful of labour supplies.

Transport: Transport by land or water is necessary for the assembly of raw material and for the marketing of finished goods. Thus, for proper industrial development, we need to have well developed transport facilities.

Market: The process of manufacturing requires that the finished goods do reach the market. Nearness to market is essential for quick disposal of manufactured goods. It helps in reducing the transport cost and enables the consumers to get products at reasonable prices. Similarly heavy machine, machine tools, heavy chemicals are located near the high demand areas as these are market orientated. Cotton textile industry uses a non-weight-losing raw material and is generally located in large urban centre, e.g. Mumbai, Ahmadabad, Surat, etc. Petroleum refineries are also located near the markets as the transport of crude oil is easier and several products derived from them are used as raw material in other industries.

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 tendency to set up industries in rural areas as cost of land has shot up in urban areas.

3.2.2. Non – Geographical Factors

Apart from the geographical factors, there are various other factors which decide the location of industries in the country. Following are some of the important non-geographical factors which influence the location of industries in the country-

Capital: Modern industries are capital intensive and require huge investments which are generally available in urban centres. Hence, many urban cities have become hub for major industries in the country.

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 an important factor. There is an increasing trend to set up industries in an area where the government policies are favourable and promote industry friendly policies.

Industrial Inertia: Industries tend to develop at the place of their original establishment, though the original cause may have disappeared. This phenomenon is known as geographical inertia or industrial inertia.

Banking Facilities: Establishment of industries involves daily exchange of Crores of rupees which is possible through banking facilities only. So areas with better banking facilities are better suited to the establishment of industries.

3.3. Major Industries

Major industries in India can be studied under the following headings:

3.3.1. Iron & Steel Industry

The development of the iron and steel industry opened the doors to rapid industrial development in India. Almost all sectors of the Indian industry depend heavily on the iron and steel industry for their basic infrastructure. The other raw materials besides iron ore and coking coal, essential for iron and steel industry are limestone, dolomite, manganese and fire clay. All these raw materials are gross (weight losing), therefore, the best location for the iron and steel plants is near the source of raw materials.

In India, there is a crescent shaped region comprising parts of Chhattisgarh, Northern Odisha, Jharkhand and western West Bengal, which is extremely rich in high grade iron ore, good quality coking coal and other supplementing raw materials. India has 11 integrated steel plants, 150 mini steel plants and a large number of rolling, re-rolling mills and foundries. Except TISCO now Tata Steels Ltd., all the big steel plants are managed by SAIL. The list of integrated iron and steel plants is-

1. Rashtriya Ispat Nigam Ltd. (Vishakhapatnam, Andhra Pradesh)
2. Jindal Steel & Power Ltd. (Raigarh, Chhattisgarh)
3. Bhilai Steel Plant (Bhilai, Chhattisgarh)
4. Boakro Steel Plant (Bokaro, Jharkhand)
5. Tata Steels Ltd. (Jamshedpur, Jharkhand)
6. JSW Steel Ltd. (Bellary, Karnataka)
7. Tata Sponge Iron Limited (Keonjhar, Odisha)
8. Rourkela Steel Plant (Rourkela, Odisha)
9. Salem Steel Plant (Salem, Tamil Nadu)
10. Durgapur Steel Plant (Durgapur, West Bengal)
11. Indian Iron & Steel Company Ltd. (Burnpur, West Bengal)

Details of some of the important iron and steel plant are as follows:

Tata Steel Ltd.: It is the oldest and the largest integrated iron and steel plant in India located at Jamshedpur in Jharkhand. TSL is most ideally located in respect to iron are, coking coal and flux supplies. The plant started producing pig iron in 1908 and steel in 1911. This plant enjoys the following advantages:

(1) **Iron ore** is obtained from the Noamundi mines of Singhbhum district in Jharkhand and the Guruma-hisani mines in Mayurbhanj district of Orissa. (2) Joda mines of Keonjhar(Kendujhar) district of Orissa supply **manganese**. (3) Dolomite, limestone and fire clay are obtained from Sundargarh district of Orissa. (4) Large requirement of **water** for cooling purposes is met from the Subernarekha and Kharkai rivers. (5) **Labour:** Labour is available locally from the Santhal tribe and from Bihar, Uttar Pradesh and Madhya Pradesh. (6) **Coal:** It is available from the mines of Jharia and West Bokaro (Jharkhand).

Indian Iron and Steel Company (IISCO): The three steel plants at Kulti, Burnpur and Hirapur are located near Asansol in West Bengal. They have merged together to form the Indian Iron and Steel

Company (IISCO). Pig iron is produced at Hirapur plant and sent to Kulti for making steel. The rolling mills are in Burnpur. The IISCO plants have the following geographical advantages: (1) **Iron ore** is brought from Singhbhum (Jharkhand) and Mayurbhanj (Orissa). (2) **Coking coal** is available from Jharia and cheap electricity from the Damodar Valley Corporation. (3) **Manganese** is supplied by Jharkhand, Bihar, Orissa and Madhya Pradesh. (4) **Dolomite** and limestone are obtained from Sundargarh (Orissa) (5) **Cheap labour** is ready available from the adjoining thickly populated states. (6)**Water** is readily available from the Damodar river.

Visvesvaraya Iron and Steel ltd. (VISL): It was established as Mysore Iron and Steel Works in 1923 by the princely state of Mysore. It is located at Bhadravati. This plant is one of the major producers of alloy and special steel in the country.(1) High grade **iron ore** is available from Chikmaglur district; (2) **Manganese** is available from Shimoga and Ghitradurga; (3) it uses **hydroelectric power** from Sharavali project.

Hindustan Steel Ltd (HSL)-Bhilai: The Bhilai Steel plant is located in the Durg district of Chhattisgarh and was built with the Russian collaboration. Bhilai steel plant has the following geographical advantages; (1) Rich **iron ore** is available from Dalli-Rajhara mines; (2) **Coal** is obtained from Korba and Kargali fields in Madhya Pradesh. (3) **Limestone** from Nandini mines (4) **Manganese** is obtained from Bhandara (Maharashtra) and Ballaghat (Madhya Pradesh) mines (5) **Dolomite** comes from Bilaspur.

3.3.2. Cotton textile Industry

The cotton textile industry is one of the traditional industries of India. The development of this industry in India was due to several factors. One, it is a tropical country and cotton is the most comfortable fabric for a hot and humid climate. Second, large quantity of cotton was grown in India. Abundant skilled labour required for this industry was available in this country.

The first modern cotton mill was established in Mumbai in 1854. By 1947, the number of mills in India went up to 423 but the scenario changed after partition when large number of mills had gone to West Pakistan. The cotton textile industry in India can be broadly divided into two sectors, the organised sector and the decentralised sector. The decentralised sector includes cloth produced in handlooms (including *Khadi*) and power looms.

Cotton is a "pure" raw material which does not lose weight in the manufacturing process. So other factors, like, power to drive the looms, labour, capital or market may determine the location of the industry. At present the trend is to locate the industry at or close to markets, as it is the market that decides what kind of cloth is to be produced. Also the market for the finished products is extremely variable; therefore, it becomes important to locate the mills close to the market.

In the second half of the nineteenth century, the cotton textile industry expanded very rapidly throughout the country. Thus, the cotton textile industry is located in almost every state in India, where one or more of the locational factors have been favourable. Presently ***Maharashtra***, ***Gujarat*** and ***Tamil Nadu*** are the leading cotton producing states. West Bengal, Uttar Pradesh, Karnataka, and Punjab are the other important cotton textile producers. Tamil Nadu has the largest number of mills and most of them produce yarn rather than cloth.

Although cotton textile is one of the most important industries of India, it suffers from many problems. Some of the ***burning problems*** include- (1) Scarcity of raw materials; (2) Obsolete Machinery; (3) Erratic power supply; (4) Low productivity of labour; (5) Labour strikes; (6) Stiff Competition in domestic and international market; (7) Sick Mills; (8) Lack of finance.

3.3.3. Sugar Industry

The sugar industry is the second most important agro-based industry in the country. India is the largest producer of both sugarcane and cane sugar. The industry provides employment for more than 4 lakh persons directly and a large number of farmers indirectly. Sugar industry is a seasonal industry because of the seasonality of raw materials. As Sugarcane is a weight-losing crop, Sugar factories hence, are located within the cane producing regions.

Maharashtra is the leading sugar producer in the country and produces more than one-third of the total production of the sugar in the country. ***Uttar Pradesh*** is the second largest producer of sugar. The sugar factories are concentrated in two belts – the Ganga-Yamuna doab and the tarai region. In the southern India, sugar mills are located in Tamil Nadu, Karnataka and Andhra Pradesh. The other States which produce sugar are Bihar, Punjab, Haryana, Madhya Pradesh and Gujarat.

Sugar Industry is a *highly localized* industry. The salient features for its localized nature are- (1) Sugar cane is the chief raw material used for making sugar. (2) Sugar cane dries up quickly after harvesting. It can neither be stored nor kept in the field after the crop matures. (3) There should be no gap between harvesting and crushing of sugar cane. (4) Sugar cane is a bulky raw material and only about 9 to 12 tonnes of sugar is produced from 100 tonnes of cane (5) Transportation of sugar cane is costly. To reduce this cost sugar mills are established in sugar cane growing areas. (6) Sugar cane is generally transported through animal *driven* transport or tractor trailers. Therefore most of the sugar mills are installed within 20 km from the cane growing area. (7) Sugar mills have no problem of fuel because the bagasse of sugar cane can be used for heating the juice or for generating electricity. The entire energy requirements of a sugar mill are met through electricity generated with using bagasse as fuel.

3.3.4. Petrochemical Industries

Petrochemical industries are one of the fastest growing industries in India. A variety of products come under this category of industries. Many items are derived from crude petroleum, which provide raw materials for many new industries; these are collectively known as petrochemical industries. This group of industries is divided into four sub-groups: (i) polymers, (ii) synthetic fibres, (iii) elastomers, and (iv) surfactant intermediate. Mumbai is the hub of the petrochemical industries. Cracker units are also located in Auraiya (Uttar Pradesh), Jamnagar, Gandhinagar and Hajira (Gujarat), Nagothane, Ratnagiri (Maharashtra), Haldia (West Bengal) and Vishakhapatnam (Andhra Pradesh).

3.3.5. Machine Tools

It is a core industry and provides mother machines to all sectors of the economy. There are about 200 units manufacturing various types of machine tools and hand tools. The Kirloskar Brothers ltd was the pioneer company, which started production in 1930s. The Hindustan Machine Tools (HMT), Bangalore, a public sector unit, is the first large scale modern machine tools factory in India. These factories produce a large variety of machine tools, such as lathes, radial drilling machines, grinding machines, gear hobbling machines, lamp making machines, etc. Besides machine tools, HMT also produces watches, tractors and printing machinery.

3.3.6. Automobile Industry

Before independence, assembling of foreign made vehicles was done in India. The real development of the industry began with the setting up of two auto mobile units: (I) Premier Automobiles (Mumbai) in 1947, and (ii) Hindustan Motors Ltd. (Kolkata), in 1948. As steel is the basic raw material for this industry, it tends to be located near iron and steel producing; centres. Port cities are preferred due to import and export facilities. The centres producing tyres, tubes, batteries, paints, etc. provide an added advantage. Recently, the trend has been to locate the automobile manufacturing units near the market.

3.3.7. Electronic Industry

The electronics industry has developed mainly after independence. It covers a wide range of products including transistor sets, televisions, telephone exchanges, telecommunication, computers and various equipments for posts and telegraph, defence, railway and meteorological departments. The setting up of the **Indian Telephone Industry (ITI)** in 1950 at Bangalore gave a boost to this industry. The software has emerged as a major industry in the field of electronics. The computer industry made a modest beginning in the: mid 1970s. Now it has achieved a major breakthrough. The main reason for its rapid growth is a big bank of technically competent manpower. Bangalore is the largest centre of: electronics goods production and is rightly called the **'Electronic Capital** of **India'.**

3.3.8. Knowledge based Industries

The advancement in information technology has significantly increased the knowledge based industries in India. The Information Technology (IT) revolution opened up new possibilities of economic and social transformation. The IT and IT enabled business process outsourcing (ITES BPO) services continue to be on a robust growth path. The IT software and services industry accounts for almost 2 per cent of India's GDP.

3.4. Liberalisation, Privatisation, Globalisation (LPG) and Industrial Development in India

After the new Industrial Policy was announced in 1991, the major objectives of the policy were to build on the gains already made, correct the distortions or weaknesses that have crept in, to maintain a sustained growth in productivity and gainful employment and attain international competitiveness. Within this policy, measures initiated are: (1) abolition of industrial licensing, (2) free entry to foreign technology, (3) foreign investment policy, (4) access to capital market, (5) open trade, (6) abolition of phased manufacturing programme, and (7) liberalised industrial location programme. The industrial licensing system was abolished for all except six industries related to security, strategic or environmental concerns.

The government also decided to offer a part of the shareholdings in the public enterprises to financial institutions, general public and workers. The threshold limits of assets have been scrapped and no industry requires prior approval for investing in the delicensed sector. In the new industrial policy, Foreign Direct Investment (FDI) has been seen as a supplement to the domestic investment for achieving a higher level of economic development. Government has permitted access to automatic route for Foreign Direct Investment under various sectors and respective limits have been setup for various fields. Besides, the industrial policy has been liberalised to attract private investor both domestic and multi-nationals. New sectors like, mining, telecommunications, highway construction and management have been thrown open to private companies. Still there has been a big gap between approved and actual foreign direct investment, even though the numbers of foreign collaborations are increasing. The thrust of globalisation has been to increase the domestic and external competition through extensive application of market mechanism and facilitating dynamic relationship with the foreign investors and suppliers of technology.

On the whole, it has been seen that the major share went to core, priority sectors while infrastructural sector was untouched. Further, the gap between developed and developing states has become wider. Major share of both domestic investment as well as foreign direct investment went to already developed states. In fact, economically weaker states could not compete with the developed states in open market in attracting industrial investment proposals and hence they are likely to suffer from these processes. Thus, we need to look ahead at balancing the act and provide initiatives for the weaker states to reap benefits of the policies of liberalisation, privatisation and globalisation.

3.5. Industrial Regions

Industries are distributed unevenly in India because the factors affecting industrial locations are not the same everywhere. Industries tend to concentrate in few pockets because of certain favourable factors. These pockets of high concentration of industries are known as industrial regions. Several indices are used to identify the clustering of industries, important among them are : (i) the number of industrial units, (ii) number of industrial workers, (iii) quantum of power used for industrial purposes, (iv) total industrial output, and (v) value added manufacturing, etc. Industrial regions have been classified into three categories: **Major Industrial region** is identified on the basis of a minimum daily factory working force of 1.5 lakh; **Minor industrial region** must have a minimum working force of 25000 labours; **industrial district** has a working labour force of less than 25000.

Following are the eight major industrial regions of India:

1. Mumbai-Pune Industrial Region*:*

Location and Extent: This region extends along the coast of the Arabian Sea in Maharashtra. It extends up to Pune to the southeast of Mumbai.

Advantages and Factors of Development:

(i) Raw material: A lot of cotton is produced in the area around Mumbai. Before independence, however, cotton used to be imported through Mumbai port.

(ii) Sources of energy: This region is situated at a long distance from the coal producing regions. But electricity is easily available from the Tata Hydro-electric power houses and the Tarapur Nuclear Power Station.

(iii) Climate: Humid climate of this region is suitable for cotton textile industry. Due to humid climate, thread does not snap while spinning.

(iv) Capital and banking facilities: Mumbai is a major trading metropolis. Capital and banking facilities are, therefore, easily available.

(v) Port facilities: The British purchased the Island of Mumbai in 1774 and built a port here. A railway line had been laid in 1853 connecting Mumbai with Thane. Mumbai port is connected to Pune through Bhorghat Pass and to Nasik through Thalghat Pass. Mumbai port developed rapidly after the opening of the Suez Canal in 1869. Its hinterland has a dense network of railways and roads. It is a point of convergence of international air routes also.

(vi) Market: This region is prosperous economically and the people here have a high purchasing power. Therefore, there is a large demand of industrial goods in the domestic market. The region has easy access to international markets also.

(vii) Labour: Skilled and unskilled labour is easily available. Services of foreign experts are also utilised these days.

Important Industries: Cotton textiles, woollen, silk and synthetic fibres and textile printing are the chief industries in this region. It is the largest cotton textile producing region in Asia. Manufacturing vegetable oils, rubber goods, soaps and detergents, electrical goods, engineering goods, automobiles, cycles, etc. and oil refining are also important industries of this region.

Chief Industrial Centres: Mumbai, the neighbouring suburbs of Thane, Lalganj, Parel, Worli, Mahi, Dadar, etc. and Pune are the chief industrial centres of this region.

2. Hugli Industrial Region*:*

Location and Extent: This region extends on both sides of the Hooghly river from Bansberia to the north of Kolkata to Birlanagar to the south.

Advantages and Factors of Development

(i) Raw material: Enough raw materials are available locally for jute, paper, chemical, silk, leather and engineering industries,

(ii) Port facilities: Kolkata and Haldia ports facilitate import of necessary inputs and export of finished products.

(iii) Sources of energy: Coal and electricity are available from Damodar Valley nearby.

(iv) Water: Enough water is available from Hooghly and groundwater sources for industries such as jute and paper mills.

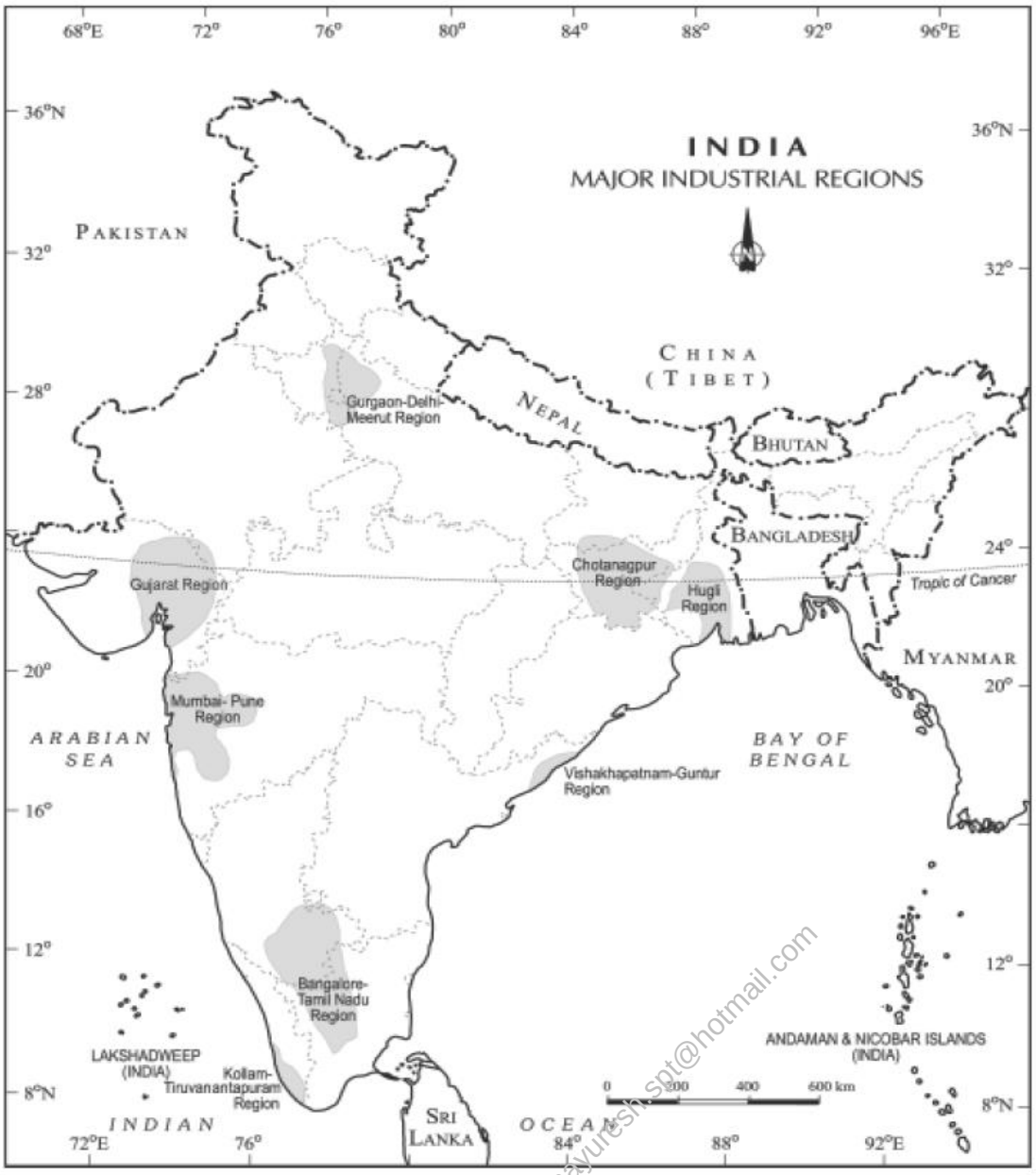
(v) Capital and banking facilities: Kolkata being a major trade centre, capital and banking services are easily available.

(vi) Transport: Railways and roads link this region with all parts of the country. Rivers Damodar and Hooghly are navigable. Before independence this region was linked with Assam and the other parts of northeast through Brahmaputra waterway.

(vii) Labour: This region is surrounded by areas of high density of population. Therefore, there is no shortage of labour. Trained manpower is also available around Kolkata.

Important Industries: Important industries of this region are jute, paper, cotton textiles, automobiles, engineering, electrical goods, chemicals, drugs and pharmaceuticals, diesel engines, machinery for textile and sugar mills, cycles, paints, rubber goods, pottery, silk textiles, vegetable oil and match industries.

Chief Industrial Centres: Haldia, Serampur, Rishra, Howrah, Kolkata, Sibpur, Naihati, Kakinara, Titagarh, Birianagar, Bansberia, etc. are the important industrial centres in this region. Silt deposition in Hooghly poses problems to navigation. Farakka Barrage has been built to regulate the flow in the Ganga to solve this problem. Special ships are used for de silting the Hooghly River. Haldia port on the coast of the Bay of Bengal has been developed to reduce pressure on Kolkata port.



3. Bangalore-Chennai Industrial Region:

Location and Extent: This region lies in the two states of Karnataka and Tamil Nadu. Madurai is situated in its southern part while Bangalore is situated in the north.

Advantages and Factors of Development

(i) Raw material: This region is an important producer of cotton and sugar cane providing raw material for cotton textile and sugar industries. Minerals like iron ore, gold, bauxite, magnetite, etc. are also found here. They serve as raw materials for a number of industries.

(ii) Climate: This region has a mild climate which is suitable for hard work round the year.

(iii) Research institutions: Research institutions like Central Sugar cane Research Institute, Coimbatore, and Indian Institute of Sciences, Bangalore, situated in this region provide skilled workers and technical support.

(iv) Transport: This region has a dense network of railways and roads and connected to Chennai, Mumbai and Mangalore ports

(v) Sources of energy: This region does not have coal reserves but hydroelectricity is available. This region has taken advantage of Mettur, Shivasamudram, Papanasam, Pykara and Sharavati hydroelectric power projects.

Important Industries: This region has a variety of industries. Industries like cotton textiles, silk textiles, sugar, leather goods, chemicals, and machine tools have developed here. A number of large public sector industries like Hindustan Machine Tools Ltd.; Indian Telephone Industries, Bharat Electronics and Hindustan Aeronautics are situated in this region. Bhadravati Steel Plant under the management control of SAIL is also situated in this region.

Chief Industrial Centres: Madurai, Sivakasi, Tiruchirapalli, Coimbatore, Madukottai, Mettur, Bangalore, Mysore and Mandya are the important industrial centres. Coimbatore (Tamil Nadu) and Bangalore (Karnataka) have witnessed a rapid industrial development during the last some years.

4. Gujarat Industrial Region:

Location and Extent: This region extends around the Gulf of Khambhat. Gujarat is situated in its northern part and Bharuch in its southern part.

Advantages and Factors of Development

(i) Raw material: Area around this region produces large amount of cotton. Mineral oil and natural gas for petrochemical industries are also locally available.

(ii) Cheap land: Land is cheap and abundant here in comparison to Mumbai.

(iii) Labour: This region has an old tradition of cloth weaving. Therefore, skilled cheap labour for cotton textile industry is easily available.

(iv) Transport: Industrial centres of this region are connected with each other and other cities with railways and roads. There are pipelines for transport of gas and oil. [t has given impetus to the development of petrochemical industries.

(v) Capital: Ahmadabad and Vadodara are cities of rich people. Therefore capital for industry is easily available.

(vi) Port Facilities: This region is served by the new port of Kandla. This port is relatively closer to Europe, Africa and Central Asia.

Important Industries: Cotton textile is the chief industry of this region. Chemical, drugs and pharmaceuticals, woollen and silk textiles, paper, milk products, match and machinery for textile industries are the other important industries. India's famous Amul Milk Industry is in this region. For the past some years, petrochemical industry using mineral oil and natural gas has been making rapid progress.

Chief Industrial Centres: Ahmadabad, Vadodara, Koyali, Bharuch, Surat, Anand, Kheda, Gandhar, etc. are the chief industrial centres.

5. Chhotanagpur Region:

Location and Extent: This region extends over West Bengal, Bihar and Orissa. The Damodar and the Subernarekha rivers flow through this region.

Advantages and Factors of Development

(i) Raw material: This region is rich in mineral resources and has large reserves of iron ore, copper, mica, bauxite, fire clay, coal, manganese, dolomite, limestone, etc.

(ii) Labour: Cheap workers from Bihar and Uttar Pradesh are easily available. Trained and skilled workers are also available.

(iii) Sources of energy: The well-known coal deposits of Damodar valley lay in this region. Electricity is also available from Damodar valley project.

(iv) Transport: This region is connected to the Kolkata port and other parts of India with roads and railways. The canal waterways of Damodar Project are also used.

Important Industries and Chief Industrial Centres: A variety of industries including iron and steel, paper, chemicals, heavy engineering, cycles, aluminium, fertilisers, cement, locomotive and railway wagons, etc. have developed in this region. Iron and steel is the most important industry of Chhotanagpur region. The public sector steel plants of Bokaro, Durgapur, Kulti and Burnpur and the private sector iron and steel plant of Jamshedpur are situated in this very region. Sindri, Chittaranjan, Dhanbad, Ranchi, Chaibasa, Hazaribagh, Daltonganj, Garwa and Japla are the chief industrial centres.

6. Vishakhapatnam-Guntur Region*:*

Location and Extent: This region extends from Vishakhapatnam in Andhra Pradesh to Prakashan and Kurnool districts in the south.

Facilities available and Reasons for Development

(i) Raw materials: This area is also agriculturally prosperous. The raw materials like sugar cane, cotton and jute are locally available. Iron ore is available nearby from Bailadila mines and bauxite reserves are also found in the area. Limestone is also available locally,

(ii) Power resources: Coal available from Godavari valley and power generated from coal is also available in the region. The benefit of oil and natural gas reserves in Krishna-Godavari basin also accrue to this region.

(iii) Port facilities: For import and export trade port facilities are available at Vishakhapatnam and Machilipatnam. It also takes advantage of Chennai and a new port at Ennore.

(iv) Water: The surface water of Krishna and Godavari rivers and coastal waters as well as groundwater in coastal areas is adequately available to industries in the region.

(v) Capital and banking: Finance and banking facilities are available from Vishakhapatnam, Vijayawada and other cities.

(vi) Transport: A network of railways and road transport is found in the area. Many principal railway routes and national highways pass through the region. In this industrial region density of population is also high. There is thus no shortage of labour. There are many higher technical institutions in the cities of Andhra Pradesh. Therefore, trained engineers and workers are also available.

(vii) Major industries: In this region chiefly the following industries have developed petrochemicals, sugar, cotton clothes, jute, paper, fertilisers, cement, aluminium, iron and steel, lead, zinc smelting, etc.

(viii) Chief industrial centres: The chief industrial centres of the region are Vishakhapatnam, Vijayawada, Vijayanagar, Rajahmundri, Guntur, Eeuru, and Kurnool.

7. Gurgaon-Delhi-Meerut Region:

Location and Extent: The industrial region is spread over the states of Delhi, Haryana, Uttar Pradesh and Union Territory of Delhi. The region extends from Agra to Ambala.

Facilities Available and Reason for Development

(i) Raw materials: This region is away from mining and power resources region. It is, however, agriculturally prosperous region. Sugar cane is the chief crop. It supplies raw materials to a large

number of sugar mills in the area. The region is also well developed in milk production.

(ii) Power resources: Two main sources are hydel and thermal power. There are many thermal power stations in the region. It gets electricity from Northern Grid of Bhakra-Nangal project.

(iii) Transport: There is a vast rail-road network in the region. There are no problems in respect of availability of raw materials, labour, capital and other facilities.

(iv) Labour: There is no shortage of trained and skilled labour because of the existence of a large number of educational and training institutions in the area.

(v) Principal industries: The industries manufacturing light engineering and consumer durables are found in the area. Chief industries are cotton, woollen and silk mills, instruments and tools, tractors, cycles and car manufacturing units, electronics and vegetable oils, electrical instruments, domestic appliances, agricultural tools, etc. Software and hardware and glass industries are also found. There are also two large oil refineries at Panipat and Mathura in this region.

8. Kollam-Tiruvanantapuram Region*:*

Location and Extent: The region extends from Trichurnagar of Kerala state to Thiruvananthapuram in the South. Five districts of Kerala namely: Trichur, Ernakulam, Allappuzha, Kollam and Thiruvananthapuram districts are located in this region.

Facilities Available and Reasons for Development

(i) Raw materials: Almonite, rutoite, zercon, and mononite sands are found in adequate quantities. Plantation, agriculture like tea, coffee, spices, etc supply raw materials to industries.

(ii) Sources of power: Hydroelectric power stations found in the region are the main sources of supply of electricity in the region. These power sources are chiefly responsible for industrialisation of the region.

(iii) Transport: The principal rail routes and national highway linking coastal regions pass through the area. Even roads are found in hilly regions. This wide network of roads and railways has helped in movement of raw materials and goods. Therefore, distribution of manufactured goods also does not face any problems.

(iv) Ports: A chief port in the area namely Kochi has many facilities available.

(v) Chief industries: Agricultural products processing related industries such as cotton textiles, sugar, rubber, matches, and fish, mineral-based industries like glass, chemical fertilisers, petroleum and its products, paperboard and coir products, fine instruments, machinery and tools, etc. are found in the area.

(vi) Principal industrial centres: The principal industrial centres of the region are Thiruvananthapuram, Kollam, Allappuzha, Kochi, Alwaye and Trichur.

There are **thirteen Minor Industrial Regions** in the country. They are Ambala-Amritsar, Saharanpur-Muzaffarnagar-Bijnor, Indore-Dewas-Uijjain, Jaipur-Ajmer, Kolhapur-South Kannada, Northern Malabar, Middle Malabar, Adilabad-Nizamabad, Allahabad-Varanasi-Mirzapur, Bhojpur-Munger, Durg-Raipur, Bilaspur-Korba, and Brahmaputra valley. Also, there are **fifteen industrial districts** which are Kanpur, Hyderabad, Agra, Nagpur, Gwalior, Bhopal, Lucknow, Jalpaiguri, Cuttack, Gorakhpur, Aligarh, Kota, Purnia, Jabalpur and Bareilly.

Student Notes:

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Student Notes:

TRANSPORT & COMMUNICATION AND INTERNATIONAL TRADE

Contents

1. Transport

Transport provides services of carrying men and materials from one place to another. It links all the spheres of earth, land, air and water. Development of cheap and efficient means of transport is necessary for the progress of a country. Transport routes serve as basic economic arteries of the country and provide important link between production and consumption. Density of transport network and its modernity is the index of economic development of any country.

Transport system can be broadly classified into *four distinct ways* i.e. land transport, water transport, air transport and pipeline transport. Land transport can be taken by man himself or through animal transport, road transport or rail transport. Water transport can be classified in inland transport systems and oceanic waterway transport systems.

1.1. Land Transport

Man has been using footpaths for transport since prehistorical times. After the invention of wheel, when manmade carts, driven by oxen, horse and camel and made use of unsurfaced roads; with the invention of steam engine need was felt for providing rail lines. First such rail line was, perhaps, from Stockton and Darlington in northern England opened in 1825. Soon the first public railway system became very popular as it was *very* convenient and fastest mode of transport. The networks of road and rail transport threw open remote interior parts of continents to human settlements, grain farming and industrialisation.

1.1.1. Road Transport

Pt. Jawaharlal Nehru said, *"The path of development goes to villages through roads"*. This is true to other fields too. The roads are harbingers of economic development. Only 20 per cent population of the world lives in developed countries, but it has 72 per cent cars, buses, trucks, etc. of the world. Road networks are found in high density in areas with higher population density round the world. With the advancement in technology, metalled roads are reaching the countryside and helping in connecting people.

1.1.1.1. Advantages of Roads

The major advantages of road transport over other means of transport are as follows: -

1) Road transport is cheaper than rail transport. Its cost of construction, repair and maintenance is comparatively less than railway transport.
2) Roads are available up to the house of consumer. The producer and trader prefer roads only because there arise no need of loading and unloading of their goods at different places. The raw material and the machines reach the factory directly and the products to the consumers safely.
3) Road transport is the best for short and medium distances. People and goods take less time in reaching their destination.
4) Roads are highly useful for transporting ephemeral goods such as green vegetables, fruits and milk. The roads are basis of truck farming.
5) Anytime, anywhere no problem of time and travel.
6) Regular expenditure on roads is *very* low as compared to rail transport which is high on maintenance of stations, platforms, rail-routes and on employing large number of employees for running the railways.
7) The construction and usage of roads in inaccessible hilly areas with steep slopes and forested areas is difficult but possible.
8) Packing of goods is not always necessary in road transport. Sometimes, fruits and vegetables are loaded without packing.

9) Roads can negotiate steep slopes and sharp turns and are more flexible means of transport.

1.1.1.2. Distribution of Roads in the World

The road network is not evenly spread throughout the world; the density of roads is not the same everywhere nor is there any system of distribution of roads between small towns and cities. City roads suffer from chronic traffic congestion. There are peaks (high points) and troughs (low points) of traffic flow between certain hours of the day. It is estimated that total length of roads in the world is three crore nine lakh km. Out of this only 1.5 crore km roads can be used in all seasons. The North American continent alone has 35 per cent of world's good roads. The economically and industrially advanced countries have generally a good road network whereas developing and poor countries cannot cope with the demands of traffic. The United States of America has also highest road density.

Having consideration for safety on roads, many theories of transportation or traffic-flows have been put forward. These seek to describe in a precise mathematical way the interactions among vehicles, drivers, and the infrastructure. It has been found that there is some kind of relationship between these elements which if studied properly could help in planning, design, and operations of roadway facilities. Particular attention is paid in respect of *flow, density and velocity.* In most cities of the world there is chronic traffic congestion. Many suggestions have been made for urban transport solutions. Among these suggestions include:

(i) Higher Parking Fee
(ii) Mass Rapid Transit (MRT)
(iii) Improved Public Bus Service
(iv) Expressways / Toll Roads

1.1.1.3. Distribution of Roads in India

India has one of the largest road networks in the world with a total length of 46.9 lakh km (2013). About 65% of freight and 80% passenger traffic is carried by the roads. National Highways in India constitute only about 1.7% of the road network but carry about 40% of the total road traffic. Number of vehicles has been growing at an average pace of 10.16% per annum over the last five years.

India has a long tradition of building roads since the times of Chandragupta Maurya and Asoka. The real progress was made during Mughal period, when Sher Shah Suri constructed a road between Peshawar and Kolkata. It is now called *Grand Trunk (G.T.) Road.* Road transport in modern sense was very limited in India before World War-II. The first serious attempt was made in 1943 when *'Nagpur Plan'* was drawn. This plan could not be implemented due to lack of coordination among the princely states and British India. After Independence, twenty-year road plan (1961) was introduced to improve the conditions of roads in India. However, roads continue to concentrate in and around urban centres. Rural and remote areas had the least connectivity by road. Currently, the Indian road network consists of National Highways, State Highways, District roads and Village roads. Besides these, there are International highways and the Expressways, which are of recent development.

1.1.1.3.1. National Highways

These are the main roads, which are constructed and maintained by the Central Government through *National Highway Authority of India (NHAI)*[1], which was established in 1995. These roads are meant for interstate movement and connect the state capitals, important ports, major cities and railway junctions. The total length of the National Highways was about 19,700 km in 1951. It has increased to about 70,934 km in 2012. The National Highways are only 2 per cent of the total road length in India, but these roads carry about 40 per cent of the total road traffic of India.

As of now about 26 per cent (18,350 km) of the total length of National Highways (NHs) is single lane/intermediate lane, about 51 per cent (36,031 km)is two-lane standard, and the balance 23 per cent (16,553 km)is four-lane standard or more.

The NHDP project is composed of the following phases:

Phase I: The Golden Quadrilateral (GQ) connecting the four major cities of Delhi, Mumbai, Chennai and Kolkata. This project connecting four metro cities would be 5,846 km (3,633 mi). Total cost of the project is Rs.300 billion (US$6.8 billion), funded largely by the government's special petroleum product tax revenues and government borrowing. In January 2012, India announced the four lane GQ highway network as complete.

Phase II: North-South and East-West corridors comprising national highways connecting four extreme points of the country. The North-South and East-West Corridor (*NS-EW*; 7,300 km) connecting Srinagar in the north to Kanyakumari in the south, including spur from Salem to Kanyakumari (Via Coimbatore and Kochi) and Silchar in the east to Porbandar in the west. Total length of the network is 7,300 km (4,500 mi). The Golden Quadrilateral and the corridors will also be connected to 10 major ports of India, namely Kandla, Jawaharlal Nehru Port, Marmagao, New Mangalore, Kochi, Tuticorin, Ennore, Vishakhapatnam, Paradip and Haldia, through a road length of 363 km.

Phase III: The government recently approved NHDP-III to upgrade 12,109 km (7,524 mi) of national highways on a Build, Operate and Transfer (BOT) basis, which takes into account high-density traffic, connectivity of state capitals via NHDP Phase I and II, and connectivity to centres of economic importance.

Phase IV: The government is considering widening 20,000 km (12,000 mi) of highway that were not part of Phase I, II, or III. Phase IV will convert existing single lane highways into two lanes with paved shoulders. The plan will soon be presented to the government for approval.

Phase V: As road traffic increases over time, a number of four lane highways will need to be upgraded/ expanded to six lanes. The current plan calls for upgrade of about 5,000 km (3,100 mi) of four-lane roads, although the government has not yet identified the stretches.

Phase VI: The government is working on constructing ***expressways*** that would connect major commercial and industrial townships. It has already identified 400 km (250 mi) of Vadodara (earlier Baroda)-Mumbai section that would connect to the existing Vadodara (earlier Baroda)-Ahmadabad section. The World Bank is studying this project. The project will be funded on BOT basis. The 334 km (208 mi) Expressway between Chennai—Bangalore and 277 km (172 mi)

[1] The National Highways Authority of India (NHAI) was formed in 1995. It is an autonomous body under the Ministry of Surface Transport. It is entrusted with the responsibility of development, maintenance and operation of National Highways. This is also the apex body to improve the quality of the roads designated as National Highways.

Expressway between Kolkata—Dhanbad has been identified and feasibility study and DPR contract has been awarded by NHAI.

Phase VII: This phase calls for improvements to city road networks by adding ring roads to enable easier connectivity with national highways to important cities. In addition, improvements will be made to stretches of national highways that require additional flyovers and bypasses given population and housing growth along the highways and increasing traffic. The government has not yet identified a firm investment plan for this phase.

1.1.1.3.2. The State Highways

These highways are constructed and maintained by the State Governments through their respective Public Works Departments (PWD). The State Highways provide linkages with the National Highways, district headquarters, important towns, tourist centres and minor ports and carry the traffic along major centres within the state. These arterial routes provide connectivity to important towns and cities within the state with National Highways or State Highways of the neighbouring states. Their total length is about 137,712 km. These constitute 4 per cent of total road length in the country.

1.1.1.3.3. The District Roads

These roads are constructed and maintained by Zila Parishads and the Public Works Departments. The district roads mostly connect the district headquarters with the main towns and large villages within the districts. Now most of these roads are metalled roads and provide accessibility to the rural areas. The total length is about 4,70,000 km. They account for 14 per cent of the total road length of the country.

1.1.1.3.4. The Village Roads

These roads are constructed and maintained by the Village Panchayat. They connect the villages with the neighbouring towns and cities. These roads made great progress under the Pradhan Mantri Grameen Sadak Yojana (PMGSY). Under this scheme, the all weather roads are constructed to provide easy access to the villages. Their total length in 2005 was 26,50,000 km, which was about 80 per cent of all types of roads in India.

1.1.1.3.5. The Border Roads

The Border Roads Organisation (BRO) was established in 1960. Its main aim was to plan and construct roads of strategic importance in the northern and north-eastern border areas of the country. BRO has constructed roads in high altitude mountainous areas. Apart from this main work, the BRO also undertakes snow clearance in high altitude areas.

1.1.1.3.6. Expressways

Expressways are the highest class of roads in the Indian Road Network. An expressway is a controlled-access highway; it is a highway that controls entrances to it and exits from it by incorporating the design of the slip roads for entry and exit into the design of the highway itself. Expressways make up approximately 1,208 km (751 mi) of India's road network, as of 2013. The expressways in use are:

Student Notes:

NATIONAL HIGHWAYS DEVELOPMENT PROJECT PHASE - I, II & III

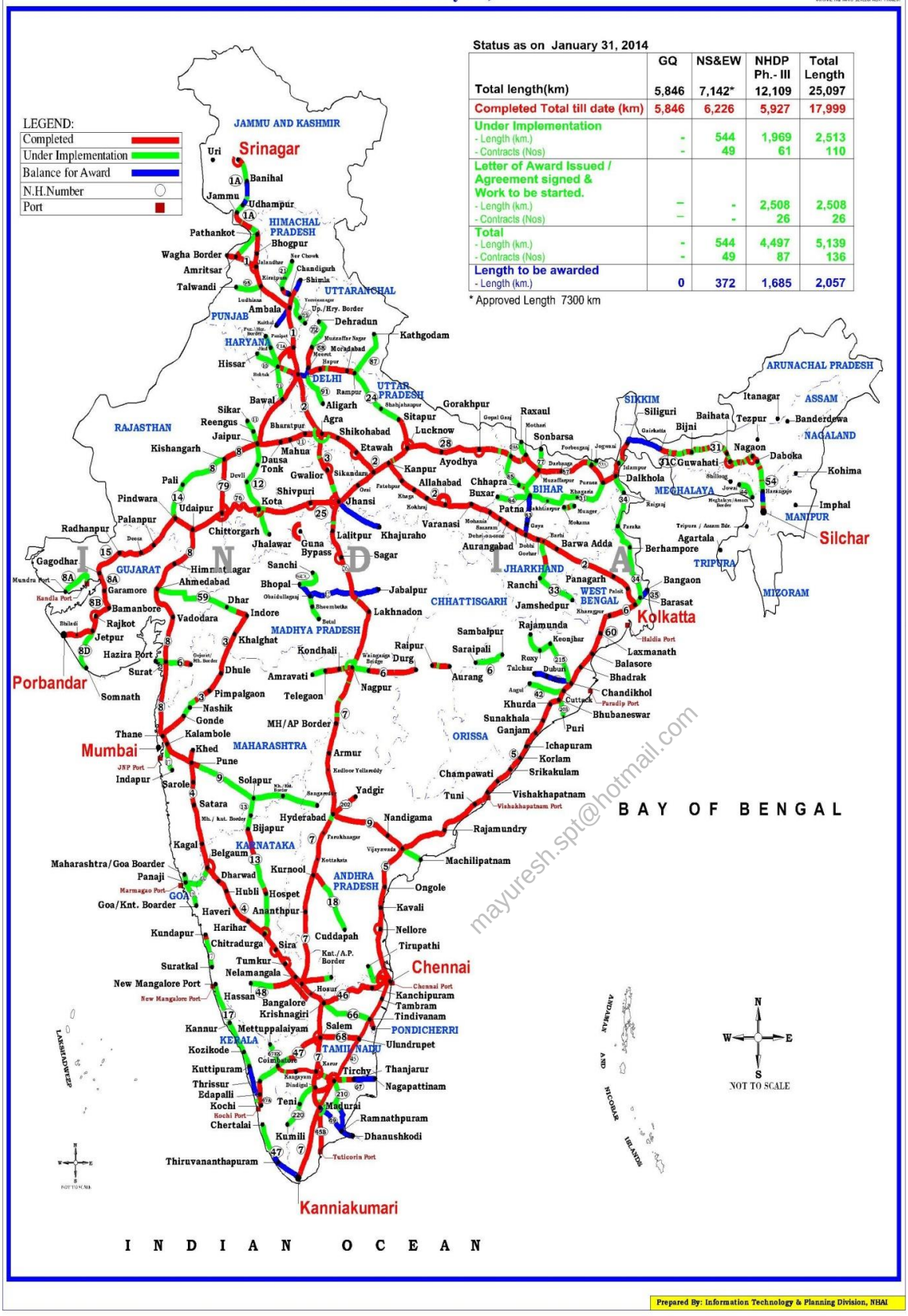
Status as on January 31, 2014

राष्ट्रीय राजमार्ग विकास परियोजना
NADP
NATIONAL HIGHWAYS DEVELOPMENT PROJECT

Status as on January 31, 2014

	GQ	NS&EW	NHDP Ph.- III	Total Length
Total length(km)	5,846	7,142*	12,109	25,097
Completed Total till date (km)	5,846	6,226	5,927	17,999
Under Implementation				
- Length (km.)	-	544	1,969	2,513
- Contracts (Nos)	-	49	61	110
Letter of Award Issued / Agreement signed & Work to be started.				
- Length (km.)	–	-	2,508	2,508
- Contracts (Nos)	–	-	26	26
Total				
- Length (km.)	-	544	4,497	5,139
- Contracts (Nos)	-	49	87	136
Length to be awarded				
- Length (km.)	0	372	1,685	2,057

* Approved Length 7300 km



National Highway	Route	Distance
NH-1	Jalandhar – Uri	663
NH-1A	New Delhi-Ambala-Jalandhar-Amritsar	456
NH-2	Delhi-Mathura-Agra-Kanpur-Allahabad-Varanasi-Kolkata	1465
NH-3	Agra-Gwalior-Nasik-Mumbai	1161
NH-4	Thane and Chennai via Pune and Belgaum	1235
NH-5	Kolkata - Chennai	1533
NH-6	Kolkata – Dhule	1949
NH-7	Varanasi – Kanyakumari	2369
NH-8	Delhi-Mumbai-(via Jaipur, Baroda and Ahmedabad)	1428
NH-9	Mumbai-Vijayawada	841
NH-10	Delhi-Fazilka	403
NH-11	Agra- Bikaner	582
NH-12	Jabalpur-Jaipur	890
NH-13	Sholapur-Mangalore	691
NH-15	Pathankot-Samakhiali	1526
NH-17	Panvel-Edapally	1269
NH-22	Ambala-Shipkitr	459
NH-28	Lucknow-Barauni	570

List of Main National Highways in India

1) Greater Noida – Agra Yamuna Expressway (165 kilometres)
2) Ahmadabad Vadodara Expressway (95 kilometres)
3) Mumbai-Pune Expressway (93 kilometres)
4) Jaipur-Kishangarh Expressway (90 kilometres)
5) Allahabad Bypass Expressway (86 kilometres)
6) Durgapur Expressway (65 kilometres)
7) Ambala Chandigarh Expressway (35 kilometres)
8) Chennai Bypass Expressway (32 kilometres)
9) Delhi-Gurgaon Expressway (28 kilometres)
10) NOIDA-Greater NOIDA Expressway (24 kilometres)
11) Delhi-NOIDA Flyway (23 kilometres)
12) Mumbai Nasik Expressway (150 kilometres)
13) PVNR Hyderabad Airport Expressway (12 kilometres)
14) Hyderabad ORR Expressway (150 kilometres)
15) Guntur-Vijayawada Outer ring road Expressway (46 Kilometres) Outer Ring Road, Guntur & Vijayawada
16) Coimbatore Bypass expressway (28 kilometres)

1.1.1.3.7. The Asian Highway (AH)

The Asian Highway (AH) project, also known as the Great Asian Highway, is a cooperative project among countries in Asia and Europe and the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), to improve the highway systems in Asia. It is one of the three pillars of the Asian Land Transport Infrastructure Development (ALTID) project, endorsed by the ESCAP commission at its 48th session in 1992, comprising Asian Highway, Trans-Asian Railway (TAR) and facilitation of land transport projects. Agreements have been signed by 32 countries to allow the highway to cross the continent and also reach to Europe. Some of the countries taking part in the highway project are India, Sri Lanka, Pakistan, China, Japan, South Korea and Bangladesh. Most of the funding comes from the larger, more advanced Asian nations like Japan, India and China as well as international agencies such as the Asian Development Bank.

The following are the routes which pass through India –

1) AH1; Petrapole to Atari via NH 1 & 2
2) AH42, 3,754 km (2346 miles); Lanzhou, China (on AH5) to Barhi, India (on AH1)
3) AH43, 3,024 km (1892 miles); Agra, India (on AH1) to Matara, Sri Lanka
4) AH44, 107 km (67 miles); Dambulla, Sri Lanka (on AH43) to Trincomalee, Sri Lanka
5) AH45, 2,030 km (1269 miles); Kolkata, India (on AH1) to Bangalore, India (on AH43/AH47)
6) AH46, 1,967 km (1,222 miles); named Great Eastern Highway within India from its East Coast to West Coast - Hazirah-Surat-Jalgaon-Howrah(Kolkata) till AH2.
7) AH47, 2,057 km (1286 miles); Gwalior, India (on AH43) to Bangalore, India (on AH43/AH45)
8) AH48, 1 km (.625 miles); Phuentsholing, Bhutan to border between Bhutan and India

1.1.1.4. Road Density

The distribution of roads in India is highly uneven. The density of roads (length of roads per 100 sq km of area) varies from only about 10.5 km in Jammu and Kashmir to about 400 km in Kerala. The national average of road density is about 75 km per 100 sq km. The density of roads is generally high in most of Northern and Southern states. It is low in the Himalayan region, Madhya Pradesh and Rajasthan. This is due to the topography and the level of economic development of the areas. The construction of roads is easy and cheaper in plain areas than in the hilly and plateau regions. Keeping in view the volume of goods traffic and passengers, the road network is not only insufficient, but also inefficient. About 45 per cent of the roads in India are unmetalled and this restricts their use during the rainy season and also for heavy vehicles.

1.1.1.5. Problems of Road Transport

The road transport in India is facing a number of problems. Some of them are as under:

1) About half of the Indian roads are unsurfaced. These can be used only in fair weather and becomes muddy and unfit during the rainy season.
2) Most of the National Highways suffer from inadequate capacity, weak pavements, old and broken bridges, unbridged level crossings, lack of by-pass roads and lack of amenities and safety measures. The mixing of traffic by high speed cars, trucks, buses, tractors, two wheelers, animal driven vehicles, cyclists, etc. increases traffic time, congestion, pollution and road accidents.
3) The existence of multiple check posts, toll tax, and octroi duties collection points on roads waste time and retards the traffic movement and speed.
4) Important amenities, such as repair shops, first aid centres, telephones, clean toilets, food outlets, rest places are lacking along the roads.

Student Notes:

State wise Length of Roads in India

(in km)

Sl. No.	States/UTs	2003	2004	2005	2006	2007	2008	CAGR (%) (2003-08)
1	Andhra Pradesh	201895	206125	329407	336982	339002	345012	11.31
2	Arunachal Pradesh	15661	15712	17751	17216	17430	16494	1.04
3	Assam	160380	192980	208788	215819	223450	230334	7.51
4	Bihar	78750	73834	119958	120127	120127	120127	8.81
5	Chhattisgarh	72729	73993	72322	73892	73705	74434	0.46
6	Goa	10231	10240	10331	10420	10523	10569	0.65
7	Gujarat	142755	143660	143419	144777	145631	146630	0.54
8	Haryana	28511	28673	28657	29055	29397	29726	0.84
9	Himachal Pradesh	32039	32582	23452	23614	34954	36298	2.53
10	Jammu & Kashmir	20272	21095	21811	22043	22058	22323	1.95
11	Jharkhand	11391	11783	18038	18055	18071	17531	9.01
12	Karnataka	199711	200112	210415	214211	253901	255454	5.05
13	Kerala	139590	143276	169516	187147	197454	204757	7.96
14	Madhya Pradesh	164803	165340	163920	164801	165407	165740	0.11
15	Maharashtra	271369	272684	220937	220447	223142	223322	-3.82
16	Manipur	12594	12599	16502	16502	16502	16502	5.55
17	Meghalaya	9564	9701	9662	9691	9752	9839	0.57
18	Mizoram	4913	4898	5426	5974	6144	6158	4.62
19	Nagaland	20523	20647	26241	22085	21947	22304	1.68
20	Orissa	213049	213820	215141	215214	215300	215404	0.22
21	Punjab	40023	45767	46490	45165	45135	45178	2.45
22	Rajasthan	140160	144898	149753	152435	159902	171479	4.12
23	Sikkim	2023	2063	2076	2118	1873	1873	-1.53
24	Tamil Nadu	167450	170823	176209	179348	180823	181213	1.59
25	Tripura	22295	23856	31716	31731	31731	31733	7.32
26	Uttar Pradesh	259928	244442	256683	263555	272362	284673	1.84
27	Uttarakhand	34716	58054	35659	36061	39167	41041	3.40
28	West Bengal	88500	89699	195679	199052	208415	211770	19.07
	State Total	**2565825**	**2633356**	**2925959**	**2977537**	**3083305**	**3137918**	**4.11**
	Union Territories							
1	A & N Island	1181	1481	1298	1301	1303	1301	1.95
2	Chandigarh	1637	1637	2118	2118	2118	2118	5.29
3	D & N Haveli	559	632	632	632	632	632	2.49
4	Daman & Diu	240	318	223	223	223	224	-1.37
5	Delhi	29802	29812	29458	29462	29479	29559	-0.16
6	Lakshadweep	154	160	160	162	166	168	1.76
7	Puducherry	2559	2600	2613	2624	2696	2696	1.05
	UT Total	**36132**	**36640**	**36502**	**36522**	**36617**	**36698**	**0.31**
	India Total	**2601957**	**2669996**	**2962463**	**3014063**	**3119924**	**3174620**	**4.06**

* Excludes Roads Constructed under JRY and PMGSY

Source: 1.Material supplied by TRW, M/o Road Transport & Highways
2.Basic Road Statistics published by TRW, M/o Road Transport & Highways

5) The rules of road safety and traffic are wilfully violated by the drivers and there is no efficient system of checking.

6) The road engineering and construction techniques are out-dated and are not able to meet the challenges of the future.

7) The participation of private sector in road development is very little due to high investments and low returns.
8) The policy relating to highway development is not stable, as it changes with the change of government.
9) The multiplicity of agencies involved in the planning, construction and maintenance of different types of roads.
10) There is a shortage of funds for the construction and maintenance of roads, even for highways, in India.

1.1.2. Rail Transport

The first train of the world started in 1825 A.D. between Stockholm to Darlington in northern England. Since then, railways became an important means of land transport. Railroad is normally called a ***track***. Distance between two parallel rails is known as ***gauge***. Over sixty percents of world's rail routes are of ***standard gauge*** of 1435 mm. Rail gauge larger than standard gauge is called ***broad gauge*** and smaller than standard gauge is called **narrow gauge**. The measurements of *narrow* and *broad* gauges slightly varies from country to country – narrow gauge between 914 mm and 1067 mm and broad gauge between 1520 mm and 1676 mm [as in India]. Further many countries have 1,000 mm gauge, also known as ***metre gauge***.

1.1.2.1. Advantages of Rail Transport

The major advantages of the rail transport are as follows:

1) It is a cheap means of transport for long distance journeys of people and goods.
2) It is a fast transport for long distances.
3) Due to development of new technology in railway lines, wagons and coaches, engines and operation system, the speed of trains has become more than 300 km per hour. The fast running trains are in vogue in Japan, France and Germany.
4) On account of air-conditioned coaches, excellent arrangement in sleeper coaches and catering travel by trains has become very comfortable.
5) Trains transport heavy and bulky goods over long distances.
6) Trains are convenient mode of transport for sending agro-products to consumers and raw materials to factories.
7) After introduction of big containers, trains and trucks together help the goods to reach at the doorstep of the consumers.
8) Provision of container services has considerably reduced expenses on packing, loading and unloading.
9) Perishable goods are transported in refrigerated wagons.
10) Railways contribute greatly to economic development of a region.

1.1.2.2. Limitations of Rail Transport

Some of the limitations of the modern rail transport are-

1) Huge capital investment is imperative in constructing railway track, stations, platforms and manufacturing wagons and coaches, etc.
2) It is difficult to construct and maintain rail routes in hilly terrains with steep slopes and deserts.
3) Rail transport is generally impossible in areas of heavy rainfall and snowfall.
4) Sending of goods through rail transport becomes difficult due to different gauge of railway lines i.e. broad, metre and narrow. This increases the expenditure on loading and unloading.

1.1.2.3. Distribution of Railways in the World

The network of rail routes is unevenly distributed across the world. The economically developed countries of the world have more railways. Railways have played an important role in the industrialisation of these countries. The colonial rulers of Europe connected the interior parts of their colonies in Asia and Africa to the ports. The main purpose of this was to bring the raw material from the interior of these colonies to the ports, which was later shipped to European countries. This was the main purpose behind connecting Delhi to Kolkata, Mumbai and Chennai. Similar course was followed in Africa by the French, Italians and other colonial powers.

Later, most of the cities were connected by the railway networks. Parts of Europe have great density of railway network. It is said that Belgium has the world's densest rail route network It has 1 km railway lines for every 6.5sq km area. In Asia the countries of Japan, China and India are densely populated. They have also dense network of railways. In other countries railways are not widespread. West Asia is least developed in rail networks because of existence of vast deserts and thinly populated regions. Very recently China has constructed railway line up to Lhasa in Tibet. The Qinghai-Tibet railway is the highest altitude railways of the world. Another project, **Trans-Asian Railway** (TAR) undertaken by the United Nations Economic and Social Commission for Asia and Pacific [UNESCAP] integrates freight railway networks across Europe and Asia. North America has the densest rail route network in the world. About 40 per cent rail routes of the world are found in this continent. Very heavy load like minerals, food grains, logs of timber etc. are transported by railways. Passengers, however, prefer air journey or road journey.

Intercontinental rail routes connect two ends of a continent. These rail routes are constructed from the political, economic and military points of view. Important among these routes are given below:

(i) Trans-Siberian Railway: This route was constructed for connecting European Russia to Siberia or Asian Russia and runs from St. Petersburg in the west to Vladivostok on the Pacific Coast in the east passing through Moscow, Ufa, Novosibirsk, Irkutsk, Chita and Khabarovsk. It is the most important route in Asia and the longest (9,332 km) double-tracked and electrified trans– continental railway in the world. It has helped in opening up its Asian region to West European markets. Its development is on account of economic, political and defence reasons.

(ii) Canadian Pacific Railway: This 7,050 km long rail-line in Canada runs from Halifax in the east to Vancouver on the Pacific Coast passing through Montreal, Ottawa, Winnipeg and Calgary. This was constructed for connecting British Columbia (an eastern Province) to other states of Canada. Later on, it gained economic significance because it connected the Quebec-Montreal Industrial Region with the wheat belt of the Prairie Region and the Coniferous Forest region in the north. Thus each of these regions became complementary to the other.

(iii) Australian Intercontinental Rail Route: The main purpose of constructing this was to connect the Western Australia to east Australian states so as to keep it within the union.

(iv) The Union and Pacific Railway: This rail-line connects New York on the Atlantic Coast to San Francisco on the Pacific Coast passing through Cleveland, Chicago, Omaha, Evans, Ogden and Sacramento. The most valuable exports on this route are ores, grain, paper, chemicals and machinery.

(v) Trans-Asiatic Railway: A UN assisted rail project for linking Istanbul with Bangkok via Iran, Pakistan, India, Bangladesh and Myanmar has been pending since a very long time.

1.1.2.4. Distribution of Railways in India

The network of the Indian Railways is the largest in Asia and fourth largest in the world. It is the life-line of the country catering to its need for large-scale movement of traffic, both passengers and freight. Mahatma Gandhi said, the Indian railways *"brought people of diverse cultures together to contribute to India's freedom struggle."*

Indian Railway was introduced in 1853, when a line was constructed from Bombay to Thane covering a distance of 34 km. Indian Railways is the largest government undertaking in the country. The length of Indian Railways network is about 64,000 km. It's very large size puts lots of pressure on a centralised railway management system. Thus, in India, the railway system has been divided into sixteen zones.

On the basis of *width of the track* of Indian Railways, three categories have been made:

Broad Gauge: The distance between the rails in the broad gauge is 1.676 metres. The total length of broad gauge line is about 46,800 km, which accounts for about 74 per cent of the total length of rail routes in the country.

Metre Gauge: The distance between the rails in the metre gauge is one metre. The total length of the metre gauge line is about 13,300 km, which accounts for about 21 per cent of the total length of rail routes in the country.

Narrow Gauge: The distance between the rails in the narrow gauge is 0.762 metre or 0.610 metre. The total length of the narrow gauge is about 3,124 km, which accounts for about 5 per cent of the total length of rail routes in the country. The narrow gauge is generally confined to hilly areas.

The Government of India has nationalised the railways and adopted a policy of gauge conversion, mainly from metre gauge to broad gauge. The **unigauge** system of railways will assure larger capacity, higher speed and consequently cheaper transportation. The process of gauge conversion is very slow due to the shortage of funds and it will take many more years to bring the total railway system under single gauge.

The distribution of Indian Railway network has been influenced by the geographical, economical and political factors. The Northern Plains of India with level land, high density of population, fertile soils and intense agriculture activities presents the most favourable environment for the development of railways. The relief of Himalayas and the plateaus is not suitable for the large scale development of railway network. The development of railways is more in economically active areas. Railways also bring economic development and prosperity to those regions through which they pass. Due to this economic link, we find the highest density of railways near big urban and industrial centres, and also in areas which are rich in minerals and agricultural resources. The present railway system in India is the legacy of British Rule. They planned the pattern of the railway network according to their needs.

1.1.2.5. Problems of Railways in India

Railways being the largest public sector undertaking has varied and complex problems. Some of them are as under:

1) Its present railway network is overburdened and inadequate to meet the new challenges of a fast developing economy.
2) Some regions are beyond the reach of railways due to unfavourable geographical conditions. These areas need to be opened to railways for removing regional inequalities in economic growth.
3) Railways are facing stiff competition from road transport and thus its share in passenger and goods traffic is declining.

4) Railways are overburdened with surplus staff on its regular pay roles. This burden hinders the further development of railways.
5) The railways have to develop uneconomic projects due to political pressures and interferences.
6) Railways have huge outstanding payments to diesel and electric power supply companies.
7) The State Electricity Boards and NTPC increase the tariffs arbitrarily and thus add to the burden of railways.
8) Railways are the largest consumer of diesel. Any increase in the rates of diesel, adversely affect the financial resources.
9) Most of the equipment used by the railways are now obsolete and need immediate replacements.
10) There is mounting deficit due to non increase in fares and tariffs by the Government due to political reasons.

Despite these problems and shortcomings, there is no other substitute for railways, as these are 5 times more energy efficient and four times more economical than road transport. In the last few years, some administrative changes have been implemented to reduce the deficit. As a result of consistent efforts, the Indian Railways are now generating surplus funds. Some of the measures taken include sharpening of marketing capability; Strengthening of high density network; Cutting down of unnecessary overheads; Commercial exploitation of railway lands; Participation by the private sector; and Effective and efficient use of available financial resources.

1.2. Water Transport

Man has been using water transport since ancient times. Waterways were being used mainly for transporting goods for the last few years. But now, big passenger ships are moving from one corner of the world to another with the load of thousands of tourists. Water transport is *the* cheapest as compared to other means of transport because no cost is involved in constructing the roads or on their maintenance. Waterways are highly suitable for heavy and bulky materials. Waterways are of two types: (i) Inland Waterways, and (ii) Ocean Waterways.

1.2.1. Inland Waterways

The rivers, lakes and canal used for transporting goods or people are called inland waterways. The inland waterways were very important before the invention of trains and motor vehicles. They were very much in use for transporting passengers and goods. But, rail routes and roads have reduced their importance to some extent.

1.2.1.1. Necessary Conditions for Inland Waterways

The following are the necessary conditions which need to be met for successful inland water transport in the country.

1) Rivers should be perennial or water should flow in sufficient quantity throughout the year. Seasonal rivers are unsuitable for navigation.
2) Water transport cannot take place in river having rapids or waterfalls.
3) The water in rivers, lakes and canals should not freeze during winter season.
4) Soil or sand should not be deposited on the mouth of rivers. The deposition of sand or soil reduces the depth of water.
5) The course of rivers should not be full of curves. These curves increase the time of transportation.
6) Rivers should not change their courses during floods.

1.2.1.2. Advantages of Inland Waterways

Inland waterways are advantageous in many ways. These can be summarised as –

1) Transportation of heavy and bulky goods is easy and cheap. Coal, different ores, wood and big size manufactured goods are suitable for water transport.
2) Rivers and lakes are natural routes. Expenditure on their construction and maintenance is not required.
3) Waterways experience comparatively few accidents.
4) Rivers are the only means of transport in thick forested lands of heavy rainfall.

1.2.1.3. Limitations of Inland Waterways

In spite of the above mentioned advantages, the inland waterways have following limitations-

1) Time is lost due to slow speed. Hence, they are not suitable for transporting perishable goods such as fruits, vegetables and milk and their by products.
2) Most of the rivers flow far away from the densely populated areas where demand for transportation is more. Hence, this mode of transportation presents difficulties.
3) Seasonal change in the flow and depth of water creates problem in transportation
4) For keeping desired depth in the rivers, lakes and canals, silting of sand and soil is to be removed regularly. This involves expenditure and the navigation is halted during such an exercise.

1.2.1.4. Distribution of Inland Waterways in the World

All the rivers and lakes of the world are more or less used for transportation. But, navigable rivers which pass through densely populated areas are more used for navigation. The major inland water ways used extensively round the globe can be studied as follows-

Rhine Waterway: Rhine River flows through industrial The Rhine flows through industrially advanced nations of Switzerland, Germany, France, Belgium and the Netherlands. The Rhine River is navigable from Rotterdam for about 870 km. At its source in Switzerland, it flows along boundary of France and Germany and drains Germany and the Netherlands and has its mouth near North Sea. On its banks are located main cities of Europe like Strasbourg {France}, Bonn, Cologne, Dusseldorf and Rotterdam. The vessel take the cargo of industrial products, coal food grains in addition to passengers and tourists which have seen considerable rise in the past few decades. For the benefit of tourists, the vessels are fitted with modern conveniences and sail in both directions of the rift valley. One can enjoy the scenic beauty of the Vossages of France and Black Forest of Germany. Each year more than 20,000 ocean-going ships and 2, 00,000 inland vessels sail in this waterway.

Danube Waterway: It is an important inland waterway of Eastern Europe. The Danube rises in the Black Forest of Germany and flows eastwards through Austria, Slovak Republic, Hungary Croatia, Bulgaria, Romania and other countries and then joins the landlocked Black Sea. It is 2,850 km long. In 1992, a 171 km canal was constructed linking it with **Kohlheim.** Now Danube covers a distance of 3,500 km to fall into Black Sea. Cargoes carrying export items are wheat, maize, timber, and machinery sail in the river. The waterway is also gaining importance on account of rising tourism.

Great Lakes· St. Lawrence Seaway: This waterway flows through the industrially advanced region and estuary St. Lawrence River of the United States and Canada. It is therefore the longest and busiest inland waterway of the world. Ships can ply up to a distance of 3760 km in it. The ships plying on this route are long and narrow and are capable of transporting 45,000 tonnes of freight. Agro-products, machines, iron ore, coal, petroleum, limestone, etc. are mainly transported from the ports like Duluth and Buffalo, which are equipped with all modern

Student Notes:

facilities. The Great Lakes region of North America consists of Lakes Superior, Michigan, Huron, Erie and Ontario.

Mississippi Waterway: Mississippi River is one of the main rivers of North America. It has its source in Lake Itasca in Minnesota and flow 3,718 km draining fertile lands of interior parts of North America. It then joins the Gulf of Mexico. This waterway has become more important these days. About 16 km north its tributary Saint Louis Missouri joins it. Together with Missouri, its total length is 6238 km. For greater part it is navigable. Steamers can ply in this river up to Minneapolis some distance away from Lake Superior. The Mississippi-Ohio waterway connects the interior part of U.5.A with the Gulf of Mexico in the south.

Volga Waterway: Volga is Europe's biggest river and has large number of developed waterways. After rising from in the Valdai Hills north-west of Moscow, it flows for about 3689 km before draining into Caspian Sea. Oaka River is its major right bank tributary. The river is connected to river Don by a canal which flows into the Black Sea.

1.2.1.5. Distribution of Inland Waterways in India

The inland waterways refer to using inland water bodies, such as rivers, canals, creeks, backwaters, etc. for transporting goods and people from one place to another. A number of rivers, like Ganga, Brahmaputra Yamuna, Mahanadi, Godavari, Krishna, Kaveri, Narmada, Tapi, etc. were the main arteries of inland waterways in India. At present, the inland waterways in India are about 14,500 km in length, contributing about 1% to the country's transportation. Out of this about 3,700 km are navigable by mechanised boats.

In order to increase the significance of inland waterways and to improve their efficiency, the **Inland Waterways Authority of India** (IWAI) was set up in 1986. The following inland waterways have been declared is the **National Waterways** by the IWAI. There are six identified national waterways in India.

National waterway-1: Allahabad–Haldia stretch of the Ganges–Bhagirathi–Hooghly River of total length 1620 km was declared as National Waterway-1 (NW-1) in the year 1986. The Hooghly river portion of the waterway from Haldia to Nabadwip is tidal. Sea going vessels navigate up to Calcutta (140 km) and the fairway up to Calcutta is maintained by the Calcutta Port Trust. From Calcutta up to Tribeni there are no restrictions for navigation by inland vessels of a loaded draft up to 4m.From Farakka upstream the navigable route is through the main Ganga River. The Feeder Canal and the navigation lock at Farakka become the link between the Bhagirathi and main Ganga upstream Farakka Barrage. The large variation in discharge along with unstable morphological condition of bank and bed, heavy sediment load, continuous braiding and meandering make development of navigational channel a complex task.

National Waterway-2: Sadiya–Dhubri stretch of the Brahmaputra River of total length 891 km was declared as National Waterway-2 (NW-2) in the year 1988. The river Brahmaputra flows down the centre of Assam Valley. It receives a number of tributaries like Subansiri,Jia Bharali, Dihing, Burhi Dihing, Disang, Dhansiri and Kopili.

National Waterway-3:

Kollam–Kottapuram stretch of West Coast Canal and Champakara and Udyogmandal canals of total length 205 km was declared as National Waterway-3 (NW-3) in the year 1993. This waterway comprises of natural lakes, back-waters, river sections and man-made canal sections. The Champakara and Udyogmandal canals link industrial centres of Ambalamugal and Udyogmandal with the Kochi port.

Student Notes:

National Waterway- 4:

Kakinada–Pondicherry stretch of canals and Kaluvelly tank, Bhadrachalam–Rajahmundry stretch of River Godavari and Wazirabad–Vijayawada stretch of River Krishna of total length 1095 km was declared as National Waterway-4 (NW-4) in the year 2008.

National Waterway-5:

Talcher–Dhamra stretch of rivers, Geonkhali–Charbatia stretch of East Coast Canal, Charbatia–Dhamra stretch of Matai river and Mahanadi delta rivers of total length 620 km was declared as National Waterway-5 (NW-5) in the year 2008.

National Waterway-6:

Lakhipur-Bhanga stretch of 121 km of the Barak River is the 6th waterway. It will result in unified development of the waterways for shipping and navigation and transportation of cargo to the North Eastern Region particularly in the states of Assam, Nagaland, Mizoram, Manipur, Tripura and Arunachal Pradesh. It was accepted as National Waterway in January 2013 by Union Cabinet.

Uttar Pradesh has the highest length of inland waterways, followed by West Bengal, Andhra Pradesh, Assam, Kerala and Bihar.

1.2.2. Oceanic Routes

The oceans are linked with each other and are for most parts negotiable. Ocean transport plays a significant role in international trade. Most of the crude oil from the oil producing countries of the world is exported through oil tankers. The transportation of agro-products, processed foods and manufactured goods including all heavy and bulky goods are moved through ocean routes.

1.2.2.1. Main Ocean Routes of the World

North Atlantic Ocean Route: It is one of the busiest sea routes in the world. It is also known as Big Trunk Route. Approx 25 per cent of the ships of the world ply on this route. The main ports of Western Europe are Glasgow and London (U.K.), Rotterdam (Netherlands), Antwerp (Belgium), I.e. Havre and Bordeaux (France). Main ports of North America are: Quebec and Montreal (Canada); Boston, New York and Baltimore (U.S.A.). Goods shipped from Europe to Canada and the U.S.A includes manufactured goods like clothes, chemicals, fertilisers, wines etc. From Canada and the U.S.A to Europe, items include food grains, iron and steel, transport equipment etc.

Mediterranean-Red Sea-Indian Ocean Route: This route connects Eastern Africa, Southern Asia and countries of Far East to West European countries. This is a very important ocean route of the world. It passes through North Sea, Atlantic Ocean Mediterranean Sea, Red Sea, Arabian Sea, Indian Ocean and South China Sea. The Suez Canal route has reduced the distance 6,400 km. Main Ports include Port Said, Aden, Karachi, Mumbai, Kochi, Colombo, Singapore and Bangkok. Materials moving towards East constitute mainly machines and industrial products etc. while materials moving towards West are raw materials, cotton, tea, coffee, sugar, rubber, petroleum, etc.

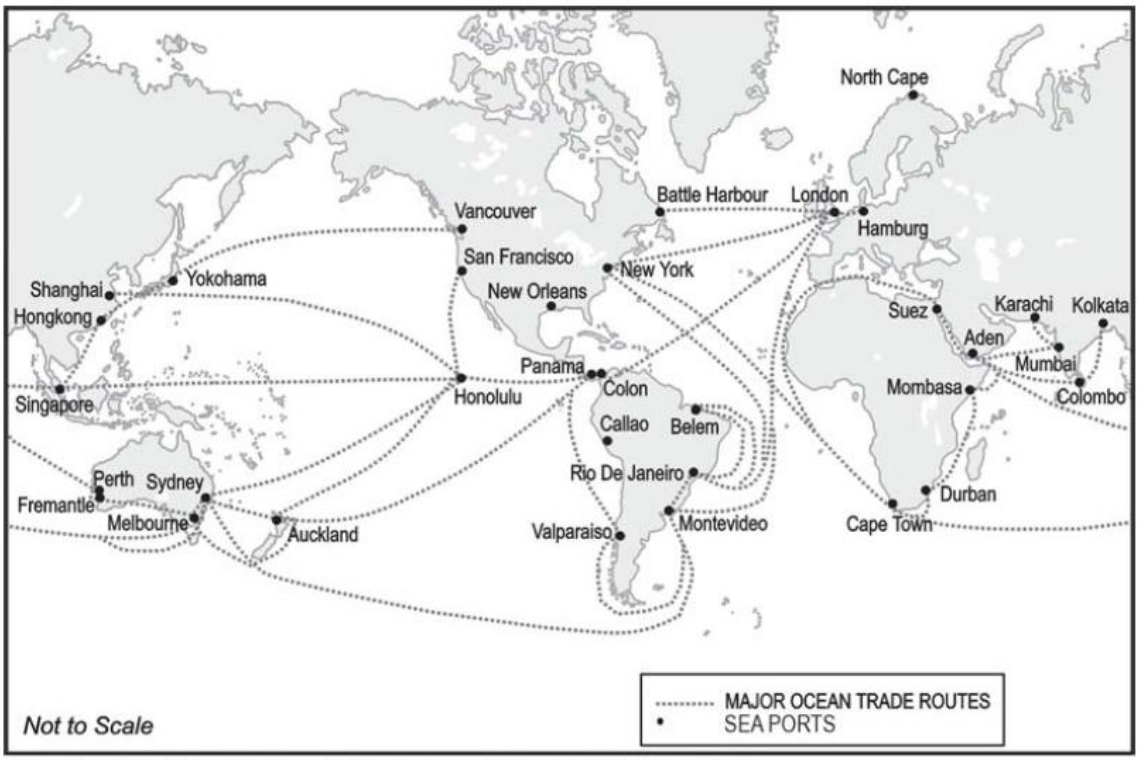
Cape Ocean Route (Cape of Good Hope Route): Before the opening of Suez Canal Route, Europeans used to pass through this route while visiting India, China and Australia. Still, this route connects Western Africa, South Africa, Australia and New Zealand to Western Europe for trade, these days. Main Ports in this route are London, Lisbon, Cape Town, Adelaide, Melbourne, Sydney, Wellington (New Zealand). Palm-oil, wood, almond and copper are sent to Europe from Africa while wheat, maize, wool, etc. are sent to Africa from Australia. Industrial products are sent from Europe to Africa and Australia.

South Atlantic Route: The trade between the countries of South America and Europe is being carried out through this route. Brazil, Argentina, Uruguay are the main countries of South America benefitted by this route. This route is comparatively less important. Quantity of trade is less because of the underdeveloped West African countries. Main Ports on this route include London, Liverpool, Hamburg (Europe) Kingston, Havana (West Indies) Rio-de Janeiro (Brazil, Buenos Aires (Argentina), Montevideo (Uruguay). Materials transported include coffee, rubber, sugar, meat, wool, wheat, are sent from countries of South America and West Indies to Europe. Coal, machines and industrial products are sent from Europe to these countries.

North Pacific Ocean Route: This route is used for trade between western regions of North America and Japan; and China and Far East Asia. These ocean routes are lengthy route and lack facilities of harbours and refilling fuels. Main Ports include Yokohama, Tokyo, Shanghai and Manila in East Asia and San Francisco, Seattle and Los Angeles in Western North America. Goods Transported are silk and tea from Japan, wool and different minerals from Australia are sent through this route to North America. In return, North America sends wood, cereals, petroleum and finished goods to Australia, Japan and New Zealand.

Student Notes:

Major Sea Routes round the world



The International Boundary shown in this map may not to be considered as authentic

1.2.2.2. Main Shipping Canals

Shipping canals are canals especially intended to accommodate ships used on the oceans, seas or lakes to which it is connected. As opposed to it, a barge canal is intended to carry barges and other vessels specifically designed for river and/or canal navigation. Because of the constraints of accommodating vessels capable of navigating large bodies of open water, a ship canal typically offers deeper water. Ship canals are constructed for a number of reasons which include creating a shortcut and avoiding lengthy detours; to create a navigable shipping link between two land-locked seas or lakes; to provide inland cities with a direct shipping link to the sea; and to provide an economical alternative to other options.

List of Important Shipping Canals in the World

Canal	Length	Lock depth	Dimension	Location	Notes
White Sea – Baltic Canal	141 mi (227 km)	3.5 m (11 ft)	135m × 14.3 m × 3.5m	Russia	Opened in 1933, is partly a canalised river, partly an artificial canal, and partly some natural lakes. Shallow depth limits modern vessels from using the canal.
Rhine-Main-Danube Canal	106 mi (171 km)	4 m (13 ft)	lock dimensions: 190m x 11.45m x	Germany	Opened in 1992, links the large rivers Rhine and Danube, and thus also the North

			4m		Sea and the Black Sea.
Suez Canal	120.11 mi (193.30 km)	No locks, but 24 m (79 ft) deep.	205 m (673 ft) wide	Egypt	Opened in 1869, links the Mediterranean Sea to the Red Sea.
Volga-Don Canal	62 mi (100 km)	3.5 m (11 ft)	lock dimensions: 140m x 16.6m x 3.5m	Russia	Opened in 1952, connects the Black, Azov, and Caspian Seas.
Kiel Canal	60 mi (97 km)	14 m (46 ft)	lock dimensions: 310m x 42m x 14m	Germany	Opened in 1895. Shortens the passage between the North Sea and the Baltic Sea.
Houston Ship Channel	56 mi (90 km)	14 m (46 ft)	161 m (528 ft) wide	USA	Connects Houston, Texas to the Gulf of Mexico.
Panama Canal	51 mi (82 km)	25.9 m (85 ft)	lock dimensions: 320m x 33.53m x 25.9 m	Panama	Opened in 1914. Links the Caribbean Sea to the Pacific Ocean, creating a shortcut.
Danube-Black Sea Canal	40 mi (64 km)	5.5 m (18 ft)	lock dimensions: 138m x 16.8m x 5.5m	Romania	Opened in 1984. Links the Danube to the Black Sea.
Manchester Ship Canal	36 mi (58 km)	8.78 m (28.8 ft)	lock dimensions: 170.68m x 21.94m x 8.78m	UK	Opened in 1894. Links the in-land city of Manchester to Irish Sea.
Welland Canal	43.4 km (27.0 mi)	8.2 m (27 ft)	lock dimensions: 225.5m x 23.8m x 8.2 m	Canada	Opened in 1931. Links Lake Erie to Lake Ontario and is part of the Saint Lawrence Seaway.
Saint Lawrence Seaway		8.2 m (27 ft)	lock dimensions: 225.5m x 2.3m x 8.2 m	Canada USA	Links Montreal with Lake Superior.

1.2.2.3. Oceanic Routes in India

The coastline of the mainland of India and of the islands is about 7,517 km long. India had a flourishing maritime trade even during the ancient days with East Indies and Middle East countries. The shipping got a setback with the arrival of European companies during the colonial rule.

India has 13 major ports and 176 non-major ones. The major ports carry about 3/4th of the total traffic. Despite adequate capacity and handling facilities the average turnaround time of major Indian ports is less than 4 days which is very high compared to the average turnaround time of about 10 hrs in Hong Kong. This undermines the competitiveness of Indian ports. Since the ports are not adequately linked to the Hinterland, the evacuation of CARGO is slow leading to congestion. To this end, all ports trust have set up groups with representatives from the National Highway Authority of India(NHAI), Railways and State Governments to prepare comprehensive plans aimed at improving road-rail connectivity of ports. The NHAI has taken up port connectivity as major component of the National Highways Development Project (NHDP).

1.2.2.3.1. Problems of Shipping in India

The Indian shipping industry is facing a number of problems. Some of them are as under:

1) Inadequacy of tonnage capacity.
2) Shortage of container fleet.
3) Over-aged vessels resulting in high operation costs.
4) Stiff competition with foreign shipping companies which provide better and cheaper service.
5) Congestion at the major ports, and
6) Inadequate infra-structural support like ship-repair facility, dry-docking and cargo handling.

1.2.3. Major Ports in India

The 13 major ports of India handle more than 95 per cent of our foreign trade by volume and 70 per cent by value. The major ports are Kandla, Mumbai, Jawaharlal Nehru (Nhava Sheva), Mormugao, New Mangalore, Kochi, Tuticorin, Chennai, Vishakhapatnam, Paradip, Haldia, Kolkata and Port Blair. Details of some of these ports are as follows-

1) **Kandla:** Kandla port was developed soon after independence to make up the loss of Karachi to Pakistan. It is a tidal port and is located at the eastern end of the Rann of Kachchh. It handles the exports and imports for Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana, Delhi, Rajasthan and Gujarat. It handles crude oil, petroleum products, cotton, fertilizers, food grains, cement, sugar, edible oils, scrap, etc.
2) **Mumbai:** It is the biggest natural harbour on the west coast of India. The opening of Suez Canal in 1869 brought it much closer to the European countries. A new port Nhava Sheva has been developed near Mumbai port. It has decongested traffic at Mumbai port. It handles a large variety of cargo from Middle-East and European countries. It serves as a hub port in this region.
3) **Mormugao:** Mormugao port is an important port of Goa and handles the iron ore export from India. It is located on the entrance of the Zuari estuary. With the opening of Konkan Railway, its importance has been enhanced and it is working as a multi-commodity port.
4) **New Mangalore:** It is a new port developed about 9 km north of the old port. The port is well linked with Mumbai and Kanyakumari. The main items of cargo from this port are iron ore, manganese ore, fertilizers, tiles, cement, coffee, cashew nuts, forest products, food grains, etc.

5) **Kochi**: It is a natural port located along the coast of Kerala and is popularly known as *"Queen of the Arabian Sea"*. Kochi has sheltered backwater bay, and is open to traffic throughout the year. The main items of export and import are coir goods, copra, coconut oil, tea, rubber, spices, cashew kernels, sea food, chemical fertilizers, etc. The Kochi Oil Refinery receives crude oil from this port.
6) **Tuticorin:** It has been recently developed along the south-eastern coast of Tamil Nadu. It has an artificial deep sea harbour and is well connected with railways and roads. Main exports and imports are tea, spices, cotton textiles, hides and skins, edible oils, sugar, petroleum products, etc.
7) **Chennai:** It is the oldest artificial harbour on the east coast of India. It is often hit by cyclones in October and November, making the shipping difficult. It is not suited for large ships due to lesser depth of water. This port mainly handles petroleum products, fertilizers, iron ore, coal, edible oils, machinery, cotton, metals, etc.
8) **Vishakhapatnam:** It is the deepest, land-locked, protected and the best natural harbour of India. An outer harbour has been developed to handle iron ore and petroleum. It also has the shipbuilding and ship-repair industry. Its main imports and exports are petroleum, fertilizers, chemical, machinery, metals, iron ore, timber, leather goods and food grains.
9) **Paradip:** It is deep water and all weather port, located about 100 km east of Cuttack. It has the deepest harbour in the country. This port handles iron ore and coal along with some dry cargo. The port is well connected through rail and road with different parts of Orissa.
10) **Kolkata-Haldia:** It is situated along the Hugli River about 148 km away from sea shore. It is one of the leading ports of India. Its importance has slightly declined due to the development of Paradip and Vishakhapatnam ports. Kolkata is a truncated port and has two dock systems-Kidderpore Docks and Netaji Subhash docks. Recently in 1978, another port Haldia (90 km downstream from Kolkata) has been developed, for handling the bulk cargo, and to relieve pressure on the old port. The port handles petroleum, chemicals, edible oils, railway equipment, machinery, tea, sugar, gunnies, leather goods, lac, mica, scrap, etc.

1.2.4. Types of Port

Generally, ports are classified according to the types of traffic which they handle. Types of port according to cargo handled:

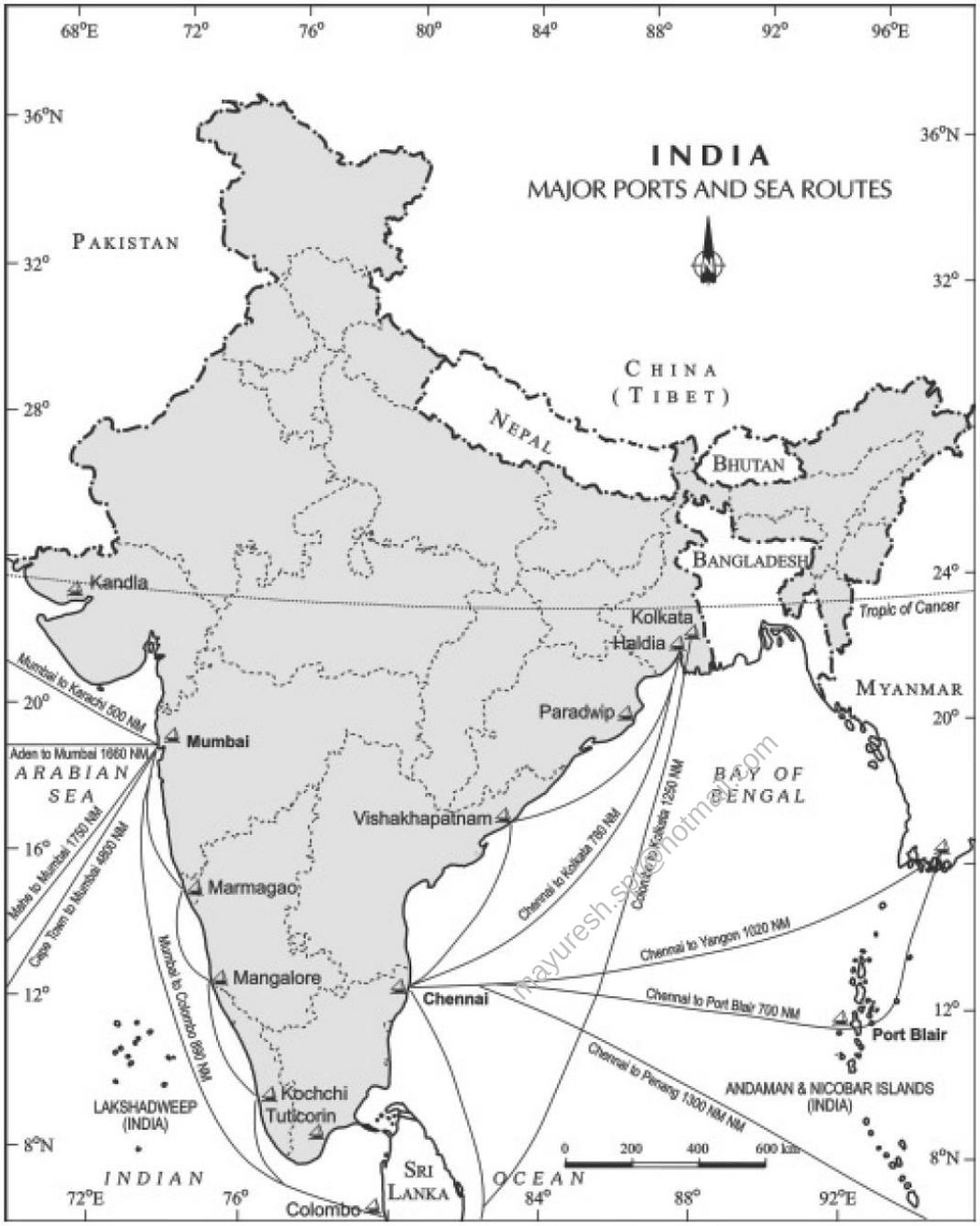
(i) ***Industrial Ports:*** These ports specialise in bulk cargo-like grain, sugar, ore, oil, chemicals and similar materials.
(ii) ***Commercial Ports:*** These ports handle general cargo-packaged products and manufactured goods. These ports also handle passenger traffic.
(iii) ***Comprehensive Ports:*** Such ports handle bulk and general cargo in large volumes. Most of the world's great ports are classified as comprehensive ports.

1.2.5. Types of port on the basis of location

(i) ***Inland Ports:*** These ports are located away from the sea coast. They are linked to the sea through a river or a canal. Such ports are accessible to flat bottom ships or barges. For example, Manchester is linked with a canal; Memphis is located on the river Mississippi; Rhine has several ports like Mannheim and Duisburg; and Kolkata is located on the river Hooghly, a branch of the river Ganga.
(ii) ***Out Ports:*** These are deep water ports built away from the actual ports. These serve the parent ports by receiving those ships which are unable to approach them due to their large size. Classic combination, for example, is Athens and its out port Piraeus in Greece.

1.2.6. Types of port on the basis of specialised functions

(i) ***Oil Ports:*** These ports deal in the processing and shipping of oil. Some of these are tanker ports and some are refinery ports. Maracaibo in Venezuela, Esskhira in Tunisia, and Tripoli in Lebanon are tanker ports. Abadan on the Gulf of Persia is a refinery port.



(iii) ***Ports of Call:*** These are the ports which originally developed as calling points on main sea routes where ships used to anchor for refuelling, watering and taking food items. Later on, they developed into commercial ports. Aden, Honolulu and Singapore are good examples.

(iv) ***Packet Station:*** These are also known as *ferry ports.* These packet stations are exclusively concerned with the transportation of passengers and mail across water bodies covering short distances. These stations occur in pairs located in such a way that they face each other across the water body, e.g. Dover in England and Calais in France across the English Channel.

(v) ***Entrepot Ports:*** These are collection centres where the goods are brought from different countries for export. Singapore is an entrepot for Asia. For e.g. Rotterdam for Europe, and Copenhagen for the Baltic region

(vi) ***Naval Ports:*** These are ports which have only strategic importance. These ports serve warships and have repair workshops for them. Kochi and Karwar are examples of such ports in India.

1.3. Air Transport

Air transport is the fastest means of movement from one place to the other. It has reduced distances by minimising the travel time. It is very essential for a vast country like India, where distances are large and the terrain and climatic conditions are diverse.

Air services can be further classified into two type's i.e. (i) domestic air services; and (ii) international services. The domestic air services provide air services by transporting passengers and goods from one part to another part within the same country; whereas international services provide connection between two or more countries.

1.3.1. Important Air Routes of the World

Generally, all the countries of the world have their own airways. But, air routes are well developed in industrially advanced countries because aeroplanes get more passengers and goods for air transport in these countries. Airlines earn a lot of profit in such countries. Areas of Dense Air routes cover Western Europe, South Eastern Canada and Eastern United States of America and South and South East Asia. Air services for different directions are available at many cities of the world.

1.3.2. Air Transport in India

Air transport in India made a beginning in 1911 when airmail operation commenced over a little distance of 10 km between Allahabad and Naini. But its real development took place in post-Independent period. In 1947, there were four companies, namely 1 Indian National Airways; 2 Tata Sons Limited, 3 Air Services of India, and 4 Deccan Airways.

The Airport Authority of India is responsible for providing safe, efficient air traffic and aeronautical communication services in the Indian Air Space. The authority manages 125 airports including 11 international, 86 domestic and 29 civil enclaves at defence air fields. To enhance airport infrastructure in India, modernization of existing airport infrastructure in metro and non-metro cities and construction of Greenfield airports were contemplated. The Twelfth Five Year Plan (2012-17) envisages an investment of Rs. 65,000 crore at Indian airports, of which a contribution of about Rs. 50,000 crore is expected from the private sector. The air transport in India was managed by two corporations, Air India and Indian Airlines after nationalisation. Now many private companies have also started passenger services. *Air India* provides International Air Services for both passengers and cargo traffic. It connects all the continents of the world through its services.

Domestic passenger traffic handled at Indian airports reached 106 million during January to November 2012; while the International passenger traffic handled at Indian airports was placed at 37.8 million during January- November 2012. International cargo throughput at Indian airports during January-November 2012 was 1.30 MMT as compared to 1.37 MMT during the previous year. Domestic cargo throughput during January- November 2012 stood at 0.73 MMT.

The Government of India approved a *Turn Around Plan* (TAP) and a Financial Restructuring Plan (FRP) for improving the operational and financial performance of Air India (AI) in April 2012. The company has taken several initiatives towards cost cutting and revenue enhancement during the year 2011-12, covering 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 from the company's real estate properties. The TAP also included operationalization of subsidiary companies in ground handling and MRO and transfer of manpower and equipment so that these could be treated as independent profit centres.

1.4. Pipeline Transport

Pipelines were used to supply water cities, factories, etc. till recently. But, nowadays, pipelines are used in transporting liquid materials mainly petroleum and its products, natural gas, slurry of iron ore and coal and even milk.

1.4.1. Advantages of Pipeline Transport

The pipeline transport provides many advantages in transport of fluid products across various centres for trade. Their salient features include-

1) It is a cheap means of transport for liquid goods.
2) Maintenance expenditure is less as compared to other modes of transport after they are laid.
3) It is possible to lay pipelines even in inaccessible and undulating areas.
4) This mode of transport is not affected by bad weather conditions.
5) There is no problem of leakage, damage and accidents in pipeline transport.

1.4.2. Limitations of Pipeline Transport

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.

1.4.3. Distribution of Pipelines in the World

The areas of the world with dense network of pipelines are as under:

(i) **United States of America** has dense network of pipelines. Most of the pipelines transport petroleum products and natural gas from the coastal areas like Gulf of Mexico to the consuming areas of north east. The total length of pipelines in USA in 2007 was 8,00,000 km. In Canada (1, 00,000 km) and Mexico (40,016 km), pipelines are also important means of transport. The most famous pipeline of the United States is called 'Big Inch'. It carries mineral oil from oil wells of Gulf of Mexico to north-eastern parts.

(ii) In many **European countries**, petroleum products and natural gas is transported through pipelines. The oil of North Sea is distributed through pipelines on the main land of the continent. Russia in 2007, alone has 2, 44,000 km long pipelines. Pipeline transport is also important in Germany and France. COMECON, 4800 km long is the longest pipeline of the world. It transports mineral oil from Volga and Ural in Russia to East European countries.

(iii) **Middle East Asia:** Oil is transported through pipelines from Saudi Arabia (6550 km), Iraq and other countries to refineries located on the Mediterranean coast. In Iran 9,800 km long pipeline exists.

(iv) **Central Asia:** The oil producing countries of central Asia i.e. Azerbaijan, Turkmenistan and Kazakhstan supply petroleum and natural gas through many pipelines to Turkey and Russia. Thousand kilometres long pipelines are under construction in this region.

1.4.4. Pipeline Transport in India

Pipeline transport in India dates back to 1959 when Oil India Limited (OIL) was incorporated as a company. Asia's first cross country pipeline covering a distance of 1,157 km was constructed by OIL from Naharkatiya oilfield in Assam to Barauni refinery in Bihar. Other extensive network of pipelines has been constructed in the western region of India of which Ankleshwar-Koyali, Mumbai High- Koyali and Hazira-Vijaipur-Jagdishpur (HVJ) are most important. Recently, a 1256 km long pipeline connecting Salaya (Gujarat) with Mathura (U.P.) has been constructed. It supplies crude oil from Gujarat to Punjab (Jalandhar) via Mathura.

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 is now extended to Kanpur in U.P.
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 offshore terminal for imported crude oil.
4. **Hajira-Vijapur-Jagdishpur (HVJ) 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 Vijapur 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.
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 Rs. 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 equivalent to transporting 3.5 lakh LPG gas cylinders across 1,269 km every day and its capacity is being increased to 5.0 lakh cylinder per day.
6. **Kandla-Bhatinda Pipeline:** This 1,331 km long pipeline is proposed to be constructed for transporting crude oil to the proposed refinery at Bhatinda. It is to be constructed by IOC at the estimated cost of Rs. 690 crore.

2. Communication

Earlier, means of transport and communication were the same. Transfer of information was done by man or animals or birds. Inventions of telegraph and telephone have given a new shape to communication system. But the revolution in the field of communication came after the invention of radio and television. This has made impossible things possible.

Major revolution in communication came when Samuel Morse invented telegraph in 1844. It played a significant role in colonisation of Western America in the 19th century. Invention of telephone in 1975 by Graham Bell and radio in 1894 by Marconi gave new direction to communication. The news was transmitted throughout the world with the help of radio and without using wire. Marconi sent the message across the Atlantic Ocean in 1901. After the fully

developed television in 1945, transmission of picture becomes possible. Modern information technology has given many forms to communication. Now, the whole world has come closer together with the help of these communication aids such as cellular phone, E-mail, Fax, Internet, etc. Compared to means of transport, the means of communication have transformed the world into a **'global village'.**

Internet is today the world's most important means of communication. It has added new dimensions to international trade, banking, remote sensing and other aspects. Today, the Internet is used in a variety of fields like, education, trade, banking, management, industry, communication, health and surgery, scientific research, meteorology, administration and in hundreds of other fields. Internet is a huge reservoir of knowledge. According to one estimate, almost half of the world's population will be connected by internet by 2020.

On the basis of scale and quality, the mode of communication can be divided into following categories: a) Personal Communication System and b) Mass Communication System.

2.1. Personal Communication System

Personal Communication System includes use of letters, telephones, telegrams, fax, emails, internet etc. Among the above means, internet is the most widely used and most effective means of communication in urban areas. The network through internet and e-mail provides an efficient access to information at a comparatively low cost. It enables us with the basic facilities of direct communication. In the rural areas, telephones and letters play the role of bridging the people. With the development of technology, internet is expected to soon penetrate in the rural areas too.

2.2. Mass Communication System

Mass communication system includes usage of radio, television, cinema, satellite, newspaper, magazine and book, public meetings, seminars and conferences etc. It focuses on a single source transmitting information to a large group of receivers.

2.2.1. Radio

Radio broadcasting started in India in 1923 by the Radio Club of Bombay. Since then, it gained immense popularity and changed the socio-cultural life of people. Government brought Radio Broadcasting under its control in 1930 under the Indian Broadcasting System. It was changed to All India Radio in 1936 and to Akashwani in 1957. All India Radio broadcasts a variety of programmes related to information, education and entertainment. With the start of FM radio services in the country, radio has reached new standards in the country.

FM broadcasting began on 23 July 1977 in Chennai, then Madras, and was expanded during the 1990s. Times FM (now Radio Mirchi) began operations in 1993 in Ahmedabad. Until 1993, All India Radio or AIR, a government undertaking, was the only radio broadcaster in India. Indian policy currently states that these broadcasters are assessed a *One-Time Entry Fee (OTEF*), for the entire license period of 10 years. Under the Indian accounting system, this amount is amortised over the 10 year period at 10% per annum. Annual license fee for private players is either 4% of revenue share or 10% of Reserve Price, whichever is higher.

2.2.2. Television (T.V.)

Television broadcasting has emerged as the most effective audio-visual medium for disseminating information and educating masses. Initially, the T.V. services were limited *Television (T.V.)* Television broadcasting has emerged as the most effective audio-visual medium for disseminating information and educating masses. Initially, the T.V. services were limited only to the National Capital where it began in 1959. After 1972, several other centres became

operational. In 1976, TV was delinked from All India Radio (AIR) and got a separate identity as Doordarshan (DD). After INSAT-IA (National Television-DD1) became operational, Common National Programmes (CNP) was started for the entire network and its services were extended to the backward and remote rural areas.

Asianet was the first private channel in India and also most popular in India. The central government launched a series of economic and social reforms in 1991 under Prime Minister Narasimha Rao. Under the new policies the government allowed private and foreign broadcasters to engage in limited operations in India. This process has been pursued consistently by all subsequent federal administrations. Foreign channels like CNN, STAR TV and private domestic channels such as Zee TV, ETV and Sun TV started satellite broadcasts. Starting with 41 sets in 1992 and one channel, by 1995, TV in India covered more than 70 million homes giving a viewing population of more than 400 million individuals through more than 100 channels.

There are *five basic types of television* in India: broadcast or "over-the-air" television, unencrypted satellite or "free-to-air", Direct-to-Home (DTH), cable television, and IPTV. Over-the-air and free-to-air TV is free with no monthly payments while Cable, DTH, and IPTV require a monthly payment that varies depending on how many channels a subscriber chooses to pay for. Channels are usually sold in groups or *a la carte*. All television service providers are required by law to provide a la carte selection of channels.

2.2.3. Satellite Communication

The beginning of era of space in the world took place with the sending of artificial satellite-Sputnik in the space on 4th October, 1957. India has placed its own satellites in orbit for communication and surveying of national resources through remote sensing techniques. This has helped in giving telephone connections to each village. Now, a resident of a small village of India can talk via mobile or satellite phone from his home to his relative or friend sitting in anywhere in the world. Artificial satellites, now, are successfully deployed in the earth's orbit to connect even the remote corners of the globe with limited onsite verification. These have rendered the unit cost and time of communication invariant in terms of distance. This means it costs the same to communicate over 500 km as it does over 5,000 km via satellite

On the basis of configuration and purposes, satellite system in India can be grouped into two: *Indian National Satellite System* (**INSAT**) and *Indian Remote Sensing Satellite System* (**IRS**). The INSAT is a multipurpose satellite system for telecommunication, meteorological observation and for various other data and programmes. Established in 1983 with commissioning of INSAT-1B, it initiated a major revolution in India's communications sector and sustained the same later. INSAT space segment consists of 24 satellites out of which 10 are in service (INSAT-3A, INSAT-4B, INSAT-3C, INSAT-3E, KALPANA-1, INSAT-4A, INSAT-4CR,GSAT-8, GSAT-12 and GSAT-10).The system with a total of 168 transponders in the C, Extended C and Ku-bands provides services to telecommunications, television broadcasting, weather forecasting, disaster warning and Search and Rescue operations[2].

The IRS satellite system became operational with the launching of IRS-IA in March 1988 from Vaikanour in Russia. India has also developed her own Launching Vehicle PSLV (Polar Satellite Launch Vehicle). These satellites collect data in several spectral bands and transmit them to the ground stations for various uses. The National Remote Sensing Agency (NRSA) at Hyderabad

[2] For complete list of Indian Communication Satellites, please visit http://en.wikipedia.org/wiki/List_of_Indian_satellites and http://www.isro.org/satellites/allsatellites.aspx

provides facilities for acquisition of data and its processing. These are very useful in the management of natural resources.

3. International Trade

A transaction of any kind between two or more parties is called **trade.** It may takes place at two main levels - international and national. International trade is the exchange of goods and services among two or more countries of the world. There are various reasons although economic causes like availability and lower price are generally the main cause for international trade to take place.

The initial form of trade in primitive societies was the **barter system**, where direct exchange of goods took place. It was the system prevailing in the beginning and is considered the forerunner of modern trade. The barter system of exchange was a difficult and cumbersome process. One had not only to search for sellers and buyers but also carry a lot of weight amid any season of the year. There were other difficulties as well like making enquiries to find out what was required and what not. All this was overcome with *the* introduction of money. In the olden times, before paper and coin currency came into being, rare objects with very high intrinsic value served as money, like, flint stones, obsidian, *cowrie* shells, tiger's paws, whale's teeth, dogs teeth, skins, furs, cattle, rice, peppercorns, salt, small tools, copper, silver and gold.

The **Silk Route** was an excellent example of early organised international trade between distant lands. The 6,000 km long Silk Route linked Rome to China with other connecting points like India, Persia and Central Asia. The traders transported through this route Chinese silk, Roman wool and precious metals and many other high value commodities. After disintegration of Roman Empire, ascendancy of Europe began in 12th and 13th centuries. Trade flourished along with naval warfare. There was considerable rise in Asian and European trade which helped the discovery of new land including Americas.

Fifteenth century onwards, the European colonialism began and along with trade of exotic commodities, a new form of trade emerged which was called **slave trade.** The Portuguese, Dutch, Spaniards, and British captured African natives and forcefully transported them to the newly discovered Americas for their labour in the plantations.

After the Industrial Revolution the demand for raw materials like grains, meat and wool also expanded, but their monetary value declined in relation to the manufactured goods. The industrialised nations imported primary products as raw materials and exported the value added finished products back to the non-industrialised nations. In the later half of the nineteenth century, regions producing primary goods were no more important, and industrial nations became each other's principle customers.

During the World Wars I and II, there were concerns about security, taxes and quantitative restrictions imposed by many countries for the first time. As a result of these concerns organisations like General Agreement for Tariffs and Trade (GATT) later christened the **World Trade Organisation (WTO)** came into being. Their first task was to work towards reducing tariff, which many countries had imposed. International trade is the result of specialisation in production**.** It benefits the world economy if different countries practise specialisation and division of labour in the production of commodities or provision of services. Thus, international trade is based on the principle of comparative advantage, complimentarity and transferability of goods and services and in principle, should be mutually beneficial to the trading partners.

Trends in Growth in Trade Volumes

(per cent change)

			Projections	
	2011	2012	2013	2014
World trade volume (goods and services)	**5.9**	**2.8**	**3.8**	**5.5**
Imports				
Advanced economies	4.6	1.2	2.2	4.1
Emerging market & developing economies	8.4	6.1	6.5	7.8
Exports				
Advanced economies	5.6	2.1	2.8	4.5
Emerging market & developing economies	6.6	3.6	5.5	6.9

Source: International Monetary Fund (IMF), World Economic Outlook Update, January 2013.

3.1. Factors influencing International Trade

There are many factors which influence the international trade. Important among these are described below:

Inequality in Natural Resources: The distribution of natural resources is uneven in the world. Due to diversity in geological structure, climate, natural vegetation, soil, etc., different types of natural resources are found in different countries. Some countries possess some resources more than their requirement. These countries export their products to the countries which are either poor in reserves or do not have any reserve. Hence, inequality in natural resources is the main base of international trade. This inequality is on account of three important reasons:

1) ***Geological structure:*** The diversity of relief is influenced by geological structure which is turn determines mineral resources base and diversity of agriculture and crops as well animals raised. For e.g. Lowlands have greater agricultural potential. Mountains attract tourists and promote tourism.
2) ***Mineral resources:*** They are unevenly distributed the world over. The availability of mineral resources provides the basis for industrial development.
3) ***Climate:*** It influences the type of flora and fauna that can survive in a given region. It also ensures diversity in the range of various products, e.g. wool production can take place in cold regions, bananas, rubber and cocoa can grow in tropical regions.

Population factors: Population size, distribution, diversity as well as people's tastes, likes and dislikes determine the type and volume of goods traded. Two important population factors are:

a) ***Cultural factors:*** Distinctive forms of art and craft develop in certain cultures which are valued the world over, e.g. China produces the finest porcelains and brocades. Carpets of Iran are famous while North African leather work and Indonesian batik cloth are prized handicrafts.
b) ***Size of population:*** Densely populated countries have large volume of internal trade but little external trade because most of the agricultural and industrial production is consumed in the local markets. Standard of living of the population determines the demand for better quality imported products because with low standard of living only a few people can afford to buy costly imported goods.

Stage of Economic Development: At different stages of economic development of countries, the nature of items traded undergoes changes. In agriculturally important countries, agro products are exchanged for manufactured goods whereas industrialised nations export machinery and finished products and import food grains and other raw materials.

Extent of foreign investment: Foreign investment can boost trade in developing countries which lack in capital required for the development of mining, oil drilling, heavy engineering,

and lumbering and plantation agriculture. By developing such capital intensive industries in developing countries, the industrial nations ensure import of food stuffs, minerals and create markets for their finished products. This entire cycle steps up the volume of trade between nations.

Production more than Requirement: Some countries produce more than their requirement because of their favourable environment conditions, technological efficiency and skilled labour. Hence, these countries export their surplus products to other countries.

Shortage of Goods: No country is independent in all its requirement of goods. There exists shortage of some or the other goods. For example, Japan has technology for producing best quality steel and other means, but it lacks iron ore and coal. Hence, it overcomes the shortage of raw materials by importing them from India and Australia.

Development of Transport and Communication: Transport and communication are the main bases of international trade. Surface, water, air and pipeline transport are required for transferring goods from surplus producing countries to the countries of shortage.

Technological Inequality: Some countries have developed some specific type of technology which could not be developed by other countries. For example, United States of America and France have high level technology for building passenger aeroplanes. Other countries of the world purchase aeroplanes from these countries so as to meet their demand.

Trade Policies: Developing countries provide some concessions to exporters for boosting their export e.g. tax concessions, economic aid, etc. Such policies of the government aim to balance the trade in the country's favour or to enhance the foreign currency reserve, because export help to earn more foreign money. Many countries levy heavy taxes on goods of import so as to check their import and promote their local industries.

Economic Demand: Notwithstanding these bases, if there is no economic demand of goods, its international trade is impossible in such a situation. A country may have any quantity of surplus production but without demand, it cannot be goods of trade. When it becomes an economic demand, the country tries to procure it.

3.2. Components of International Trade

International trade has three very important aspects. These are volume, sectoral composition and direction of trade.

Volume of Trade: Volume of trade can be measured in three different ways: (a) Actual tonnage of goods traded; (b) Total volume and value of goods and; (c) Value on per capita basis. However, services traded cannot be measured in tonnage. Therefore, the **total value** of goods and services traded is considered to be the volume of trade.

Composition of Trade: The nature of goods and services imported and exported by countries have undergone changes during the last century. There has been a steady rise in the volume and prices of manufactured goods. On account of rapid growth of trade of manufactured goods there has been rapid growth of manufacturing industries. Thus, the prices of manufactured goods on account of large supplies are coming down. The trend of decrease in prices of manufactured goods is also on account of decrease in tariff barriers under the World Trade Organisation (WTO).

Direction of International Trade: Historically, the developing countries of the present used to export valuable goods and artefacts, etc. which were exported to European countries. During the nineteenth century there was a reversal in the direction of trade. European countries started exporting manufactured goods for exchange of foodstuffs and raw materials from their colonies. However, during the second half of the twentieth century, Europe lost its colonies

while India, China and other developing countries started competing with developed countries. The nature of the goods traded has also changed.

3.3. Types of International Trade

International trade may be categorised into two types: (a) **Bilateral trade**: Bilateral trade is done by two countries with each other. They enter into agreement to trade specified commodities amongst them. For example, country A may agree to trade some raw material with agreement to purchase some other specified item to country B or vice versa. (b) **Multi-lateral trade**: As the term suggests multi-lateral trade is conducted with many trading countries. The same country can trade with a number of other countries. The country may also grant the status of the "*Most Favoured Nation*" (MFN) on some of the trading partners.

3.4. International Pattern of Trade

1) On account of globalisation of agricultural and industrial products, the international trade become highly complex.
2) Fast Growth Rate: The volume of trade is growing very fast.
3) The rate of growth of export trade is almost double that of production rate.
4) The rate of growth of export trade is many times more than the rate of growth of world population.
5) About 25 per cent of world production has now entered international trade.

3.5. Regional Trade Blocs and World Trade Organisation (WTO)

In1948, to liberalise the world from high customs tariffs and various other types of restrictions, General Agreement for Tariffs and Trade (GATT) was formed by some countries. In 1994, it was decided by the member countries to set up a permanent institution for looking after the promotion of free and fair trade amongst nation and the GATT was transformed into the World Trade Organisation from 1st January 1995.

WTO is the only international organisation dealing with the global rules of trade between nations. It sets the rules for the global trading system and resolves disputes between its member nations. WTO also covers trade in services, such as telecommunication and banking, and others issues such as intellectual rights.

Regional Trade Blocs have come up in order to encourage trade between countries with geographical proximity, similarity and complementarities in trading items and to curb restrictions on trade of the developing world. Today, 120 regional trade blocs generate 52 per cent of the world trade. These trading blocs developed as a response to the failure of the global organisations to speed up intra-regional trade. Though, these regional blocs remove trade tariffs within the member nations and encourage free trade, in the future it could get increasingly difficult for free trade to take place between different trading blocs.

Major Regional Trade Blocs

Regional Blocs	Head Quarters	Member Nations	Origin	Commodities	Other areas of co-operation
ASEAN (Association of South East Asian Nations)	Jakarta, Indonesia	Brunei, Indonesia, Malaysia, Singapore, Thailand, Vietnam, Philippines, Myanmar, Cambodia, Laos	Aug, 1967	Agro products, rubber, palm oil, rice, copra, coffee, minerals – copper, coal, nickel and tungsten; Energy – petroleum and natural gas and Software products	Accelerate economic growth, Cultural development, Peace and regional stability

CIS (Commonwealth of Independent States)	Minsk, Belarus	Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan.	-	Crude oil, natural gas, gold, cotton, fibre, aluminium	Integration and cooperation on matters of economics, defence and foreign policy
EU (European Union)	Brussels, Belgium	Austria, Belgium, Denmark, France, Finland, Ireland, Italy, the Netherlands, Luxemburg, Portugal, Spain, Sweden and U.K.	EEC - March 1957 EU - Feb. 1992	Agro products, minerals, chemicals, wood, paper, transport vehicles, optical instruments, clocks - works of art, antiques	Single market with single currency
LAIA (Latin American Integration Association)	Montevideo, Uruguay	Argentina, Bolivia, Brazil, Columbia, Ecuador, Mexico, Paraguay, Peru, Uruguay and Venezuela	1960	-	-
NAFTA (North American Free Trade Association)		U.S.A., Canada and Mexico	1994	Agro products, motor vehicles, automotive parts, computers, textiles	-
OPEC (Organisation of Petroleum Exporting Countries)	Vienna, Austria	Algeria, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, U.A.E. and Venezuela	1949	Crude petroleum	Coordinate and unify petroleum policies
SAFTA (South Asian Free Trade Agreement)		Bangladesh, Maldives, Bhutan, Nepal, India, Pakistan and Sri Lanka	Jan-2006	-	Reduce tariffs on interregional trade

3.6. Balance of Trade

Balance of Trade includes all transactions in goods and services including international aid and investments appearing in the current account of a country. By balances of trade we are able to compare the import-export of goods and *services* into a country. When the value of exported goods of a country exceeds the value of imported goods, it is called *positive balance of trade.* Contrary to this, if the value of imported goods exceeds the value of exported goods, it is called *negative trade balance.*

Global Top 10 Trading Countries[3]

Rank	Exporter	Value	Share	Annual Percentage Change	Rank	Importers	Value	Share	Annual Percentage Change
1	China	2049	11.1	8	1	USA	2336	12.6	3
2	USA	1546	8.4	4	2	China	1818	9.8	4
3	Germany	1407	7.6	-5	3	Germany	1167	6.3	-7
4	Japan	799	4.3	-3	4	Japan	886	4.8	4
5	Netherland	656	3.6	-2	5	UK	690	3.7	2
6	France	569	3.1	-5	6	France	674	3.6	-6
7	S.Korea	548	3.0	-1	7	Netherland	591	3.2	-1
8	Russia	528	2.9	1	8	Hong Kong	553	3.0	8
9	Italy	501	2.7	-4	9	S. Korea	520	2.8	-1
10	Hong Kong	493	2.7	8	10	India	490	2.6	5

Values in Billion Dollar and Percentage

3.7. Concerns Related to International Trade

International trade is mutually beneficial to nations provided the following conditions are met:

1) It leads to domestic competitiveness and enhances regional specialisation.
2) Increases sales and organisations *achieve* higher level of production
3) *Improves* standard of living both through income and employment opportunities.
4) It makes goods and *services* available globally.
5) Through enhancing sales potential there is equalisation of prices and wages.
6) International trade technology leads to diffusion of knowledge and culture.

3.8. Limitations of International Trade

The limitations and demerits of the international trade can be studied as follows:

1) It creates a scenario dependence on other countries.
2) More inequalities and *uneven* levels of development are created.
3) International trade promoted exploitation, and commercial rivalry leading to wars
4) Global trade affects many aspects of life.
5) Through rapid changes in consumption and production pattern, international trade impacts everything from the environment to health and well-being of the people around the world.
6) International trade works to economy's and a company's advantage and leads to more, production and the use of natural resources. It is detrimental to resources' consumption.
7) Resources get used up at a faster rate than they can be replenished.

[3] Leading exporters and importers in World merchandise trade, 2012

8) Through increased shipping on account of increase in tourism and trade marine life depletes fast.
9) As a result of exploitation of natural resources forests are being cut down.
10) The *river* basins and underground water are used sold off to private drinking water companies.
11) There is more pollution on account of expanding business especially by multinational corporations trading in oil, gas mining, pharmaceuticals and agri-business.
12) The norms of sustainable development are neglected as there is more profit maximisation.

3.9. India's Foreign Trade

After moderating in the two years following the global economic crisis, world trade in both goods and services in the financial year 2013-14 reached and surpassed pre-crisis levels in 2011. However, the deceleration in world growth and trade in 2012 and forecast of only a gradual upturn in global growth by international institutions portend a weak and slow recovery for world trade.

India's merchandise trade increased exponentially in the 2000s decade from US$ 95.1 billion in 2000-1 to US$ 620.9 billion in 2010-11 and further to US$ 793.8 billion in 2011-12. India's share in

Commodity Composition of India's Imports

Commodity Group	Percentage share					CAGR	Growth rate[a]			
	2000-01	2010-11	2011-12	2011-12 (Apr.-Nov.)	2012-13 (Apr.-Nov.)	2000-01 to 2009-10	2010-11	2011-12	2011-12 (Apr.-Nov.)	2012-13 (Apr.-Nov.)
I. Food and allied products, of which	**3.3**	**2.9**	**3.1**	**3.1**	**3.5**	**22.7**	**2.2**	**44.4**	**38.0**	**11.6**
1. Cereals	0.0	0.0	0.0	0.0	0.0	24.3	15.8	-34.2	-46.6	6.8
2. Pulses	0.2	0.4	0.4	0.4	0.4	38.3	23.1	27.2	11.3	9.2
3. Edible oils	2.6	1.8	2.1	2.1	2.5	17.2	19.0	57.7	55.3	18.0
II. Fuel, of which	**33.5**	**30.9**	**37.4**	**34.3**	**38.0**	**21.0**	**22.4**	**59.7**	**52.3**	**9.8**
4. POL	31.3	28.7	31.7	30.7	34.6	21.0	21.6	46.2	50.6	11.7
III. Fertilizers	**1.3**	**1.9**	**2.4**	**2.3**	**2.2**	**29.0**	**4.8**	**72.1**	**32.2**	**-6.8**
IV. Capital goods, of which	**10.5**	**13.6**	**14.1**	**12.6**	**11.8**	**26.1**	**19.2**	**36.9**	**25.6**	**-6.5**
5. Machinery except electrical & machine tool	5.9	7.0	7.2	6.7	6.3	24.4	24.0	35.8	28.2	-5.8
6. Electrical machinery	1.0	1.0	1.0	1.0	0.9	22.7	25.1	33.1	26.6	-5.5
7. Transport equipment	1.4	3.1	3.0	2.5	2.3	36.4	-0.9	31.8	13.1	-8.3
V. Others, of which	**52.5**	**49.6**	**49.0**	**47.6**	**44.3**	**19.3**	**43.2**	**30.8**	**29.6**	**-7.6**
8. Chemicals	5.9	5.2	5.1	5.0	5.1	19.5	29.6	31.8	24.3	1.1
9. Pearls, precious, semi-precious stones	9.7	9.3	6.1	6.1	4.1	14.0	116.9	-13.3	4.3	-32.3
10. Gold & silver	9.3	11.5	12.6	13.0	10.5	23.0	43.0	44.5	59.2	-20.4
11.Electronic goods	7.0	7.1	7.1	7.0	6.5	21.6	28.4	31.7	22.2	-7.7
Total imports	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**21.5**	**28.2**	**32.3**	**36.2**	**-0.8**

Source: Computed from DGCI&S data. [a] Growth rate in US dollar terms

global exports and imports also increased from 0.7 per cent and 0.8 per cent respectively in 2000 to 1.7 per cent and 2.5 per cent in 2011 as per the WTO. Bolstered by the measures taken by the government to help exports in the aftermath of the world recession of 2008 and the low base effect, India's export growth in 2010-11 reached an all time high since Independence of 40.5 per cent. Though it decelerated in 2011-12 to 21.3 per cent, it was still above 20 per cent and higher than the compound annual growth rate (CAGR) of 20.3 per cent for the period 2004-5 to 2011-12.

India faced serious food shortage during 1950s and 1960s. The major item of import at that time was food grain, capital goods, machinery and equipments. The balance of payment was adverse as imports were more than export in spite of all the efforts of import substitution. After 1970s, food grain import was discontinued due to the success of green revolution but the energy crisis of 1973 pushed the prices of petroleum, and import budget was also pushed up. Food grain import was replaced by fertilisers and petroleum. Machine and equipment, special steel, edible oil and chemicals largely make the import basket.

The export-import ratio highlights the direction of trade between the two countries. Most of the countries want to maintain this ratio greater than one in order to boost their exports and reduce dependency on imports. A look at the trade share and export-import ratio of India with its major trading partners is as follows:

Sl. No.	Country	Share in total trade					Export/Import ratio[a]				
		2009-10	2010-11	2011-12	2011-12 (Apr-Nov.)	2012-13 (Apr-Nov.)	2009-10	2010-11	2011-12	2011-12 (Apr-Nov.)	2012-13 (Apr-Nov.)
1	China	9.09	9.50	9.52	9.62	8.95	0.38	0.36	0.31	0.29	0.23
2	U A E	9.31	10.72	9.03	8.99	9.74	1.23	1.03	1.00	0.98	0.92
3	U SA	7.82	7.30	7.46	7.29	8.23	1.15	1.26	1.42	1.42	1.51
4	Saudi Arabia	4.50	4.04	4.63	4.57	5.43	0.23	0.23	0.18	0.17	0.28
5	Switzerland	3.27	4.11	4.22	4.30	3.50	0.04	0.03	0.03	0.03	0.04
6	Singapore	3.01	2.73	3.21	3.30	2.53	1.18	1.38	1.96	1.85	1.75
7	Germany	3.37	3.00	3.05	3.02	2.75	0.52	0.57	0.49	0.50	0.48
8	Hong Kong	2.70	3.18	2.97	3.09	2.53	1.67	1.10	1.21	1.09	1.51
9	Indonesia	2.51	2.52	2.68	2.69	2.50	0.35	0.57	0.46	0.38	0.34
10	Iraq	1.61	1.56	2.48	2.49	2.73	0.07	0.08	0.04	0.03	0.07
11	Japan	2.22	2.21	2.32	2.19	2.29	0.54	0.59	0.52	0.46	0.47
12	Belgium	2.09	2.32	2.22	2.21	1.91	0.62	0.67	0.69	0.71	0.52
13	Kuwait	1.93	1.96	2.21	2.02	2.38	0.09	0.18	0.07	0.08	0.06
14	Korea RP	2.57	2.29	2.20	2.20	2.30	0.40	0.36	0.33	0.35	0.29
15	Nigeria	1.86	2.08	2.19	2.19	2.14	0.19	0.19	0.18	0.18	0.20
	Total of 15 countries	57.84	59.50	60.40	60.16	59.91	0.58	0.55	0.51	0.49	0.50
	India's trade	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**0.62**	**0.68**	**0.62**	**0.62**	**0.58**

Source **: Computed from DGCI&S data.**

Note **: [a] A coefficient of export and import ratio between 0 and 1 implies that India's imports are greater than exports and if the coefficient is greater than one, India exports more than what it imports.**

3.10. Challenges in International Trade for India

The challenges for India on the trade front are many. While India has successfully diversified its export basket, more needs to be done on the product diversification front. It also has to reposition itself in its traditional areas of strength like textiles and leather & leather manufactures where it has lost considerable ground, while at the same time making forays into new areas. With multilateral trade negotiations stalled, and RTAs on the rise, India also has to follow a strategic regional trading policy focusing on the potential technology-intensive items in the more important RTAs. Though geopolitical considerations are important, India may have to bargain more in its regional trade negotiations, particularly in cases where livelihood concerns of large pockets of the population are involved, There is also need to address the inverted duty structure in sectors like electronics, textiles, and chemicals and the artificial inverted duty structure caused by some FTAs/RTAs. On the services front, a gold mine of opportunity in sectors like tourism including health tourism is waiting to be tapped.

Thus there are many micro, port-specific and sector-specific issues that need urgent attention. These are related to infrastructure, trade facilitation, tax and tariffs, and credit, and can realistically be addressed in the short and medium term. Addressing these issues, as is currently being done by the government, can exponentially promote India's export growth.

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Student Notes:

LOCATION OF INDUSTRIES

Contents

1. Factors affecting Location of Industries

The location of industry at a particular place is the result of a number of decisions taken at various levels. There are certain geographical factors which facilitate this decision making. There are other factors which fall outside the subject matter of geography. The validity or importance of a factor also changes with time and space.

Industries maximise profits by reducing costs. Therefore, industries should be located at points where the production costs are minimum. Some of the factors influencing industrial locations are as under:

1.1. Access to Market

The existence of a market for manufactured goods is the most important factor in the location of industries. 'Market' means people who have a demand for these goods and also have the purchasing power (ability to purchase) to be able to purchase from the sellers at a place. Many industries are located near large urban centres because the concentration of population in those areas ensures readily available market. Remote areas inhabited by a few people offer small markets.

The developed regions of Europe, North America, Japan and Australia provide large global markets as the purchasing power of the people is very high. The densely populated regions of South and South-east Asia also provide large markets. Some industries, such as aircraft manufacturing, have a global market. The arms industry also has global markets.

1.2. Access to Raw Material

Raw material used by industries should be cheap and easy to transport. Raw materials are the basic requirements for manufacturing industry. Some raw materials lose weight during processing but others do not. **Industries based on cheap, bulky and weight-losing material (ores) are located close to the sources of raw material such as steel, sugar, and cement industries**. *Perishability* is a vital factor for the industry to be located closer to the source of the raw material. Agro-processing and dairy products are processed close to the sources of farm produce or milk supply respectively.

Many industries do not require much of raw materials and these can be located anywhere independent of raw material sources such as garment and electronic industries. There are some industries which are not wedded to any particular raw material. Such industries are known as *foot-loose* industries.

With the expansion and development of means of transportation the role of raw materials in location of industries has almost lost its significance. The establishment of iron and steel industry in Japan and cotton textile industry in Liverpool prove the fact that the multi-nationals and countries with sufficient capital can manipulate the means of transportation in their favour and obtain raw materials.

1.3. Access to Labour Supply

Labour supply is an important factor in the location of industries. Two aspects of labour are important for the location of industry. **First, the availability of cheap labour in large numbers and second, the level of their skills**. For labour intensive industries, cheap labour should be available. Skilled labour is costly but their efficiency and skill compensate for the higher wages. Some industries are located at a particular place due to the availability of skilled labour like electronic industry in Japan, glass industry in Ferozabad (Uttar Pradesh) and utensil industry in Jagadhari and Moradabad.

Labour is more mobile than other factors of production. It can be moved from villages to towns, from towns to metropolis, from one industry or place to another or even from one country to the other country. This mobility is namely ascribed to differential wage rates in different situations.

1.4. Access to Sources of Energy

In the earlier phase of the industrial revolution, the industries were generally located near the source of energy as they have fixed locations. Now, large scale generation of hydroelectric power and ability to transmit at high voltage to far off places and proper distribution over larger areas through grid system have made it possible to take the energy to any location. Thus the dependence of industries for their location on energy resources has considerably reduced. However, some energy intensive industries such as aluminium industry are still located near the energy sources.

1.5. Access to Transportation and Communication Facilities

Speedy and efficient transport facilities to carry raw materials to the factory and to move finished goods to the market are essential for the development of industries. The cost of transport plays an important role in the location of industrial units. **Modern industry is inseparably tied to transportation systems. Improvements in transportation led to integrated economic development and regional specialisation of manufacturing.**

The means of transportation help in the development of industry. **At the same time, after the location of industries at a place, the means of transportation also develop very fast.** The concentration of large industries in the Great Lakes region has been caused by cheap means of water transportation provided by the lakes. Almost all large industrial towns in Japan are ports. The cheap water transport has facilitated the development and concentration of Jute mills in the Hoogly valley in India and large industrial towns in the Rhine valley of Europe.

1.6. Government Policy

Sometimes Government adopt 'regional policies' to promote 'balanced' economic development and hence set up industries in particular areas.

1.7. Access to Agglomeration Economies/Links Between Industries

Many industries benefit from nearness to a leader-industry and other industries. These benefits are termed as agglomeration economies. Savings are derived from the linkages which exist between different industries.

1.8. Other Miscellaneous Factors

Some other factors are crucial for the location of certain industries, for example, the cotton mills were established earlier in the hinterland of Bombay because coastal location provided high humidity in the air. It prevented the yarn from breaking. Now it is possible to maintain the required amount of humidity in the mills with technological intervention. It is therefore, possible to establish spinning mills away from the coast.

Water is an important factor in industrial location. It is required in large quantities in cotton textile industry for bleaching and in Iron and steel industry for cooling. It is possible, now, to carry water from one place to the other through pipelines. In certain situations the demand of water is so large that it cannot be met through transportation of water and such establishments are taken to the sources of water such as nuclear reactors.

The location of some industries is decided by institutional factors like historical, social and political decisions. Location of industries in backward regions in order to reduce economic

disparity and shifting of industries to the interior parts of a country due to strategic reasons during war are examples of institutional decisions in the location of industries.

So, the location of modem industries is not guided by a single factor due to its complex nature. All aspects have to be considered and analysed before deciding location of industries.

2. Primary Activities

Primary activities are directly dependent on environment as these refer to utilisation of earth's resources such as land, water, vegetation, building materials and minerals. It, thus includes, hunting and gathering, pastoral activities, fishing, forestry, agriculture, and mining and quarrying.

2.1. Hunting and Gathering

The earliest human beings depended on their immediate environment for their sustenance. They subsisted on: (a) animals which they hunted; and (b) the edible plants which they gathered from forests in the vicinity.

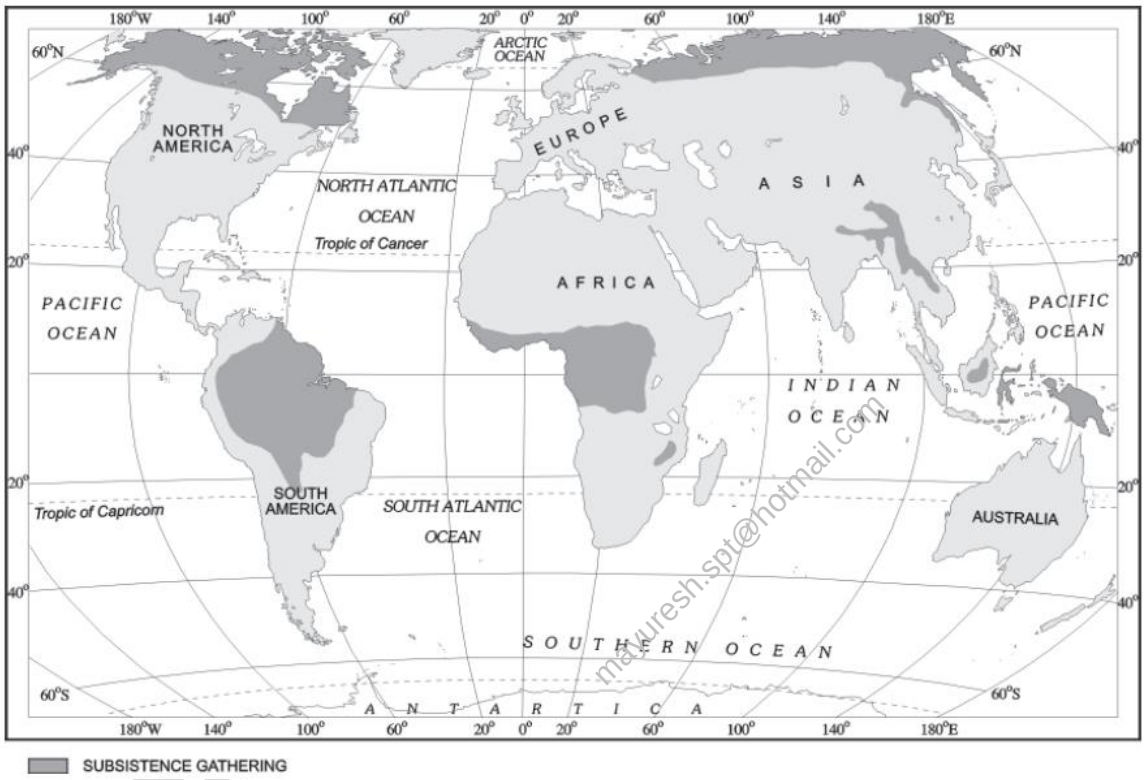

Fig 1. Areas of Gathering

Gathering is practised in regions with harsh climatic conditions. It often involves primitive societies, which extract, both plants and animals to satisfy their needs for food, shelter and clothing. This type of activity requires a small amount of capital investment and operates at very low level of technology. The yield per person is very low and little or no surplus is produced.

Gathering is practised in:

- High latitude zones which include northern Canada, northern Eurasia and southern Chile;
- Low latitude zones such as the Amazon Basin, tropical Africa, Northern fringe of Australia and the interior parts of Southeast Asia.

In modern times some gathering is market oriented and has become commercial. Gatherers collect valuable plants such as leaves, barks of trees and medicinal plants and after simple processing sell the products in the market.

2.2. Pastoralism or Animal Rearing

At some stage in history, with the realisation that hunting is an unsustainable activity, human beings thought of **domestication of animals**. People living in different climatic conditions selected and domesticated animals found in those regions. Depending on the geographical factors, and technological development, animal rearing today is practised either at the subsistence or at the commercial level.

2.2.1. Nomadic Herding

Nomadic herding or pastoral nomadism is a primitive subsistence activity, in which the herders rely on animals for food, clothing, shelter, tools and transport. They move from one place to another along with their livestock, depending on the amount and quality of pastures and water. A wide variety of animals is kept in different regions. In tropical Africa, cattle are the most important livestock, while in Sahara and Asiatic deserts, sheep, goats and camel are reared. In the mountainous areas of Tibet and Andes, yak and llamas and in the Arctic and sub-Arctic areas, reindeer are the most important animals.

Pastoral nomadism is associated with three important regions. **The core region extends from the Atlantic shores of North Africa eastwards across the Arabian peninsula into Mongolia and Central China. The second region extends over the tundra region of Eurasia. In the southern hemisphere there are small areas in South-West Africa and on the island of Madagascar**.

2.2.2. Commercial Livestock Rearing

Unlike nomadic herding, commercial livestock rearing is more organised and capital intensive. Commercial livestock ranching is essentially associated with western cultures and is practised on permanent ranches. These ranches cover large areas and are divided into a number of parcels, which are fenced to regulate the grazing. When the grass of one parcel is grazed, animals are moved to another parcel. The number of animals in a pasture is kept according to the carrying capacity of the pasture.

New Zealand, Australia, Argentina, Uruguay and United States of America are important countries where commercial livestock rearing is practised.

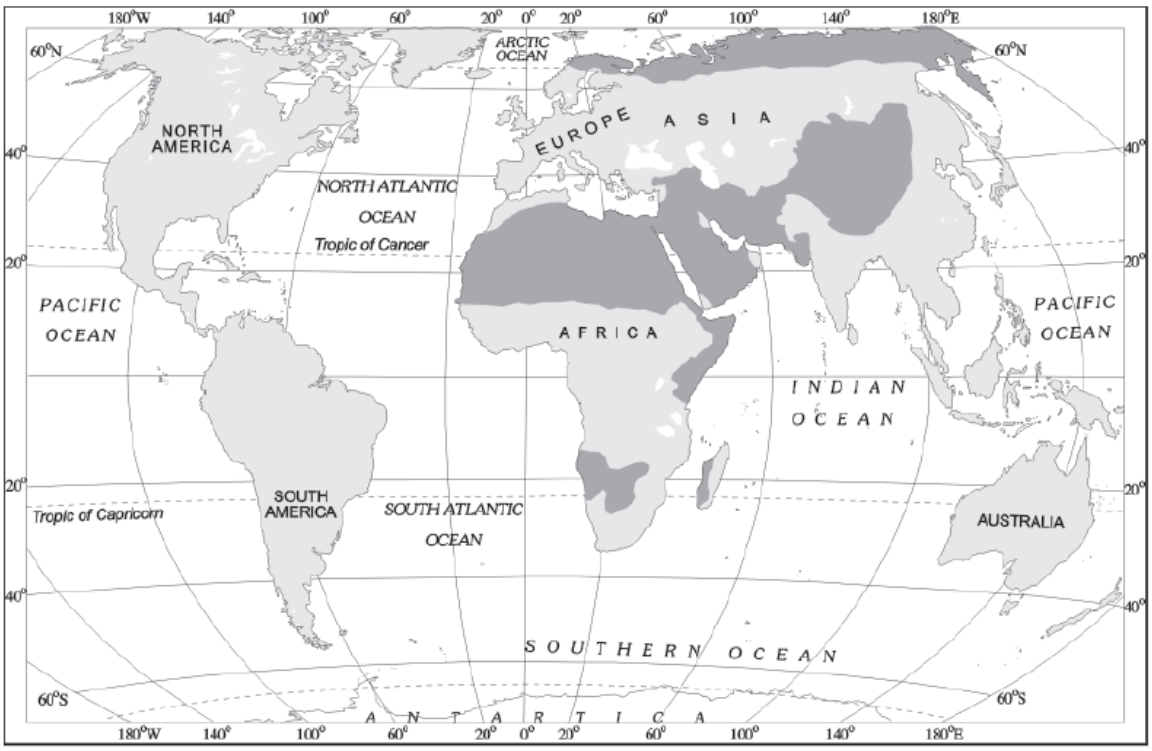

Fig. 2 Areas of Nomadic Herding

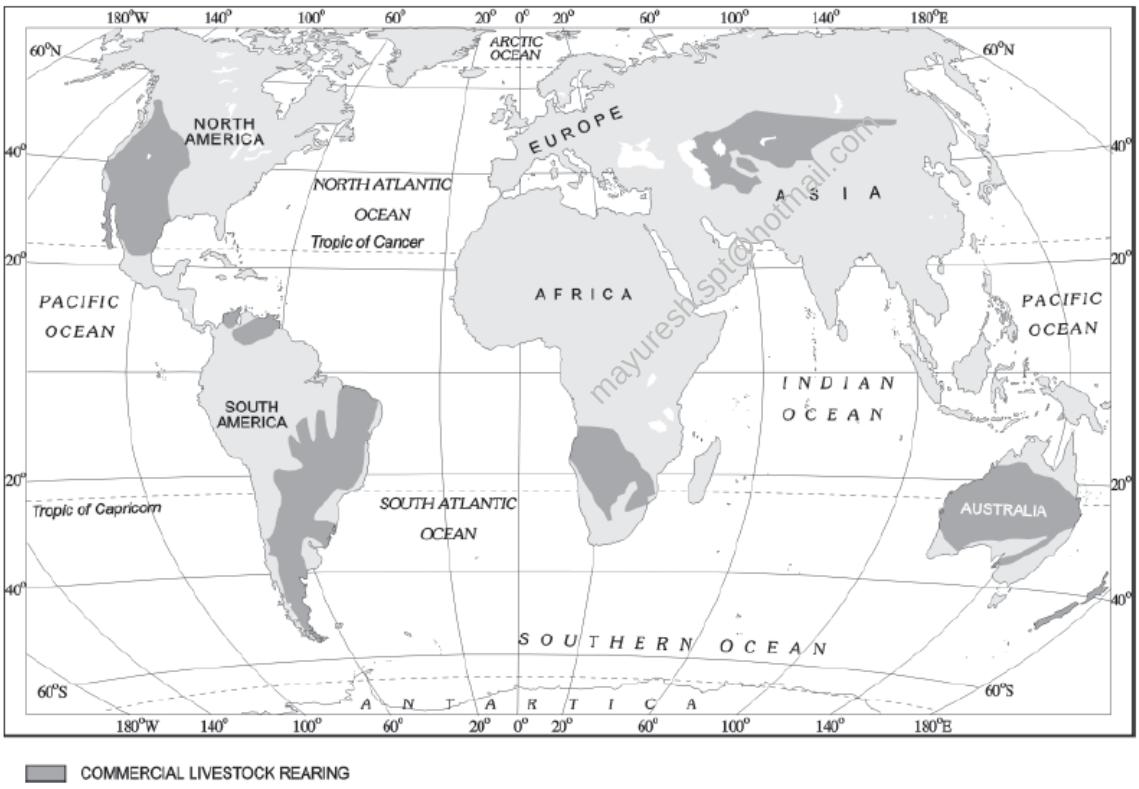

Fig. 3 Areas of Commercial Livestock Rearing

2.3. Agriculture

Agriculture is practised under multiple combinations of physical and socio-economic conditions, which gives rise to different types of agricultural systems. The following are the main agricultural systems:

2.3.1. Subsistence Agriculture

Subsistence agriculture is one in which the farming areas consume all, or nearly so, of the products locally grown. It can be grouped in two categories — Primitive Subsistence Agriculture and Intensive Subsistence Agriculture.

2.3.1.1. Primitive Subsistence Agriculture

Primitive subsistence agriculture or shifting cultivation is widely practised by many tribes in the tropics, especially in **Africa, south and Central America and South East Asia**. The vegetation is usually cleared by fire, and the ashes add to the fertility of the soil. Shifting cultivation is thus, also called **slash and burn agriculture**.

It is prevalent in tropical region in different names, e.g. **Jhuming** in North eastern states of India, **Milpa** in Central America and Mexico and **Ladang** in Indonesia and Malaysia.

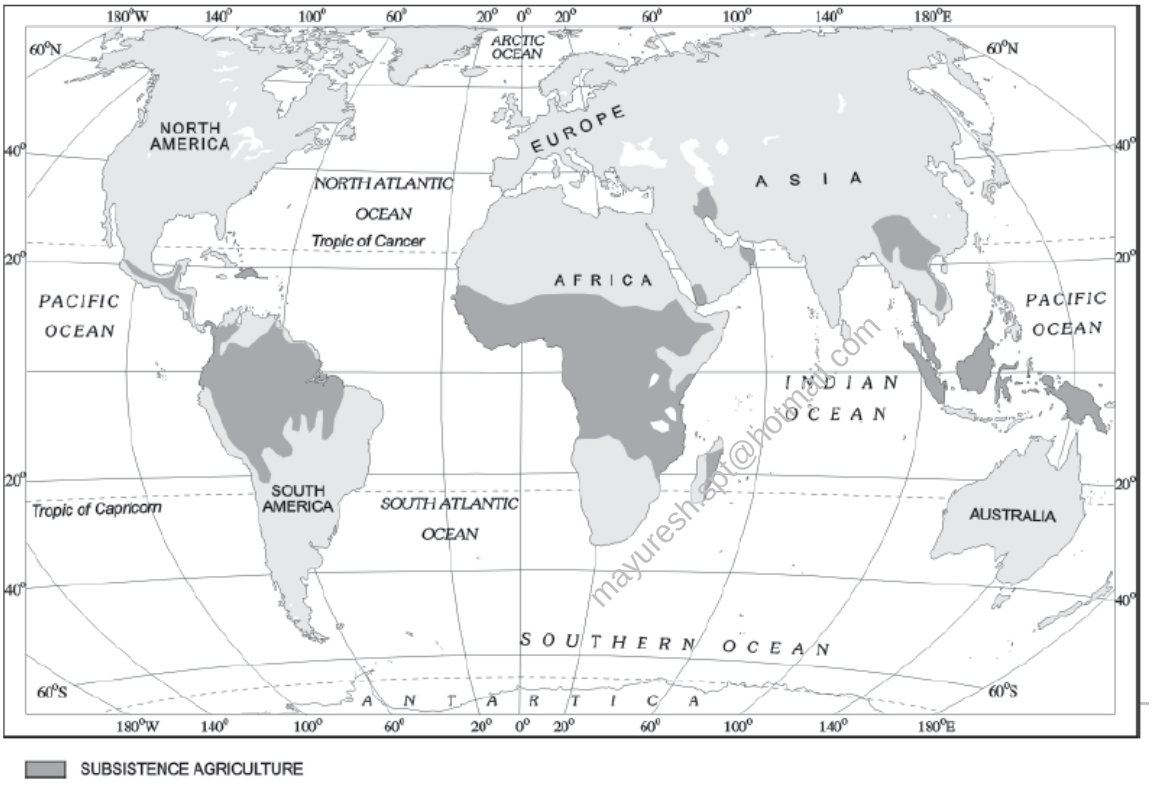

Fig. 4 Areas of Primitive Subsistence Agriculture

2.3.1.2. Intensive Subsistence Agriculture

This type of agriculture is largely found in densely populated regions of monsoon Asia. There are two types of intensive subsistence agriculture:

1. ***Intensive subsistence agriculture dominated by wet paddy cultivation:*** This type of agriculture is characterised by dominance of the rice crop. Land holdings are very small due to the high density of population.

2. ***Intensive subsidence agriculture dominated by crops other than paddy:*** Due to the difference in relief, climate, soil and some of the other geographical factors, it is not practical to grow paddy in many parts of monsoon Asia. Wheat, soyabean, barley and sorghum are grown in northern China, Manchuria, North Korea and North Japan. In India wheat is grown in western parts of the Indo-Gangetic plains and millets are grown in dry parts of western and southern India.

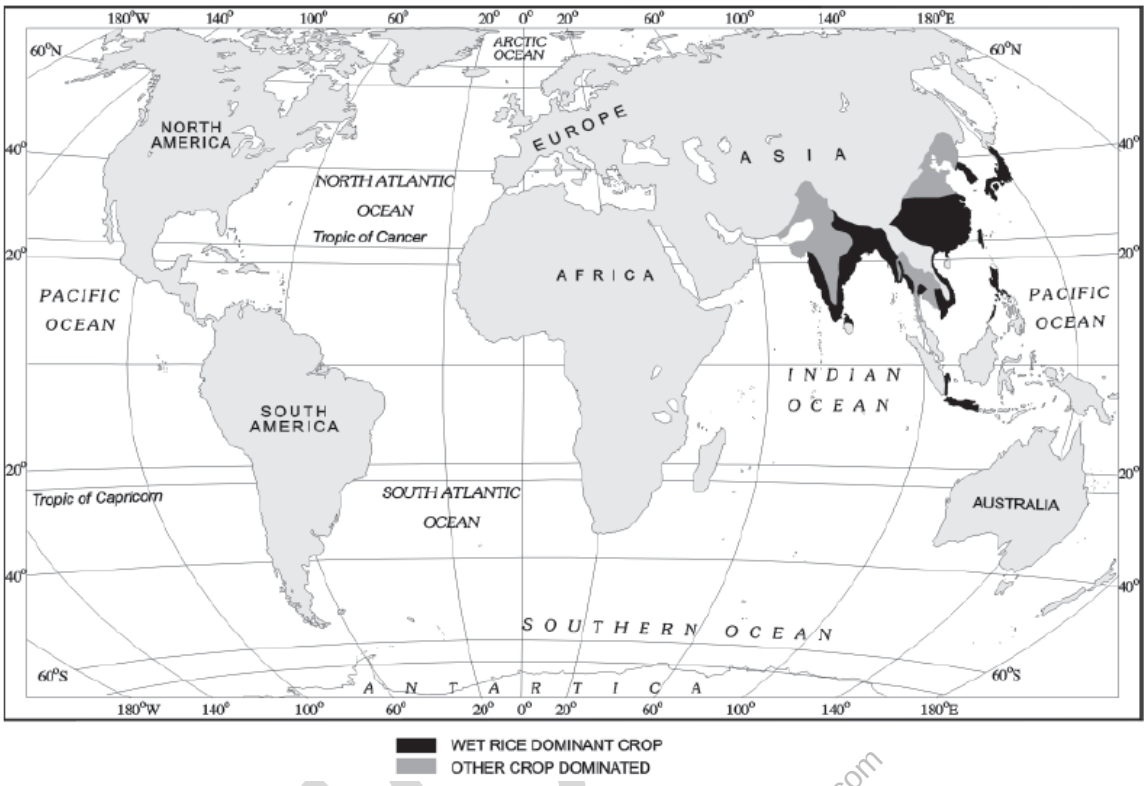

Fig. 5 Areas of Intensive Subsistence Agriculture

2.3.2. Plantation Agriculture

Plantation agriculture as mentioned above was introduced by the Europeans in colonies situated in the tropics. Some of the important plantation crops are tea, coffee, cocoa, rubber, cotton, oil palm, sugarcane, bananas and pineapples. The characteristic features of this type of farming are large estates or plantations, large capital investment, managerial and technical support, scientific methods of cultivation, single crop specialisation, cheap labour, and a good system of transportation which links the estates to the factories and markets for the export of the products.

The French established cocoa and coffee plantations in west Africa. The British set up large tea gardens in India and Sri Lanka, rubber plantations in Malaysia and sugarcane and banana plantations in West Indies. Spanish and Americans invested heavily in coconut and sugarcane plantations in the Philippines. The Dutch once had monopoly over sugarcane plantation in Indonesia.

2.3.3. Extensive Commercial Grain Cultivation

Commercial grain cultivation is practised in the interior parts of semi-arid lands of the mid-latitudes. Wheat is the principal crop, though other crops like corn, barley, oats and rye are also grown. **This type of agriculture is best developed in Eurasian steppes, the Canadian and American Prairies, the Pampas of Argentina, the Velds of South Africa, the Australian Downs and the Canterbury Plains of New Zealand.**

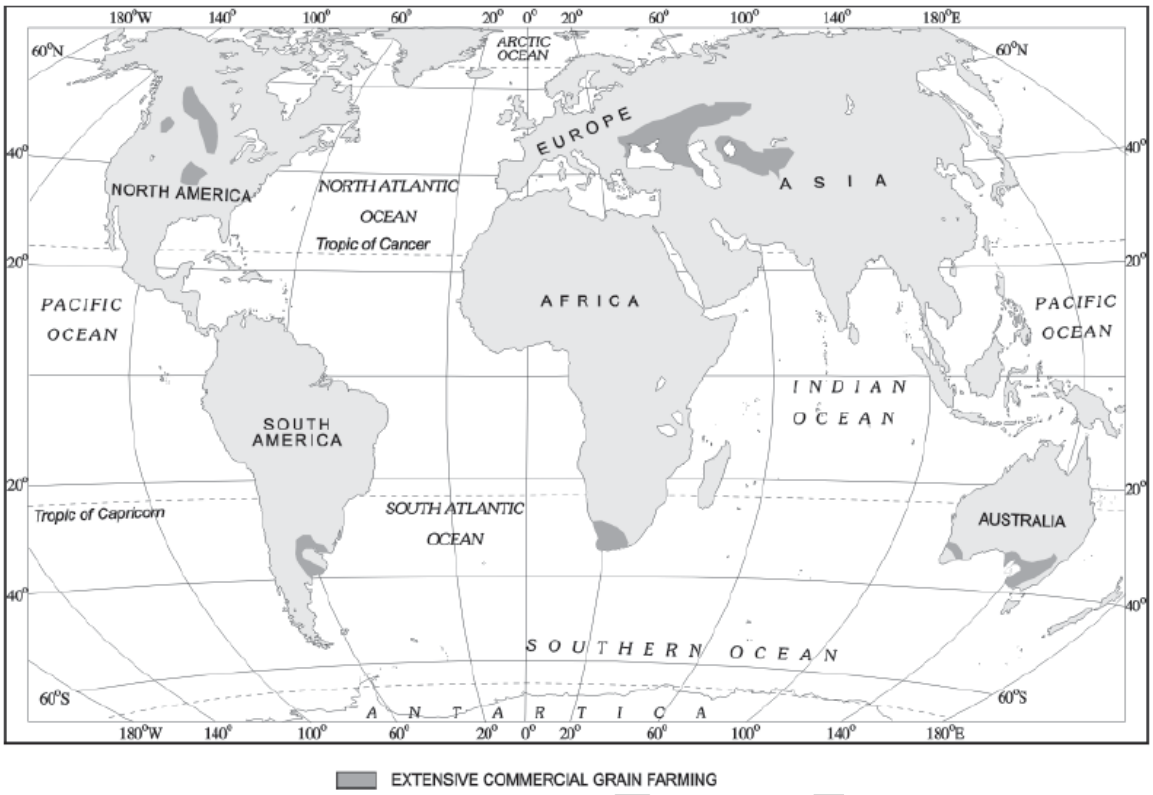

Fig 6. Areas of Extensive Commercial Grain Cultivation

2.3.4. Mixed Farming

Mixed farms are moderate in size and usually the crops associated with it are wheat, barley, oats, rye, maize, fodder and root crops. Fodder crops are an important component of mixed farming. Equal emphasis is laid on crop cultivation and animal husbandry. Animals like cattle, sheep, pigs and poultry provide the main income along with crops.

This form of agriculture is found in the highly developed parts of the world, e.g. North-western Europe, Eastern North America, parts of Eurasia and the temperate latitudes of Southern continents.

2.3.5. Dairy Farming

It is practised mainly near urban and industrial centres which provide neighbourhood market for fresh milk and dairy products. The development of transportation, refrigeration, pasteurisation and other preservation processes have increased the duration of storage of various dairy products.

There are three main regions of commercial dairy farming. The largest is **North Western Europe** the second is **Canada** and the third belt includes **South Eastern Australia, New Zealand and Tasmania**.

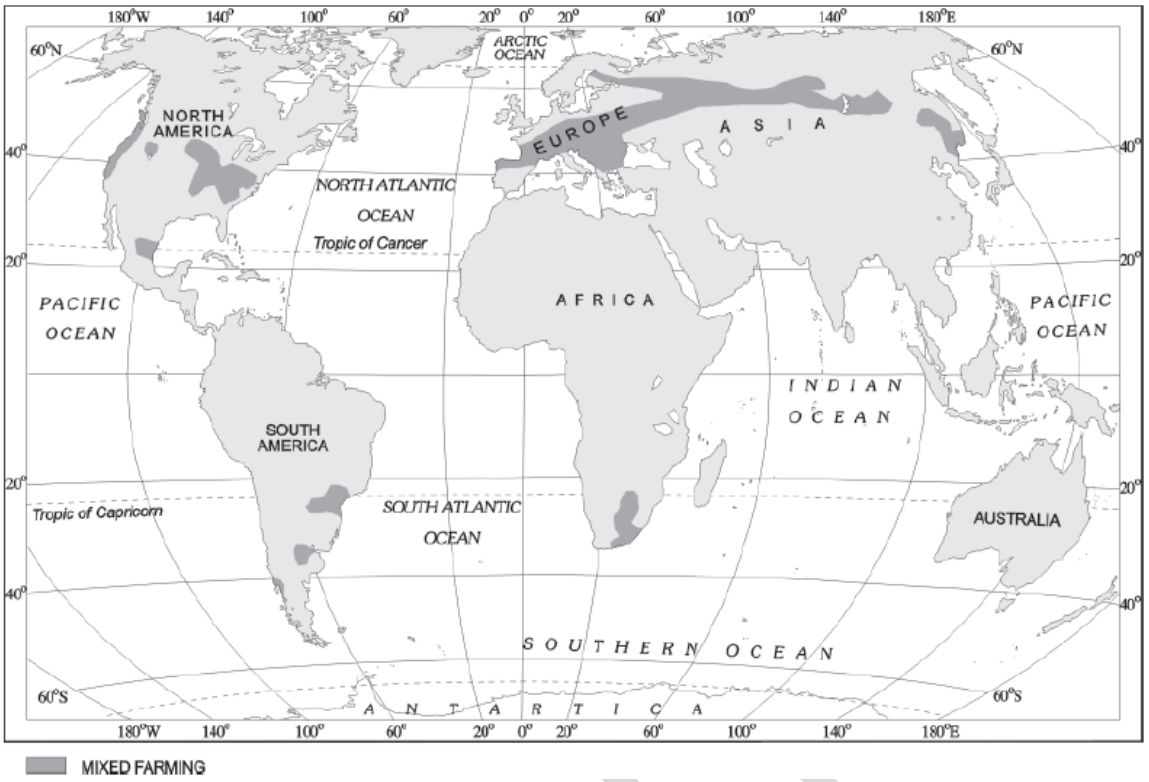

Fig. 7 Areas of Mixed Farming

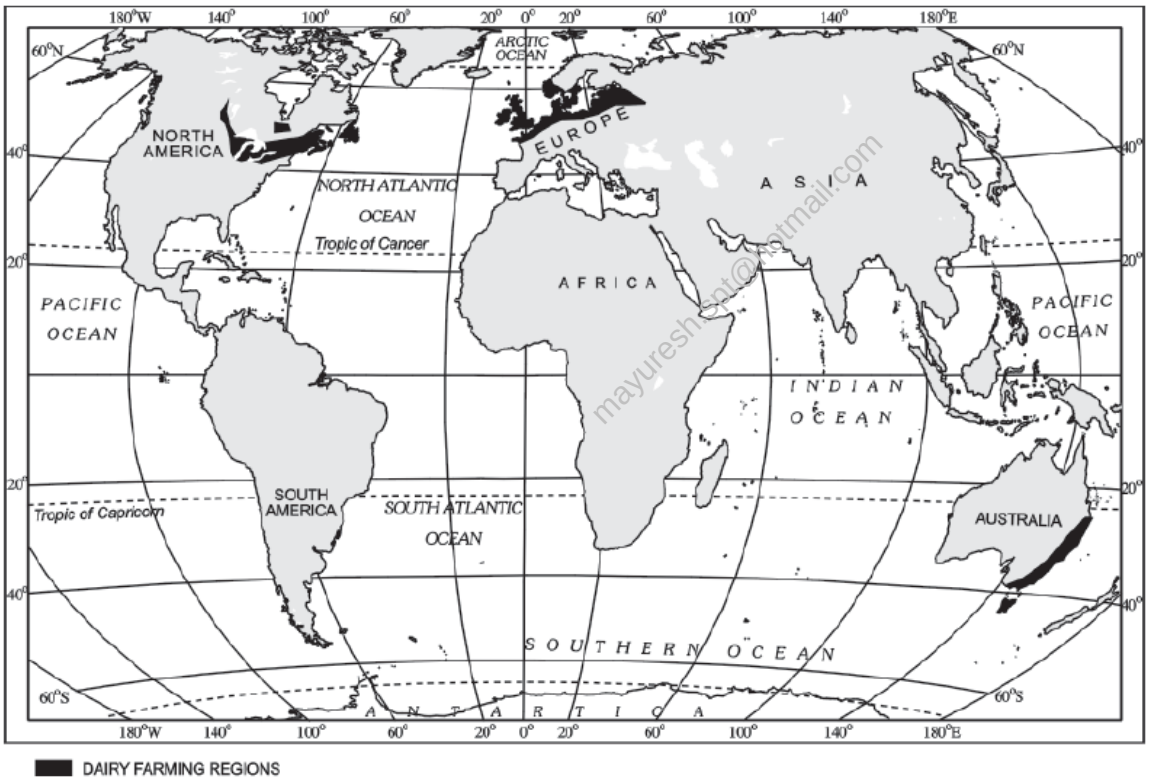

Fig. 8 Areas of Dairy Farming

2.3.6. Mediterranean Agriculture

Mediterranean agriculture is highly specialised commercial agriculture. **It is practised in the countries on either side of the Mediterranean Sea in Europe and in north Africa from Tunisia to Atlantic coast, southern California, central Chile, south western parts of South Africa and south and south western parts of Australia.** This region is an important supplier of citrus fruits.

Viticulture or grape cultivation is a speciality of the Mediterranean region. Best quality wines in the world with distinctive flavours are produced from high quality grapes in various countries of this region.

2.3.7. Market Gardening and Horticulture

Market gardening and horticulture specialise in the cultivation of high value crops such as vegetables, fruits and flowers, solely for the urban markets. Farms are small and are located where there are good transportation links with the urban centre where high income group of consumers is located.

This type of agriculture is well developed in densely populated industrial districts of **north west Europe, north eastern United States of America and the Mediterranean regions**. The **Netherlands** specialises in growing flowers and horticultural crops especially tulips, which are flown to all major cities of Europe.

2.3.8. Co-operative Farming

Co-operative societies help farmers, to procure all important inputs of farming, sell the products at the most favourable terms and help in processing of quality products at cheaper rates. Co-operative movement originated over a century ago and has been successful in **many western European countries like Denmark, Netherlands, Belgium, Sweden, Italy** etc. In Denmark, the movement has been so successful that practically every farmer is a member of a co-operative.

2.3.9. Collective Farming

The basic principal behind this type of farming is based on social ownership of the means of production and collective labour. Collective farming or the model of **Kolkhoz** was introduced in **erstwhile Soviet Union** to improve upon the inefficiency of the previous methods of agriculture and to boost agricultural production for self-sufficiency.

The farmers pool in all their resources like land, livestock and labour. However, they are allowed to retain very small plots to grow crops in order to meet their daily requirements. Yearly targets are set by the government and the produce is also sold to the state at fixed prices. Produce in excess of the fixed amount is distributed among the members or sold in the market. The farmers have to pay taxes on the farm produces, hired machinery etc. **This type of farming was introduced in former Soviet Union under the socialist regime which was adopted by the socialist countries**. After its collapse, these have already been modified.

2.4. Mining

The use of minerals in ancient times was largely confined to the making of tools, utensils and weapons. The actual development of mining began with the industrial revolution and its importance is continuously increasing.

The profitability of mining operations depends on two main factors:

1. Physical factors include the size, grade and the mode of occurrence of the deposits.
2. Economic factors such as the demand for the mineral, technology available and used, capital to develop infrastructure and the labour and transport costs.

The developed economies are retreating from mining, processing and refining stages of production due to high labour costs, while the developing countries with large labour force and striving for higher standard of living are becoming more important. Several countries of Africa and few of South America and Asia have over fifty per cent of the earnings from minerals alone.

3. Manufacturing Activities

Manufacturing activities add value to natural resources by *transforming* raw materials into valuable products. Manufacturing involves the application of power, mass production of identical products and specialised labour in factory settings for the production of standardised commodities. Manufacturing may be done with modern power and machinery or it may still be very primitive.

Some of the major manufacturing industries and their locations are discussed below.

3.1. Iron and Steel Industry

Iron and steel industry is Important in United States of America, Soviet Union, European countries, Australia and India. Japan, South Africa, Brazil and Colombia are other Iron and steel producing countries. Continent wise distribution can be discussed as under:

3.1.1. America

The Great Lakes region in United States of America is the leading iron and steel producing region. The good quality coke is available from **Pennsylvania**. Iron ore is brought from the mines of **Lake Superior region**. Limestone is obtained from the neighbourhood of Alpena located on the western coast of Lake Huron. Water is available in plenty from the local rivers and lakes for cooling. This part of United States is densely populated which ensures large supply of labour. The high density of population and development of iron and steel based industries have created large market in this region. **Pittsburgh and Youngtown to the east of the Great Lakes and Chicago and Gary to its west are the major centres of iron and steel industries.**

There is a great demand for iron and steel in the industrial complexes of Detroit, Toledo and Cleveland as well as the rail industry of Chicago. The demand for iron ore is high in the industries located on the coasts of Lake Erie. It is met from the mines of Lake Superior region and the Labrador mines. They are brought by ships through St. Lawrence Seaway.

Iron and steel Industry has also developed in the **Atlantic coastal region**. **Iron ore is imported from Venezuela, Labrador and Chile as the coast location has facilitated the oceanic transport**. **Alabama** is the third important Iron and steel producing region. **Birmingham** is the most important iron and steel centre of this region.

The iron and steel industry in South America is located in **Colombia, Venezuela and Brazil**. In **Colombia**, coal is available from Tunza district located north of Bogota, iron ore and limestone is available locally and hydro-electric power is obtained from Toba Lake. In **Venezuela**, the iron and steel industry is based on the iron ore from El Pao, Serra Bolivar and Dagiana Hills, coal and limestone from Nankol and hydroelectric power from Caroni river. The iron and steel industry in **Brazil** developed after the Second World War. The main steel plants in Brazil are located are located at Volta Redona, Montevarde and Santos. **Chile** is also an important steel producing country of South America.

3.1.2. Europe

The Second World War created a situation before west European nations that they had to turn towards cooperation rather than competing with each other. Six countries joined together to form a cooperative community in 1952. France, Germany, Netherlands, Belgium, Luxembourg and Italy became its members. In 1973, United Kingdom, Ireland and Denmark also joined it. It

is known as European Coal and Steel Community. The major objective of the community is to provide facilities for the supply of iron ore and coal to the members of the community without any hindrance. Earlier, iron and steel industry in Europe was closely linked with coal mines but now some industries have moved to the port towns and some have been established near the iron ore mines.

The iron and steel industry in **Europe** has developed in **France-Belgium, Loraine (France) – Luxembourg – Saar (Germany), Ruhr (Germany) and north, north-eastern and central parts of United Kingdom.** Loraine has the largest iron-ore reserve in Europe. Ruhr region has high quality coking coal. Rhine River and the canal network developed in the region provide cheap water transport. Demand for iron and steel in the local industries is large as most of the west European countries have high level of industrialisation.

In **United Kingdom** some iron and steel industries are located near the coal mines such as **Birmingham**. Some are located near the iron ore mines such as **Fordingham** and some are located near the ports like **Talbot**. Other iron and steel producing countries of Europe are Sweden, Poland and Czechoslovakia.

Iron and steel industry has developed in **southern Ukraine** which is based on the iron ore from **Krivoy Rog and Kerch peninsula, coal from Donetsk Basin (Donbas) and local manganese. The Ural region is another important steel producing region of Russia.** Iron ore in this region is obtained from Magnet Mountains, coal from Kuznetsk Basin (Kuzbas) and Karaganda basin. Trans-Siberian railway provides surface transport. Sverdlovsk, Magnitogorsk and Nizhny Tagil are major iron and steel centres. Besides these major regions, Iron and steel industry has also been located in Kuzbas and Caucasus region.

3.1.3. Asia

In Asia, iron and steel industry has developed in **Japan, China and India.**

The iron and steel industry in Japan developed in response to the large demand in engineering, and ship-building industry. This demand accounts for the rapid development of iron and steel industry in Japan in spite of the fact that she neither had large iron ore deposits nor coal reserves. **Kyushu island of Japan has very limited coal reserves.** Japan imports large quantities of coke, iron ore, pig iron as well as scrap iron. **The iron and steel industry has been located in southern Honshu and northern Kyushu Islands.**

The history of the development of iron and steel industry in **China** started in the post revolution period i.e. after 1949, though Japanese had established it at Anshan and Fushan in Manchuria earlier. **Besides Manchuria, Shanxi, Shenxi, Hobei and Shandong are the major iron and steel producing provinces.**

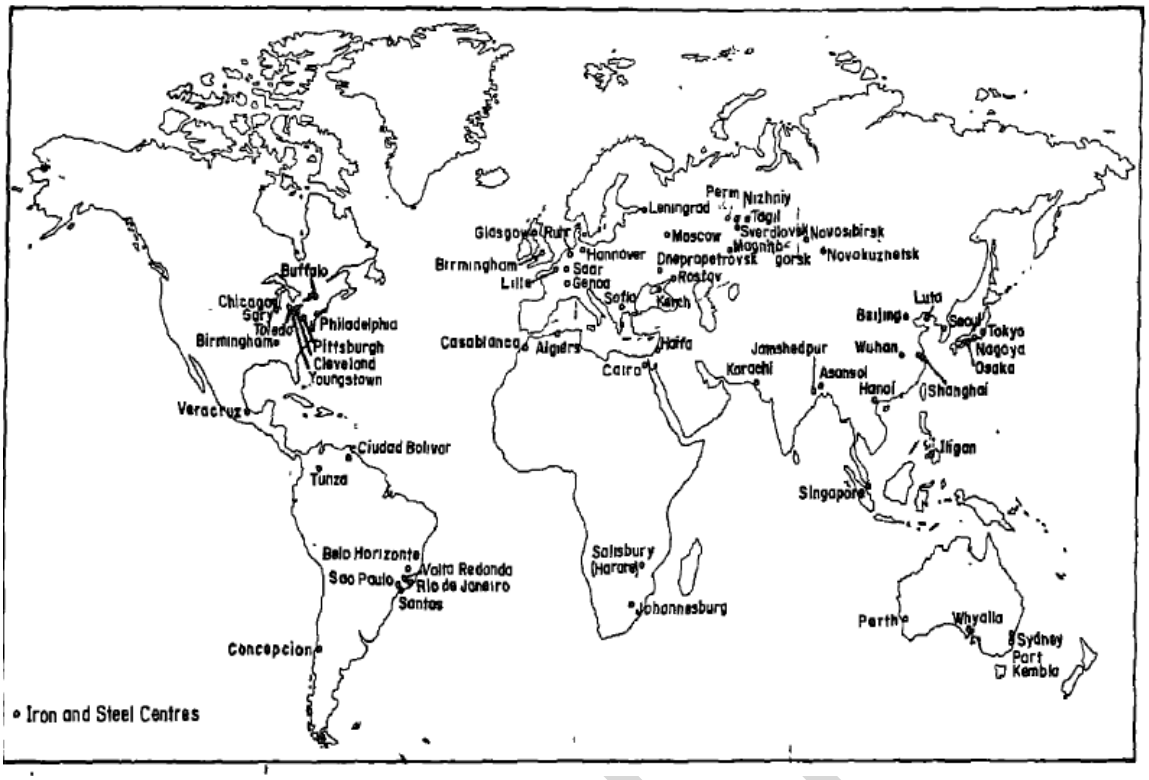

Fig. 9 World- Iron and Steel industry

Three iron and steel plants were established in India before Independence. Two of these were located at **Jamshedpur and Kulti -Burnpur** based on the iron ore, coal and manganese resources of Bihar, West Bengal and Orissa. **Mysore Steel Works at Bhadravati** was established by exploiting the iron ore resources of Karnataka. **In India, iron ore reserves are located in Keonjhar, Mayurbhanj, Guru Mahisani, Badam Pahar, Bonai and Noamundi. Coal is available from Jharia, Raniganj, Karnpura, Giridhih, Talchir, Singrauli and Korba. Manganese is obtained from Bonai and limestone from Birmitrapur.** The high density of population in eastern India provides cheap labour. There is a dense network of rail and roads. Water is available from rivers. The industrial hinterland of Calcutta has large demand for iron and steel. This is why three Iron and steel plants i.e. Durgapur, Rourkela and Bokaro, have been established in this region after independence. Bhilai was located in backward tribal region in order to reduce the regional imbalance in economic development..

3.1.4. Australia

Australian Iron and steel industry is based on the coal found in the **Hunter valley of New Castle**. It is located on the eastern coast. **There is an iron and steel plant at Port Kembla in the south of Sydney**.

3.1.5. Africa

Iron and steel industry has developed in Algeria, Egypt, Zimbabwe and South Africa. South Africa is the major steel producing country in Africa. The industry at Vereeniging utilizes scrap iron and pig iron from Natal.

3.2. Chemical Industry with Special Reference to Petro-chemicals

Chemical industry is based on two types of raw materials: **natural** like minerals, coal, petroleum, salts, potash, sulphur, limestone, gypsum and vegetable products and **by products** of other industries such as paper and pulp industry, iron and steel industry and gas

manufacturing industry. **Major factor for the location of chemical industry are availability of raw materials, cheaper means of transport for bulky materials, water supply, sources for energy and demand of chemicals in other industries.**

The major industry based on mineral oil is its refining. The oil refining technology was developed in United States of America, Europe and former USSR. Earlier the refineries were generally located near the oil wells. The petrochemical industry developed in Europe and United States of America after the Second World War. **The development of large tankers and pipelines facilitated the transportation of petroleum in bulk and this provided favourable conditions for locating the refineries and petro-chemical industries near the markets as well as ports.**

3.2.1. America

Most of the petro-chemical complexes in North-America are located in the coastal regions. **About 30 per cent of the oil in United States of America is refined along the Gulf of Mexico coast and another 15 per cent is refined on the Pacific Coast**. The refineries located on the East Coast get crude oil from Venezuela and West Asia. The refined oil is transported from the Gulf Coast to the eastern region through pipelines and to the west by tankers. **Petro-chemical complexes have developed in Philadelphia and Delaware in the eastern region and at Chicago and Toledo in the Great Lakes region.**

Los Angeles has a big petrochemical complex on the western coast of United States. In **Canada, Montreal** has a large petro-chemical industry. The crude oil is brought from **Portland** and **Maine** through pipelines and by tankers from **Venezuela.** The other important petrochemical complex in **Canada** is located at **Sarnia** in **Ontario province.**

After the Second Wold War, a refinery was constructed in the Paraguayan Peninsula of Venezuela which receives crude oil through pipelines from the wells located near **Maracaibo Lake.**

3.2.2. Europe

The petro-chemical complexes in Europe are located near the markets where these products are demanded. The major complexes are located on the **coasts of Southern North Sea** and **English Channel.** Main centres are **Antwerp**, **Rotterdam**, **Southampton** and the **cities located in the lower Sein Valley**. The petro-chemical complexes of **Germany** are located in **Ruhr region**. The **French** refineries and petro-chemical complexes are concentrated between **Le Havre-Roven and Marseilles including Paris and Lyons**. The first petro-chemical complex in former **Soviet Union** was located at **Baku and Grozny because the mineral oil was available from the Caucasian oil fields**. New petro - chemical complexes are generally located near the consumption centres. **Moscow, Volga, Ural and Soviet Central Asia** are the main regions where new petro-chemical complexes have been recently located.

3.2.3. West Asia

The largest refinery in **West Asia is located at Abadan** (Iran). **West Asia is a large producer of petroleum but there is little demand because the region is not industrially developed. Thus, most of the petrochemical complexes are located on the coasts in order to facilitate export. Saudi Arabia has a large petro-chemical complex at Ras Tanura while Mina-el-Ahmadi is the largest petro-chemical complex of Kuwait**.

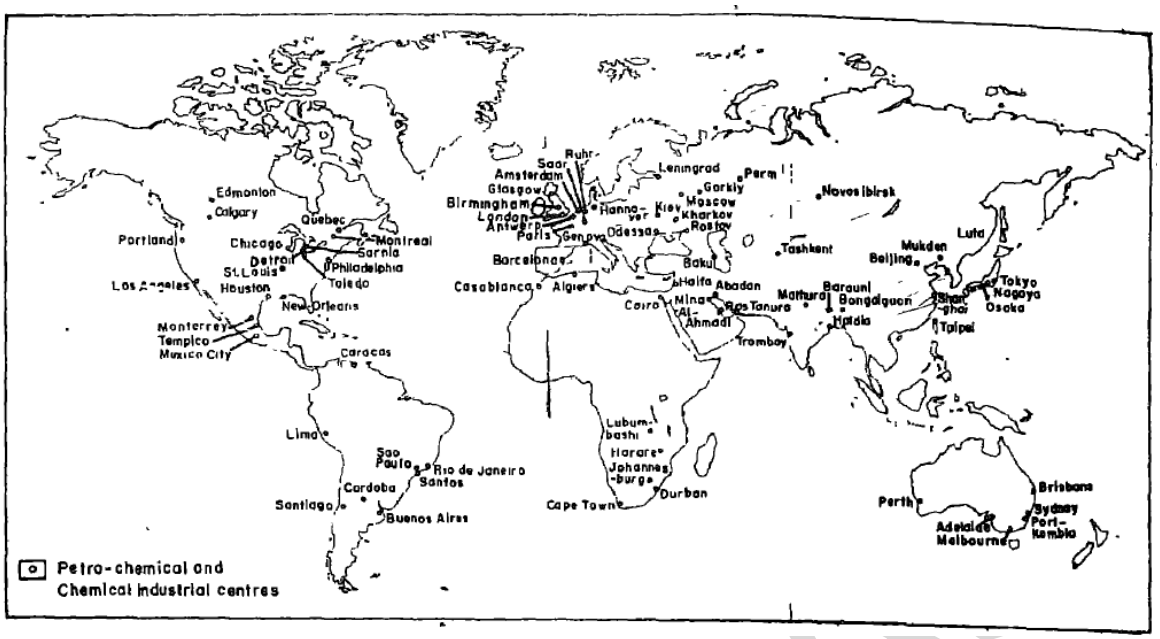

Fig. 10 World-chemical and petrochemical industries

3.2.4. India

The largest petro-chemical complex In India was established by **Union Carbide at Trombay** (Mumbai). A petrochemical complex has been developed along with refinery at **Koeli** in **Vadodra. Indian Petro Chemical Corporation** has been established under public sector. It has started a petrochemical complex at **Jawahar Nagar near Vadodara**. **Bongaigaon in Assam** is another petro-chemical complex under the public sector. **Haldia** (West Bengal) and **Barauni** (Bihar) have been established for petro-chemical processing.

Three large fertiliser complexes are being developed at **Bijaipur, Sawai Madhopur and Jagdishpur** by utilising the gas brought through HBJ (Hazira-Bijaipur-Jagdishpur) pipelines. The **Mathura refinery** has started diversification of products besides refining the oil.

3.3. Textile Industry

History of industrial development in Japan, India, Brazil and Egypt started with the development of the textile industry. The raw material for textile industry is obtained from hair of animals and vegetation. Wool, silk, cotton and flax etc. are raw materials derived from natural sources. Some raw materials for textile industry have been developed by man using his technological and scientific knowledge e.g. nylon, rayon, terelene, terewool, etc.

The technology for manufacturing synthetic fibres has been developed by economically developed countries and therefore, they have monopolised the production of these fibres.

United States of America is an important producer of synthetic fibres. **Here this industry is located in eastern Pennsylvania and mid-eastern Atlantic coastal region**. **Recently it has been developed in Virginia and Tennessee states as they have plenty of water and energy resources, besides the reserves of coal**. **The major synthetic fibre producing countries in Europe are Germany, United Kingdom, Italy, France, Netherlands, Switzerland and Spain**. These countries import the pulp from Norway, Sweden and Finland.

Japan like United States of America is an important producer of synthetic fibre. **This industry is concentrated along with the chemical industry in southern Honshu, Kyushu and Shikoku islands.** The softwood from the **Taiga conical forest belt in Russia** is an asset to the synthetic fibre industry. This industry is concentrated in the western and mid-northern parts of Ural

industrial region because this region lies at the meeting point of chemical industry and the conical forest belt.

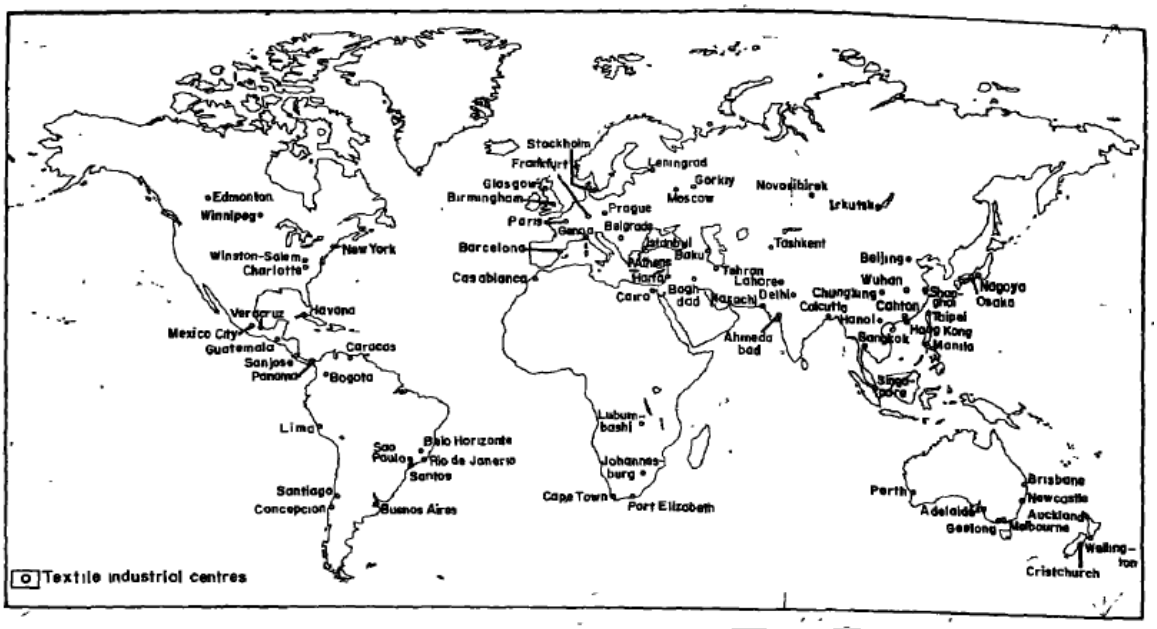

Fig. 11 World-textile industry

Student Notes:

HUMAN DEVELOPMENT

Contents

1. 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.

1.1. Concept of Development and Indian aspects

It is believed that "Development is freedom" which is often associated with modernisation, leisure, comfort and affluence**. In the present context, 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.** Every individual, community and government measures its performance or levels of development in relation to the availability and access to some of these things. But, this may be partial and one-sided view of development. **It 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.**

Thus, for India, development is a mixed bag of opportunities as well as neglect and deprivations. There are a few areas like the metropolitan centres and other developed enclaves that have all the modern facilities available to a small section of its population. At the other extreme of it, there are large rural areas and the slums in the urban areas that do not have basic amenities like potable water, education and health infrastructure available to majority of this population.

The situation is more alarming if one looks at the distribution of the development opportunities among different sections of our society. It is a well-established fact that majority of the scheduled castes, scheduled tribes, landless agricultural labourers, poor farmers and slums dwellers, etc. are the most marginalised lot. A large segment of female population is the worst sufferers among all. It is also equally true that the relative as well as absolute conditions of the majority of these marginalised sections have worsened with the development happening over the years. Consequently, vast majority of people are compelled to live under abject poverty and subhuman conditions.

1.2. Measuring Human Development

Most systematic effort towards measuring Human Development was the **publication of the First Human Development Report by United Nations Development Programme (UNDP) in 1990**. Since then, UNDP has been bringing out World Human Development Report every year. This report does not only define human development, make amendments and changes its indicators but also ranks all the countries of the world based on the calculated scores.

1.2.1. Human Development Index (HDI)

The first Human Development Report introduced a new way of measuring development by combining indicators of **life expectancy, educational attainment** and **income** into a composite human development index, the HDI. *The breakthrough for the HDI was the creation of a single statistic which was to serve as a frame of reference for both social and economic development.*

The HDI sets a minimum and a maximum for each dimension, called goalposts, and then shows where each country stands in relation to these goalposts, expressed as a value between 0 and 1.

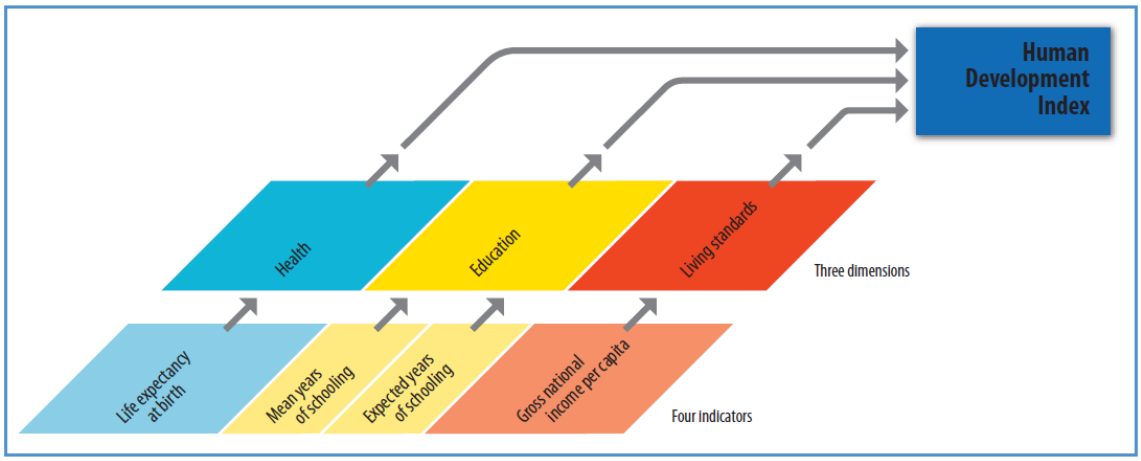

Figure 1. Components of HDI

The education component of the HDI is measured by *mean of years of schooling* for adults aged 25 years and *expected years of schooling* for children of school entering age. Mean years of schooling is estimated based on educational attainment data from censuses and surveys available in the UNESCO Institute for Statistics database and Barro and Lee (2010) methodology. Expected years of schooling estimates are based on enrolment by age at all levels of education and population of official school age for each level of education. Expected years of schooling is capped at 18 years. *The education index is the geometric mean of two indices.*

The decent standard of living component is measured by GNI per capita (PPP$). The HDI uses the logarithm of income, to reflect the diminishing importance of income with increasing GNI. The life expectancy at birth component of the HDI is calculated using a minimum value of 20 years and maximum value of 83.57 years. *The scores for the three HDI dimension indices are then aggregated into a composite index using geometric mean.*

Given the imperfect nature of wealth as gauge of human development, the HDI offers a powerful alternative to GDP and GNI for measuring the relative socio-economic progress at national and sub-national levels. Comparing HDI and per capita income ranks of countries, regions or ethnic groups within countries highlights the relationship between their material wealth on the one hand and their human development on the other.

1.3. Other Multi-dimensional measures of Human Development

To obtain a full picture of the evolution of human development, one must go beyond the dimensions in the HDI. Significant aggregate progress in health, education and income is qualified by high and persistent inequality, unsustainable production patterns and disempowerment of large groups of people around the world. In the most notable innovations in the 20th anniversary year of Human Development Report, three new multidimensional measures of inequality and poverty were introduced.

1.3.1. Inequality adjusted HDI (IHDI)

The 2010 Report introduced the Inequality-adjusted HDI (IHDI), **a measure of the level of human development of people in a society that accounts for inequality**. Under perfect equality the IHDI is equal to the HDI, but falls below the HDI when inequality rises. In this sense, the IHDI is the actual level of human development (taking into account inequality), while the

HDI can be viewed as an index of the potential human development that could be achieved if there is no inequality.

The IHDI takes into account not only a country's average human development, as measured by health, education and income indicators, but also how it is distributed. IHDI accounts for inequalities in life expectancy, schooling and income, by "discounting" each dimension's average value according to its level of inequality. The difference between the HDI and the IHDI measures the "loss" in potential human development due to inequality.

1.3.2. Gender Inequality Index (GII)

The disadvantages facing women and girls are a major source of inequality. All too often, women and girls are discriminated against in health, education and the labour market — with negative repercussions for their freedoms. The GII is unique in including educational attainment, economic and political participation and female-specific health issues and in accounting for overlapping inequalities at the national level.

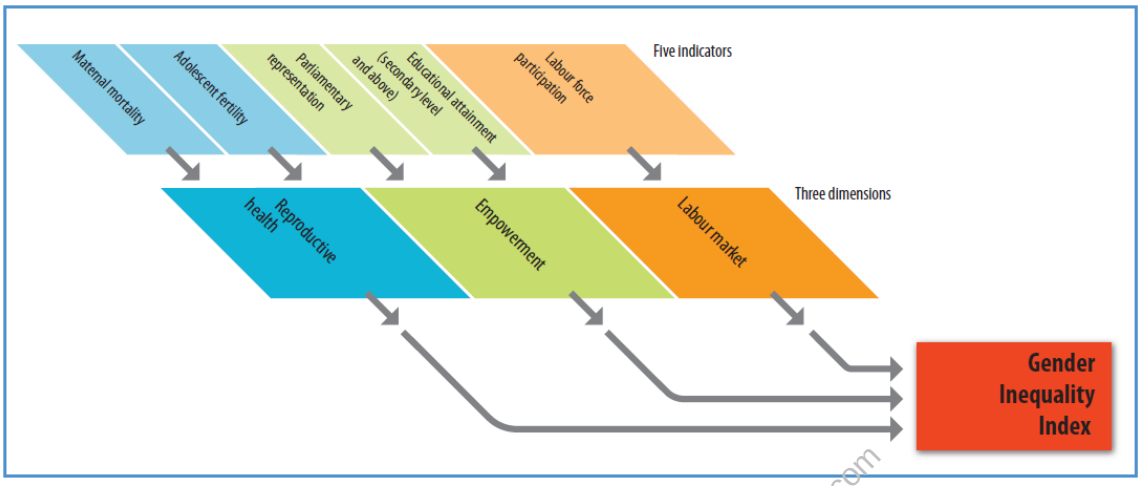

Figure 2. Components of GII

Like the IHDI, the GII captures the loss of achievement in key dimensions due to gender inequality. It ranges from 0 (no inequality in the included dimensions) to 1 (complete inequality). The GII increases when disadvantages across dimensions are associated—that is, the more correlated the disparities between genders across dimensions, the higher the index.

1.3.3. Multi-Dimensional Poverty Index (MPI)

The dimensions of poverty go far beyond inadequate income—to poor health and nutrition, low education and skills, inadequate livelihoods, bad housing conditions, social exclusion and lack of participation. The Multidimensional Poverty Index (MPI) complements money-based measures by considering multiple deprivations and their overlap. The index identifies deprivations across the same three dimensions as the HDI and shows the number of people who are multi-dimensionally poor and the number of deprivations with which poor households typically contend.

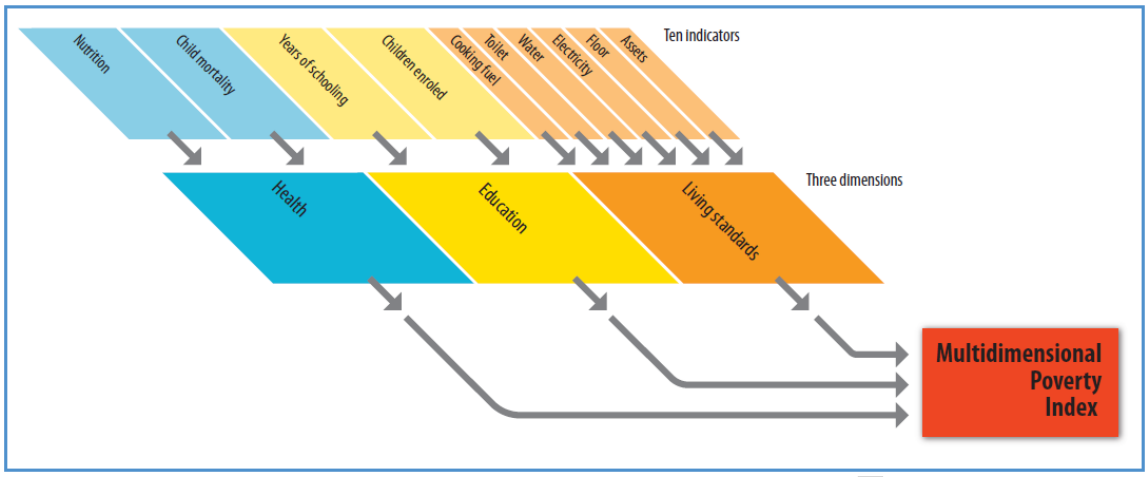

Figure 3. Dimensions of MPI

1.4. Human Development in India

The Human Development Report of the United Nations Development Programme (UNDP) for 2013, released on Thursday, puts India's HDI value for the last year at 0.554, placing it in the medium human development category. India has been ranked 136 among 187 countries evaluated for human development index (HDI).

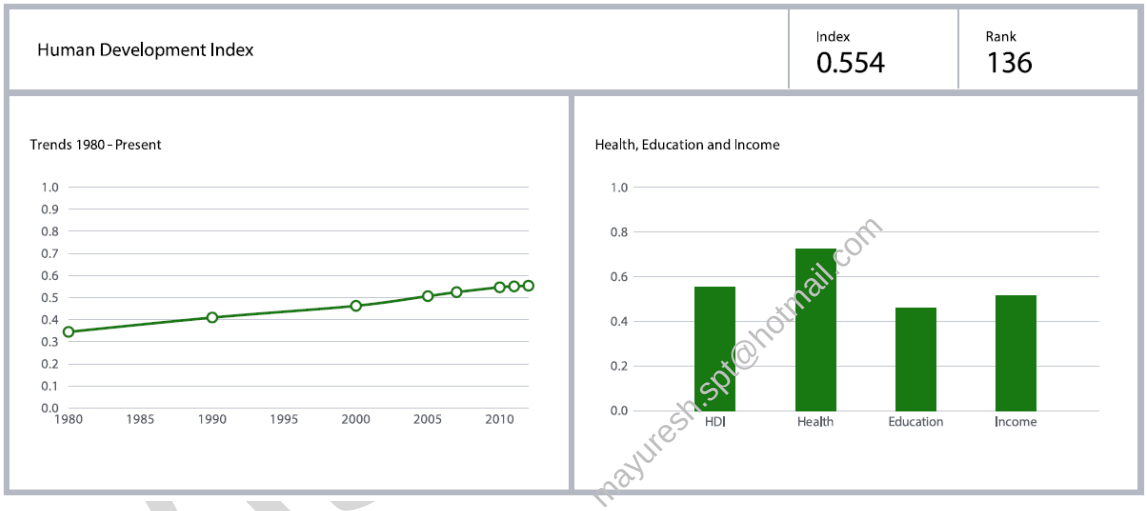

Figure 4. HDI progress of India

On the positive side, India's HDI value went up from 0.345 to 0.554 between 1980 and 2012, an increase of 61 per cent or an average annual increase of 1.5 per cent. Life expectancy at birth increased by 10.5 years, mean years of schooling by 2.5 years and expected years of schooling by 4.4 years. Importantly, the gross national income (GNI) per capita went up 273 per cent, the report says.

There is a word of appreciation for India for its policies on internal conflicts. "India has shown that while policing may be more effective in curbing violence in the short term, redistribution and overall development are better strategies to prevent and contain civil unrest in the medium term," the report says, referring to Operation Green Hunt launched against Maoists, which has come under sharp criticism from human rights activists within the country. The other initiatives that have been lauded are the right to education and the rural employment guarantee scheme that provides up to 100 days of unskilled manual labour to eligible poor at a statutory minimum wage. "This initiative [the job guarantee scheme] is promising because it provides access to

income and some insurance for the poor against the vagaries of seasonal work and affords individual the self-respect and empowerment associated with work."

Despite India's progress, its HDI of 0.554 is below the average of 0.64 for countries in the medium human development group, and of 0.558 for countries in South Asia. From South Asia, countries which are close to India's HDI rank and population size are Bangladesh and Pakistan with HDIs ranked 146 each. But the report points out that the ranking masks inequality in the distribution of human development across the population.

Even on the Gender Inequality Index — India has been ranked 132nd among the 148 countries for which data is available. In India, only 10.9 per cent of the parliamentary seats are held by women, and 26.6 per cent of adult women have reached a secondary or higher level of education, compared with 50.4 per cent of their male counterparts. For every 100,000 live births, 200 women die of causes related to pregnancy, and female participation in the labour market is 29 per cent, compared with 80.7 per cent for men.

As for the Multidimensional Poverty Index (MPI), India's value averages out at 0.283, a little above Bangladesh's and Pakistan's. The figures for evaluating MPI have been drawn from the 2005-06 survey, according to which 53.7 per cent of the population lived in multidimensional poverty, while an additional 16.4 per cent were vulnerable to multiple deprivations.

The values of various indicators for India are:

1. Life expectancy at birth (Health) – 65.8 years
2. Mean years of schooling (Education) – 4.4 years
3. GNI per capita in PPP terms (Income) – 3285 dollars
4. Inequality adjusted HDI – 0.392
5. Gender Inequality Index – 0.610
6. Multi-Dimensional Poverty Index – 0.283

1.5. India Human Development Report 2011

The purpose of this report is to capture the progress in human development at the state level in India. In order to do this, three indices are constructed—**the Health Index, the Education Index, and the Income Index**. The Health Index is constructed using life expectancy at birth, which is indicative of a long and healthy life and is the most comprehensive indicator of the state of health of the population.

To construct the Education Index, the two indicators used are 'adjusted mean years of schooling' and 'literacy rate for population 7 years and above'. These indicators are expected to reflect people's ability to acquire education and knowledge, which are important components of human development. To construct the Income Index, the mean per capita expenditure (at 1999–2000 prices) weighted by the Gini coefficient of inequality of consumption expenditure is taken for each state.

The findings of the report for different indicators are discussed as under:

1.5.1. Human Development Index

The states that perform better on health and education outcomes are also the states with higher HDI and thus higher per capita income. Most of the states that are performing low on human development outcomes are concentrated in the northern and central belt.

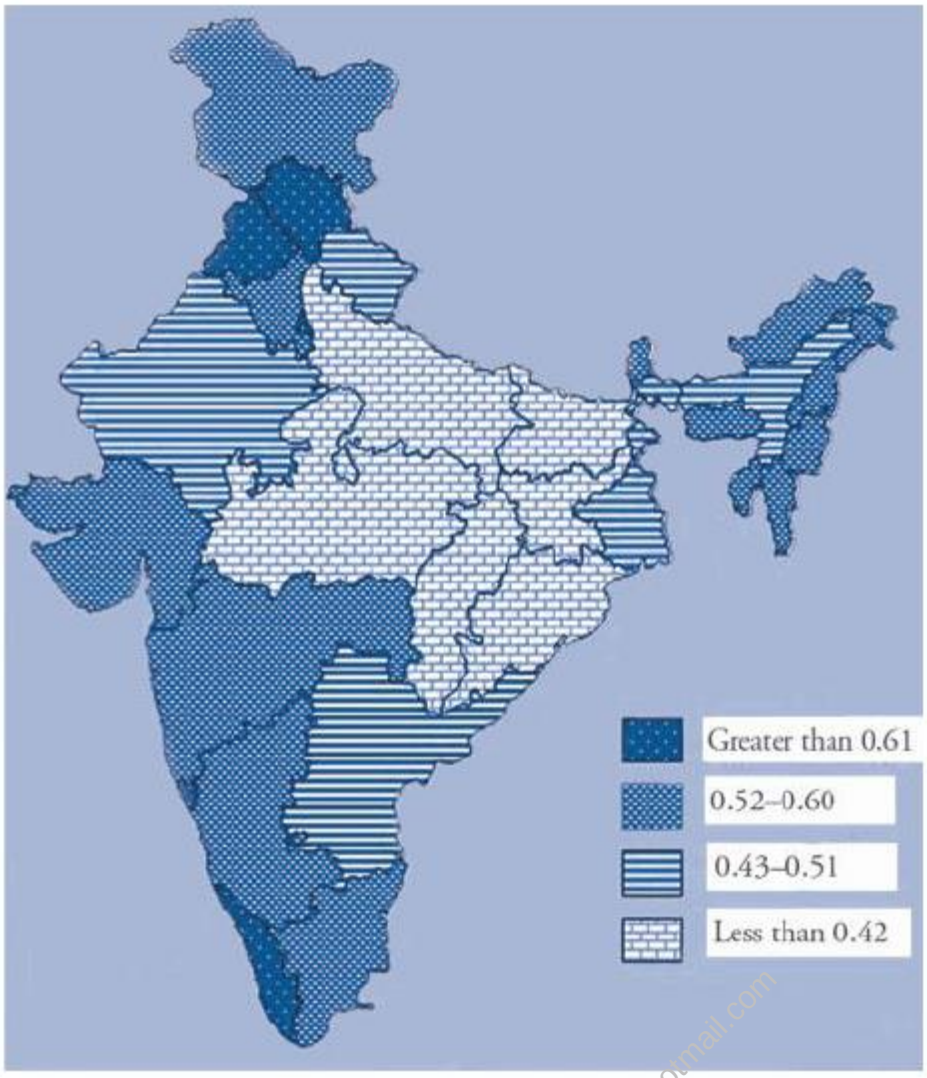

Figure 5. HDI across states (2007-08)

The highest HDI (0.79) is for Kerala, followed by Delhi and Himachal Pradesh. Fourteen states and the north-eastern states (excluding Assam) have an HDI higher than the national average, that is, Andhra Pradesh, Uttarakhand, West Bengal, Karnataka, Gujarat, Jammu & Kashmir, Haryana, Tamil Nadu, Maharashtra, the north-eastern states excluding Assam, Punjab, Goa, Himachal Pradesh, Delhi, and Kerala. Eight states (Chhattisgarh, Orissa, Bihar, Madhya Pradesh, Jharkhand, Uttar Pradesh, Rajasthan, and Assam), again listed in ascending order, have an HDI value below the national average of 0.47. Except for Rajasthan, these are also the states with a low Income Index reflecting a lower standard of living.

1.5.2. Income Index

The lowest standard of living as highlighted by the Income Index is evident in the poorer states like Assam, Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Orissa, and Uttar Pradesh . These are also the states that have high concentrations of the marginalized groups like SCs, STs, and Muslims.

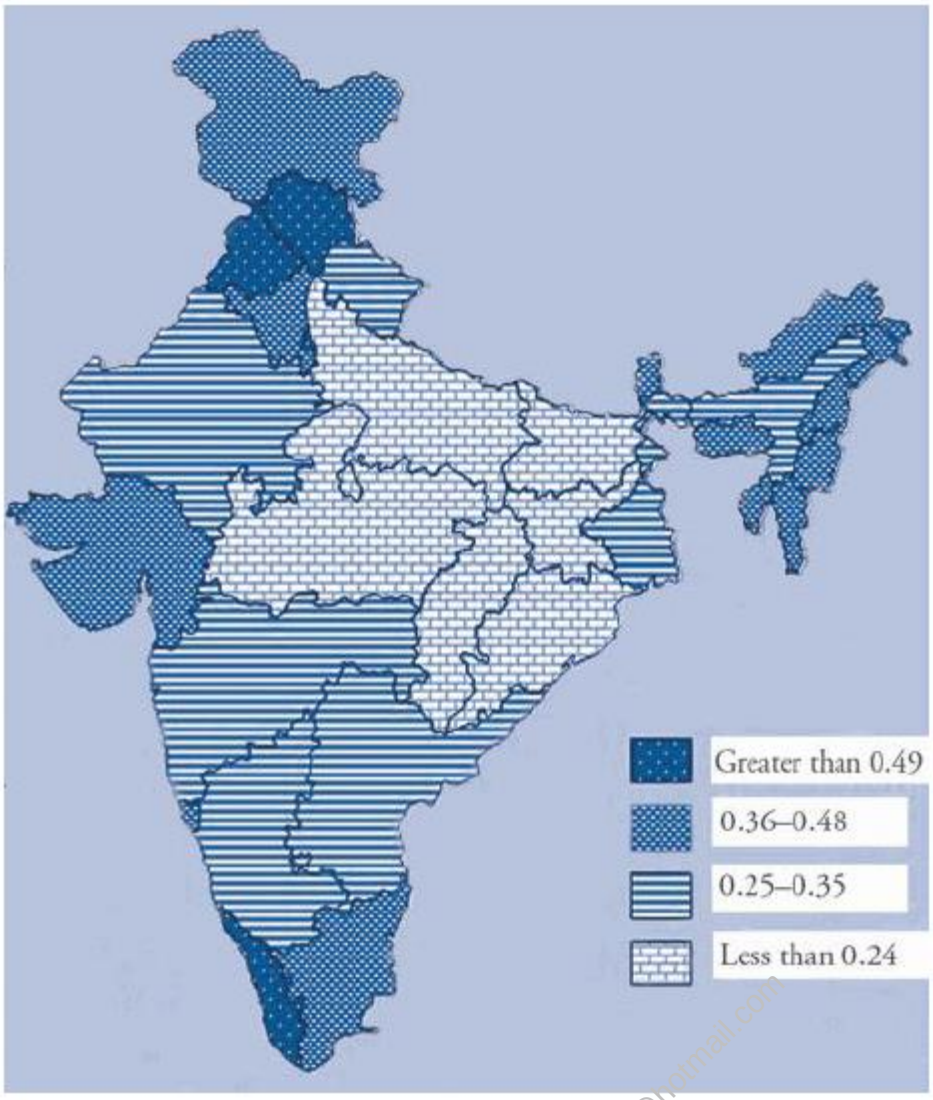

Figure 6. Income Index across various states (2007-08)

These states have incomes below the national average, with Bihar having the lowest income per capita. This is also reflected in the lowest monthly per capita consumption expenditure (MPCE) adjusted for inflation and inequality for the state. Yet, what is worth highlighting is that these poorer states, despite low absolute incomes, have witnessed high Net State Domestic Product (NSDP) growth rates (especially Bihar, Chhattisgarh, Orissa, and Uttarakhand which had growth rates above 10 per cent per annum).

The change in the Income Index between 1999–2000 and 2007–8 is almost the same as the change in the HDI over the same period for India (that is, 21 per cent).

1.5.3. Education Index

The Education Index, defined as the arithmetic mean of adjusted mean years of schooling index and literacy rate index, has seen a very impressive improvement for all states. **Education Index for India has improved by 28 per cent between 1999 and 2000 and 2007–8, that is, much more than the Income Index**.

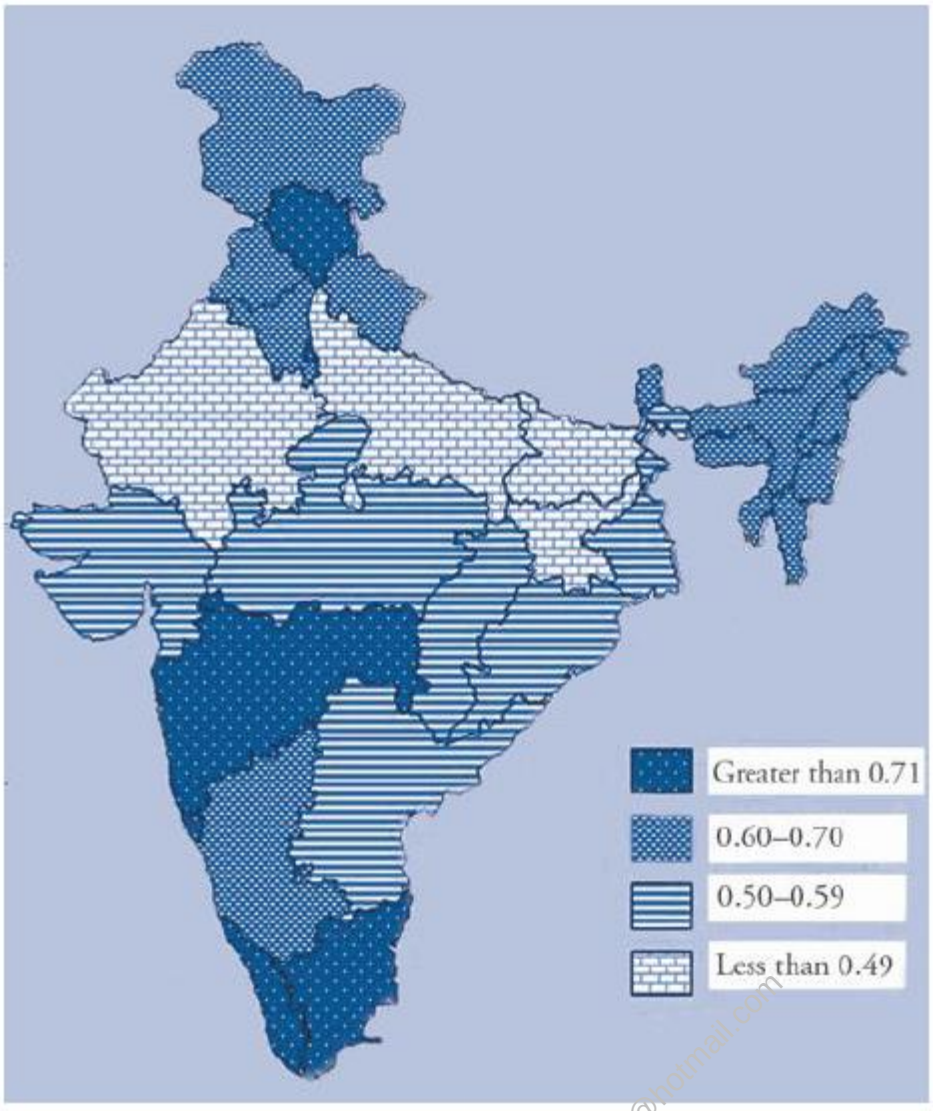

Figure 6. Education Index across states

Even in the relatively poorer states like Assam, Chhattisgarh, Orissa, Madhya Pradesh, and Uttarakhand the Education Index is above 0.5. The north-eastern states have been good performers despite low levels of income. This highlights the fact that income is not a necessary condition for improvement in educational outcomes

The improvement of 28.5 per cent in the Education Index during the period 1999–2000 to 2007–8 has driven the HDI for the country upwards. Again, as with the Income Index, the improvement in the Education Index has been the greatest in the educationally backward and poorer states of India—Uttar Pradesh, Rajasthan, Orissa, Madhya Pradesh, Andhra Pradesh, Chhattisgarh, Bihar, Uttarakhand, and Jharkhand— listed here in ascending order of the improvement in the Education Index. The improvement in the educationally backward states suggests a strong trend of convergence across the states in terms of outputs and outcomes.

1.5.4. Health Index

The Health Index is defined in terms of life expectancy at birth since a higher life expectancy at birth reflects better health outcomes for an individual.

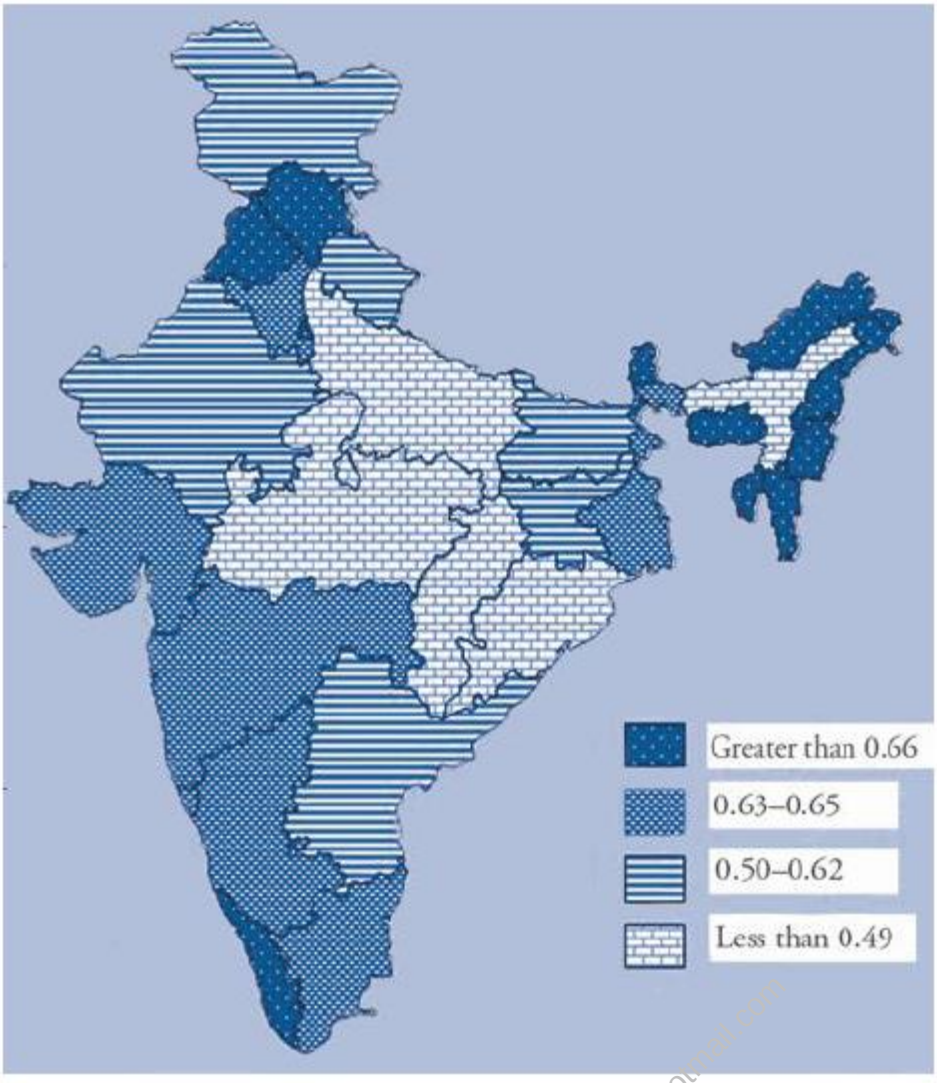

Figure 7. Health Index across states

The improvement in the Health Index for India between 1999–2000 and 2007–8 was much lower than both the Income Index and the Education Index. The improvement in the Health Index during the period 1999–2000 to 2007–8 (13 per cent) is well below the improvement in the overall HDI of the country. **In other words, while the Income Index has improved at the same rate as the HDI, and the Education Index by much more than the improvement in the HDI, the Health Index has not shown any significant change.**

There are already well-known cases of success in building an effective public health system in several states of India (for example, Kerala and Tamil Nadu). With the best public health system in the country Kerala has the highest life expectancy at birth. What is worth mentioning is that Bihar, the state that ranks the lowest in terms of almost all human development indicators, has a life expectancy at birth at par with the national average. Similarly, the relatively poorer state of Rajasthan performs marginally better than the national average. The north-eastern states, excluding Assam, have a higher life expectancy at birth compared to the national average.

It is the states with the most serious health outcome indicators and the worst health process/input indicators, which have shown the most improvement over this period, namely, Madhya Pradesh, Uttar Pradesh, Orissa, and Assam.

Overall the states' policies play a crucial role in shaping the nature of the development process. How inclusive the development process is for all the social groups residing in the state is a reflection of the state's commitment towards various dimensions of human welfare. This is supported by the success of social mobilization states like Tamil Nadu, Kerala, and the north-eastern states, where strong state commitment resulted in the upliftment of the backward castes such that their performance in health and education indicators is even better than the upper castes in most of the other states.

1.6. Planning and Development

There are two approaches to planning, i.e. sectoral planning and regional planning. The sectoral planning means formulation and implementation of the sets of schemes or programmes aimed at development of various sectors of the economy such as agriculture, irrigation, manufacturing, power, construction, transport, communication, social infrastructure and services.

There is no uniform economic development over space in any country. Some areas are more developed and some lag behind. This uneven pattern of development over space necessitates that the planners have a spatial perspective and draw the plans to reduce regional imbalance in development. This type of planning is termed as regional planning.

In order to arrest the accentuation of regional and social disparities, the Planning Commission introduced the '*target area'* and *target group* approaches to planning. Some of the examples of programmes directed towards the development of target areas are *Command Area Development Programme, Drought Prone Area Development Programme, Desert Development Programme, Hill Area Development Programme, etc.*

AGRICULTURE MARKETING, TRANSPORATION AND TECHNOLOGY

Contents

Student Notes:

1. Agricultural Marketing: Issues and Related Constraints

1.1. Introduction

The term agricultural marketing is composed of two words -agriculture and marketing. Agriculture, in the broadest sense means activities aimed at the use of natural rural resources for human welfare, and marketing connotes a series of activities involved in moving the goods from the point of production to the point of consumption. Specification, the subject of agricultural marketing includes marketing functions, agencies, channels, efficiency and cost, price spread and market integration, producer's surplus etc. The agricultural marketing system is a link between the farm and the non-farm sectors.

In India Agriculture was practiced formerly on a subsistence basis; the villages were self sufficient, people exchanged their goods, and services within the village on a barter basis. With the development of means of transport and storage facilities, agriculture has become commercial in character; the farmer grows those crops that fetch a better price. Marketing of agricultural produce is considered as an integral part of agriculture, since an agriculturist is encouraged to make more investment and to increase production. Thus there is an increasing awareness that it is not enough to produce a crop or animal product; it must be marketed as well.

Agricultural marketing involves in its simplest form the buying and selling of agricultural produce. But, in modem times, marketing of agricultural produce is different from that of olden days. In modem marketing, agricultural produce has to undergo a series of transfers or exchanges from one hand to another before it finally reaches the consumer.

The National Commission on Agriculture defined agricultural marketing as a process which starts with a decision to produce a saleable farm commodity and it involves all aspects of market structure of system, both functional and institutional, based on technical and economic considerations and includes pre and post- harvest operations, assembling, grading, storage, transportation and distribution. The Indian council of Agricultural Research defined involvement of three important functions, namely (a) assembling (concentration) (b) preparation for consumption (processing) and (c) distribution.

1.2. Characteristics of Agricultural Product

Agricultural products differ in nature and contents from industrial goods in the following respects.

- Agricultural products tend to be bulky and their weight and volume are great for their value in comparison with many industrial goods.
- The demand on storage and transport facilities is heavier, and more specialized in case of agricultural products than in the case of manufactured commodities.
- Agricultural commodities are comparatively more perishable than industrial goods. Although some crops such as rice and paddy retain their quality for long time, most of the farm products are perishable and cannot remain long on the way to the final consumer without suffering loss and deterioration in quality.
- There are certain agricultural products such as mangoes and grapes which are available only in their seasons but this condition of seasonal availability is not found in the case of industrial goods.
- Agricultural produce is to be found scattered over a vast geographical area and as such its collection poses a serious problem. But such is not condition in the case of industrial goods.
- There are various kinds and varieties in farm produce and so it is difficult to grade them.
- The farmers especially in countries like India have low holding-back. Therefore he has to sell

his produce immediately after the harvest at whatever price he can fetch because of his pressing needs.

- Finally, both demand and supply of agricultural products are inelastic. A bumper crop, without any minimum guaranteed support price from the government may spell disaster for the farmer. Similarly the farmer may not really be in a position to take advantage of shortages or deficit crop. These benefits may pass on only to the middleman.

1.3. Importance and Objectives of Agricultural Marketing

The farmer has realized the importance of adopting new techniques of production and is making efforts for more income and higher standards of living. As a consequence, the cropping pattern is no longer dictated by what he needs for his own personal consumption but what is responsive to the market in terms of prices received by him. While the trade is much organized the farmers are not Farmer is not conversant with the complexities of the marketing system which is becoming more and more complicated. The cultivator is handicapped by several disabilities as a seller. He sells his produce at an unfavourable place, time and price.

The objectives of an efficient marketing system are:

- To enable the primary producers to get the best possible returns,
- To provide facilities for lifting all produce, the farmers are willing, to sell at an incentive price,
- To reduce the price difference between the primary producer and ultimate consumer, and
- To make available all products of farm origin to consumers at reasonable price without impairing on the quality of the produce.

1.4. Facilities Needed for Farmer in Marketing

In order to have best advantage in marketing of his agricultural produce the farmer should enjoy certain basic facilities.

- He should have proper facilities for storing his goods.
- He should have holding capacity, in the sense, that he should be able to wait for times when he could get better prices for his produce and not dispose of his stocks immediately after the harvest when the prices are very low.
- He should have adequate and cheap transport facilities which could enable him to take his surplus produce to the mandi rather than dispose it of in the village itself to the village money-lender-cum-merchant at low prices.
- He should have clear information regarding the market conditions as well as about the ruling prices, otherwise may be cheated. There should be organized and regulated markets where the farmer will not be cheated by the "dalals" and "arhatiyas".
- The number of intermediaries should be as small as possible, so that the middleman's profits are reduced. This increases the returns to the farmers.

1.5. Methods of Sale and Marketing Agencies

The marketing of agricultural produce is generally transacted in one of the following ways.

- **Under cover or the Hatta System:** - Under this system, the sale is effected by twisting or clasping the fingers of the sellers agent under cover of a cloth. The cultivator is not taken into confidence until the final bid is cleared.
- **Open auction syste:** - Under this system the agent invites bids for the produce and to the highest bidder the produce is sold.
- **Dara system:-** Another related system is to keep the heaps of grains of different quantities and sell them at fiat rates without indulging in weightment etc.

- **Moghum sale:-** Under this system, sale is based on the verbal understanding between buyers and sellers and without mentioning the rate as it is understood that the buyers will pay the prevailing rate.
- **Private agreement:** - The seller may invite offers for his produce and may sell to one who might have offered the highest price for the produce.
- **Government purchase:** - The government agencies lay down fixed prices for different qualities of agriculture commodities. The sale is affected after a gradual processing for gradation and proper weightment. This practice is also followed in co-operative and regulated markets.
- **Marketing agencies:-** The various agencies engaged in the marketing of agricultural produce can be classified into two categories, viz., (i) government and quasi private agencies like the co-operative societies and (ii) private agencies. A chain of middlemen may be found operating both in Government and private agencies.

1.6. Existing Systems of Agricultural Marketing in India

The existing systems of agricultural marketing in India are as briefly described here: -

- **Sale to moneylenders and traders:** A considerable part of the total produce is sold by the farmers to the village traders and moneylenders. According to an estimate 85% of wheat, 75% of oil seeds in U.P., 90% of jute in West Bengal and 60% of wheat, 70% of oil seeds and 35% of cotton in Punjab are sold by the farmers in the villages themselves. Often the money lenders act as a commission agent of the wholesale trader.
- **Hats and shanties:** Hats are village markets often held once or twice a week, while shanties are also village markets held at longer intervals or on special occasions. The agents of the wholesale merchants, operating in different mandies also visit these markets. Most of "hats" are very poorly equipped, are uncovered and lack storage, drainage, and other facilities. It is important to observe that only small and marginal farmers sell their produce in such markets. The big farmers with large surplus go to the larger wholesale markets.
- **Mandies or wholesale markets:** One wholesale market often serves a number of villages and is generally located in a city. In such mandies, business is carried on by arhatiyas. The farmers sell their produce to these arhatiyas with the help of brokers, who are generally the agents of arhatiyas. Because of the malpractices of these middlemen, problems of transporting the produce from villages to mandies, the small and marginal farmers are hesitant of coming to these mandies. The arhatiyas of these mandies sell off the produce to the retail merchants. However, paddy, cotton and oilseeds are sold off to the mills for processing. The marketing system for sugarcane is different. The farmers sell their produce directly to the sugar mills.
- **Co-operative marketing:** To improve the efficiency of the agricultural marketing and to save farmers from the exploitation and malpractices of middlemen, emphasis has been laid on the development of co-operative marketing societies. Such societies are formed by farmers to take advantage of collective bargaining. A marketing society collects surplus from it members and sell it in the mandi collectively. This improves the bargaining power of the members and they are able to obtain a better price for the produce. In addition to the sale of produce, these societies also serve the members in a number of other ways.

1.7. Ideal Marketing System

The ideal marketing system is one that maximizes the long run welfare of society. To do this, it must be physically efficient, otherwise the same output could be produced with fewer resources, and it must be electively efficient, otherwise a change in allocation could increase the total welfare and where income distribution is not a consideration.

For maximum physical efficiency, such basic physical functions as transportation, storage, and processing should be carried on in such a way so as to achieve the highest output per unit of cost incurred on them. Similarly an ideal marketing system must allocate agricultural products

in time, space and form to intermediaries and consumers in such proportions and at such prices as to ensure that no other allocation would make consumers better off. To achieve this condition, prices throughout the marketing system must be efficient and must at the same time be equal to the marginal costs of production and marginal consumer utility.

The following characteristics should exist in a good marketing system.

- There should not be any government interference in free and market transactions. The method of intervention include, restrictions on food grain movements, restrictions on the quantity to be processed, or on the construction of processing plant, price supports, rationing, price ceiling, entry of persons in the trade, etc. When these conditions are violated, the inefficiency in the market system creeps in and commodities pass into the black market. They are not then easily available at the fair prices.
- The marketing system should operate on the basis of the independent, but systematic and orderly, decisions of the millions of the individual consumer and producers whose lives are affected by it.
- The marketing system should be capable of developing into an intricate and far-flung marketing system in view of the rapid development of the urban industrial economy.
- The marketing system should bring demand and supply together and should establish equilibrium between the two.
- The marketing system should be able to generate employment by ensuring the development of processing industries and convincing the people to consume more processed foods, consistent with their tastes, habits and income levels.

1.8. Principles of Scientific Marketing for Farmers

The tendency among the farmers to market their produce has been increasing. Production is complete only when the produce is marketed at a price remunerative to the farmer. Increasing specialization in production of higher marketable/ marketed surplus of the produce and alternative channels of marketing has increased the importance of the marketing activity for the farmers. However, marketing activity should be guided by certain basic principles which are briefly explained. The farmers can gain more if they follow the following principles of scientific marketing:

- **Always bring the produce for sale after cleaning it: -** Impurities, when present, lower the price offered by the traders-buyers in the market. The fall in price is more than the extent of impurity present in the produce would warrant. Clean produce attracts more buyers.
- **Sell different qualities of products separately: -** The produce of different varieties should be marketed separately. It has been observed that when different varieties of products are marketed separately, the farmers get a higher price because of the buyer's preference for specific varieties.
- **Sell the produce after grading it: -** Graded produce is sold off quickly. The additional income generated by the adoption of grading and standardization is more than the cost incurred in the process of grading and standardization. This shows that there is an incentive for the farmers for the production of good quality products.
- **Keep abreast of market information: -** Price information helps him to take decisions about when and where to sell the produce, so that a better price may be obtained.
- **Carry bags/packs of standard weights: -** Farmers should weigh their produce and fill each bag with a fixed quantity. Majority of the farmers do not weigh their produce before taking it for sale and suffer loss by way of a possible malpractice in weighing, or they may have to make excess payments in transit (octroi, transport costs, etc.).
- **Avoid immediate post-harvest sales:-** The prices of the produce touch the lowest level in the peak marketing season. Farmers can get better prices by availing of warehouses facilities

existing in their areas. Farmers can meet their cash needs by pledging the warehouse receipt to nationalized banks.

- **Patronize co-operative marketing societies:-** Farmers can get better prices by sales through a cooperative and marketing society and can avoid the possibility of being cheated. The cost of marketing particularly the transportation cost for farmers having a small quantity of marketable surplus is minimized, for transportation is arranged co-operatively by the society and the profit earned by the society is shared among its members.
- **Sell the produce in regulated markets:-** The farmers should take their produce for sale to the nearly regulated markets rather than sell them in village or unregulated markets. In regulated markets marketing charges are on very few items. They get the sales slips in the regulated markets, which show the quantity of the produce marketed and the amount of charges deducted from the values of the produce. Sales slips protect farmers against the malpractices of deliberate erroneous accounting or unauthorized deductions.

1.9. Impact of Globalization: Contract Marketing

The macro level changes due to the New Economic Policy have had a direct impact in the field of agricultural marketing. So the impact of globalization has been highlighted here. As a result of globalization substantial investments in new ventures are being made by national as well as international corporations. A number of foreign companies are slated to enter the Indian market through collaborations with the well known Indian companies like Eagle Agro-farms, Maxworth Orchards, etc. It is clear that the wholesaler in the fresh products market as well as the processor will prefer contract marketing tie-ups with the farmers for sourcing his supply requirements.

The concept of contract farming is not new to India. Several years back, contract marketing was successfully tried in respect of "Hima peas". 'MARKFED' of Punjab also operated a scheme of contract marketing for green peas, Agrecotec proposes to setup country-wide retail network of shops for fresh fruit vegetable marketing. Direct marketing to consumer is already being done by the Mother Dairy through its outlets in Delhi. The successful integration of production and marketing under Apni mandi scheme in Punjab and the marketing managements of 'FRESH' in Hyderabad are clear signs that contract marketing is going to be increasingly resorted to in the years to come. “Pepsi Foods" also an another example of contract farming of potatoes and tomatoes. Under this farming farmers will be producing specific varieties or qualities tailored to meet the requirements of the processor or the fresh produce market.

The potential benefits of the contract marketing are:

- Producers can reduce the market risk,
- Post harvest losses can be reduced,
- Technology can be transferred to the producers,
- Contract serve as a security for increased access to credit by both producers and processors,
- Contract may create a greater sense of common interest among the producers and induce greater involvement in group activities etc.

Common problems may be:

- Volatility in market price,
- There is risk that the processors may manipulate the quality standards,
- Coordination problems may be there regarding delivery of inputs or produce,
- Processors may lack the competence or capacity to deliver the require technical assistance,
- Producers may become tied to a contract relationship by virtue of debt, specialization, or the disappearance of other markets and may be unable to adjust their production activities to changing conditions etc.

Many of these problems of contract farming will not arise where goodwill and credibility exist between the farmers and the concerned company.

1.10. Government Measures to Improve Agricultural Marketing

Government of India has adopted a number of measures to improve agricultural marketing, the important ones being - establishment of regulated markets, construction of warehouses, provision for grading, and standardization of produce, Standardization of weight and measures, daily broadcasting of market prices of agricultural crops on All India Radio, improvement of transport facilities, etc. These are as briefly described here : -

1.10.1. Marketing surveys

In the first place the government has undertaken marketing surveys of various goods and has published these surveys. These surveys have brought out the various problems connected with the marketing of goods and have made suggestions for their removal.

1.10.2. Rural Godown Scheme

- The scheme of Rural Godowns has been formulated for creation of scientific storage capacity with allied facilities in rural areas by encouraging private and cooperative sector to invest in the creation of storage infrastructure in the country. The eligible promoters for construction of rural godowns are individual farmers, group of farmers/ growers, partnership/ proprietary firms, NGO, companies, corporations, cooperatives, Agricultural Produce Marketing Committees, Marketing Boards and Agro Processing Corporations. Godowns built under the scheme should be structurally sound on account of engineering considerations and functionally suitable to store the agricultural produce. The general conditions for scientific construction will be as follows:
    - The construction of godown should be as per Central Public Works Department/State Public Works Department specifications or any other standard specifications laid down in this behalf.
    - The godown should be properly ventilated, should have well fitted doors, windows and ventilators and should be waterproof (control of moisture from floor, walls and roof etc.)
    - The godown structure should have protection from rodents.
    - The godown should have protection from birds (windows / ventilators with jali).
    - The openings of godown such as doors, windows etc. should be designed in such a manner that the godown can be sealed for effective fumigation etc.
    - The godown complex should have an easy approach road, pucca internal roads, proper drainage, arrangements for effective control against fire and theft and also have arrangements for easy loading and unloading of stocks.

1.10.3. Grading and Standardization

- The government has done much to grade and standardize many agricultural goods. Under the Agricultural Produce (Grading and Marketing) Act the Government has set up grading stations for commodities like ghee, flour, eggs, etc. The graded goods are stamped with the seal of the Agricultural Marketing Department -AGMARK. The "Agmark" goods have a wider market and command better prices.

1.10.4. Marketing Research & Information Network

- This Central Sector Scheme was sanctioned by the Ministry Of Agriculture in March, 2000. The objective of the scheme is to establish a nationwide information network for speedy collection and dissemination of market data for its efficient and timely utilization; to ensure

flow of regular and reliable data to the producers, traders and consumers to derive maximum advantage out of their sales and purchases, and to increase efficiency in marketing by effective improvement in the existing market information system.The AGMARKNET portal is continuously being enriched with other information related to agricultural marketing for the benefit of farmers and other market users.

1.10.5. AgmarkNet

- Agricultural Marketing 'AgmarkNet' is a unique live portal on agricultural commodities anywhere in the world, technically supported by a high capacity Central server and the programming capabilities of the NIC and the data is fed into the system in a decentralized mode through the voluntary cooperation of mandi staff. This is acceptable since the aim of the network is to keep farmers and other market functionaries informed of price and market related information. The portal is in public domain and anybody can access information from the portal as per their requirement. The portal is becoming popular as the information related to different aspects of marketing. The market information from the portal is being broadcasted by various Television News Channels and published in News Papers for benefits of farmers and other stakeholders. Efforts are also being made for dissemination of market information in association with other service providers like IKSL, NOKIA and IIT, Kanpur (BSNL Telecom Center of Excellence)etc. through SMS and voice mode to the farmers and other beneficiaries.

1.10.6. National Agricultural Market Atlas (NAMA)

- National Agricultural Market Atlas (NAMA) is an offshoot of the AGMARKNET with an additional component of spatial data. It provides GIS web interface to visualize the daily market scenario on National Map. Overlaying the above information with the Road/Rail network makes it more meaningful and strengthens the decisions taken by the planner as well as the farmer. It provides details about market functionaries, market infrastructure, etc. in the form of map. The geographical distribution of the markets in conjunction with market parameters will be of immense help both the monitoring authorities and the farming community.

1.10.7. CCS National Institute Of Agricultural Marketing, Jaipur

- The National Institute of Agricultural Marketing (NIAM) is a premier National level Institute set up by the Government of India in August 1988 to offer specialized Training, Research, Education and Consultancy in the field of Agricultural Marketing. NIAM has been involved in collecting market based data for the project of National Agricultural Marketing Atlas (NAMA) from different states by providing training, creating database of various markets. The data has been collected with the co-operation of Officers and Staff of State Agricultural Marketing Boards, Directorate of Agricultural Marketing, Department of Agriculture, Department of Horticulture of various States.

1.10.8. Terminal Market Complexes

- To encourage private sector investment in agriculture, the Union ministry of agriculture is setting up terminal market complexes (TMCs), which are reducing wastage of farm produce and thereby boosting supply. It provides facilities such as cleaning, sorting, packing, storage, cold chain and transportation. It encourages participation of private enterprises which are selected as promoters in the TMC project through competitive bidding and are eligible for subsidy. Private enterprise can be any individual or consortium, while producers' association can be farmer societies, registered NGOs, etc and the TMC project are being implemented as a separate company to be registered under the Companies Act, 1956.

1.10.9. Organization of Regulated Markets

- Regulated markets have been organized with a view to protect the farmers from the malpractices of sellers and brokers. The management of such markets is done by a market committee which has nominees of the State Government, local bodies, arhatiyas, brokers and farmers. Thus all interests are represented on the committee. These committees are appointed by the Government for a specified period of time. Important functions performed by the committees can be summarized as follows.
  - Fixation of charges for weighing, brokerages etc.,
  - Prevention of unauthorized deductions, underhand dealings, and wrong practices by the arhatiyas,
  - Enforcing the use of standardized weights,
  - Providing up to date and reliable market information to the farmers, and
  - Settling of disputes among the parties arising out of market operations.

1.10.10. Central Warehousing Corporation

- The Central Warehousing Corporation was set up in 1957 with the purpose of constructing and running godowns and warehouses for the storage of agricultural produce. The states has set-up the State Warehousing Corporations with the same purpose. At present the Food Corporation is constructing its own network of godowns in different parts of the country.

1.10.11. Directorate of Marketing and Inspection

- The directorate was set up by the Government of India to co-ordinate the agricultural marketing of various agencies and to advise the Central and State Governments on the problems of agricultural marketing. Activities of this directorate includes the following:-
  - Promotion of grading and standardization of agricultural and allied commodities;
  - Statutory regulation of markets and market practices;
  - Training of personnel;
  - Market extension;
  - Market research, survey and planning and
  - Administration of old storage order, 1980 and meat food products order, 1973.

1.10.12. Government Purchases and Fixation of Support Prices

- In addition to the measures mentioned above, the Government also announces minimum support price for various agricultural commodities from time to time in a bid to ensure fair returns to the farmers. These prices are fixed in accordance with the recommendations of the Agricultural, Price Commission. If the prices start falling below the declared level (say, as a result of glut in the market), the Government agencies like the Food Corporation of India intervene in the market to make direct purchase from the farmers at the support prices. These purchases are sold off by the Government at reasonable price through the public distribution system.

1.11. Problems in Agricultural Marketing

Indian system of agricultural marketing suffers from a number of defects. As a consequence, the Indian farmer is deprived of a fair price for his produce. The main defects of the agricultural marketing system are discussed here:-

- **Improper warehouses: -** There is an absence of proper warehousing facilities in the villages. Therefore, the farmer is compelled to store his products in pits, mud-vessels, "Kutcha" storehouses, etc. These unscientific methods of storing lead to considerable wastage. Approximately 1.5% of the produce gets rotten and becomes unfit for human consumption.

Due to this reason supply in the village market increases substantially and the farmers are not able to get a fair price for their produce. The setting up of Central Warehousing Corporation and State Warehousing Corporation has improved the situation to some extent.

- **Lack of grading and standardization: -** Different varieties of agricultural produce are still not graded properly. The practice usually prevalent is the one known as "dara" sales wherein heap of all qualities of produce are sold in one common lot thus the farmer producing better qualities is not assured of a better price. Hence there is no incentive to use better seeds and produce better varieties.
- **Inadequate transport facilities: -** Transport facilities are highly inadequate in India. Only a small number of villages are joined by railways and pucca roads to mandies. Produce has to be carried on slow moving transport vehicles like bullock carts. Obviously such means of transport cannot be used to carry produce to far-off places and the farmer has to dump his produce in nearby markets even if the price obtained in these markets is considerably low. This is even truer with perishable commodities.
- **Presence of a large number of middlemen: -** The field of agricultural marketing is viewed as a complex process and it involves a large number of intermediaries handling a variety of agricultural commodities, which are characterized by seasonality, bulkiness, perishability, etc. The prevalence of these intermediaries varies with the commodities and the marketing channels of the products. Because of the intervention of many middlemen, the producer's share in consumer's area is reduced.
- **Malpractices in unregulated markets: -** Even now the number of unregulated markets in the country is substantially large. Arhatiyas and brokers, taking advantage of the ignorance, and illiteracy of the farmers, use unfair means to cheat them. The farmers are required to pay arhat (pledging charge) to the arhatiyas, "tulaii" (weight charge) for weighing the produce, "palledari" to unload the bullock-carts and for doing other miscellaneous types of allied works, "garda" for impurities in the produce, and a number of other undefined and unspecified charges. Another malpractice in the mandies relates to the use of wrong weights and measures in the regulated markets. Wrong weights continue to be used in some unregulated markets with the object of cheating the farmers.
- **Inadequate market information:** - It is often not possible for the farmers to obtain information on exact market prices in different markets. So, they accept whatever price the traders offer to them. With a view to tackle this problem the government is using the radio and television media to broadcast market prices regularly. The news papers also keep the farmers posted with the latest changes in prices. However the price quotations are sometimes not reliable and sometimes have a great time-lag. The trader generally offers less than the price quoted by the government news media.
- **Inadequate credit facilities: -** Indian farmer, being poor, tries to sell off the produce immediately after the crop is harvested though prices at that time are very low. The safeguard of the farmer from such "forced sales" is to provide him credit so that he can wait for better times and better prices. Since such credit facilities are not available, the farmers are forced to take loans from money lenders, while agreeing to pledge their produce to them at less than market prices. The co-operative marketing societies have generally catered to the needs of the large farmers and the small farmers are left at the mercy of the money lenders.
- **Small and scattered holding: -** The agricultural holdings are very small and scattered throughout the country, as a result of which the marketable surplus generated is very meagre. It is not an easy task organizing how the goods can be assembled for efficient marketing. Moreover there are many varieties of particular crops and this poses problems in pricing.

- **Forced sales: -** The financial obligations committed during production force farmers to dispose the commodity immediately after the harvest though the prices are very low. Such forced sales or distress sales will keep the farmer in vicious cycle of poverty. Report has it that the farmer, in general, sells his produce at an unfavourable place and at an unfavourable time and usually he gets unfavourable terms.
- **Technological development problems in farm production: -** Evidence has it that technological change in performing certain farm operations brought in new problems in agricultural marketing. For example, paddy harvesters are identified to increase the moisture content problem in paddy; mechanical picking of cotton associated with the problem of mixing trash with cotton; potato diggers are found to cause cuts on the potato; sugarcane harvesters effects the problem of trash mix with the cane, etc. These problems lead to the reduction of price for the farm products. Unless corrective measures are affected, the production technologies accentuate the marketing problems.
- **Poor handling, packing, packaging, and processing facilities: -** For efficient and orderly marketing of agricultural products, careful handling and packing are required. Present packing and handling are inadequate. For instance, many times we see rough and careless treatment in the packing and initial handling of fruits and vegetables. Green vegetables are packed in heavy sacks which will be heated up quickly at the centre, wilt and rot soon. Workers or passengers are allowed to ride on top of a load of vegetables, which will result in physical damage. Careless handling of fruits and insanitary handling of the produce are other problems. Poor handling and packing expose the products to substantial physical damage and quality deterioration. If there are no processing facilities, say, for tomatoes, it means all the harvested crops must be sold within a given time and because there are packaging problems, quite a substantial part of the produce may be lost before getting to the market. Not only do these losses cut down the supply of products reaching the consumers, but also raise the price of the remaining portion, which must bear all costs.
- **Growth of urban centres: -** The growth of urban centres creates more marketing problems, concerned with inadequate supply to meet the increase in size; the need to create new markets and storage problems.
- **Communication problem: -** One of the key elements of efficient agricultural marketing system is the availability of proper communication infrastructure. Rural areas are inadequately placed with reference to posts, telegraphs and telephone. The literacy rate being low among the farmers, it poses difficulty of the communication tasks.
- **Lack of farmer's organization: -** The farmers are scattered over a wide area without any common organization. In the absence of such organization, farmers do not get anybody to guide them and protect their interests. On the other hand, traders are an organized body. Thus, the marketing system, therefore, constitutes unorganized farming community on one side and organized and powerful traders on the other side. Under such situations, farmers will be generally exploited and do not get remunerative prices for their produce.
- **Inadequate research on marketing: -** Until recently, all efforts have been geared towards producing more without thinking about how to market them. There is need to know about new technologies in food storage and preservation. There is also need for research on consumer demands and preferences, handling and packaging.
- **Problems caused by Globalization: -** The globalization has brought drastic changes in India across all sectors and it is more so on agriculture, farmers and made a deep impact on agricultural marketing. It is basically because of majority of Indians are farmers. It has brought several challenges and threats like uncertainty, turbulence, competitiveness, apart from compelling them to adapt to changes arising out of technologies. If it is the dark cloud there is silver lining like having excellent export opportunities for our agricultural products to the outside world.

1.12. Suggestions to Improve Agricultural Marketing

Improving the marketing system of agricultural products would help the farmer to better his economy. The following are suggested measures that could reflect an improved agricultural marketing system:

- **Establishment of More Regulated Markets: -** A regulated market is one, which aims at the elimination of the unhealthy and unscrupulous practices, reducing marketing charges and providing facilities to producers. Under the regulated markets, its management should be vested with market committees in which the members would be producers, traders, officials of the marketing societies, officials of agricultural and animal husbandry etc. The institute should be self-financed, statutory and autonomous. Funds would be raised through licensing fees and market fees on the notified agricultural produce transacted in the premises of the market yard. The regulated market however has the following benefits:
  - Farmers are encouraged to bring their produce directly to the markets.
  - Farmers are protected from the exploitation of market functionaries.
  - Farmers are ensured better prices for their produce.
  - Farmers have access to up-to-date market information.
  - The marketable surplus of the farmers will be increased.
  - Marketing costs are lowered and producers share will be increased.
- **Improvement in Standardization and Grading: -** Standard specifications and grading should be designed to be useful to as many producers, traders and consumers as possible i.e., standards should reflect market needs and wants. One grade should have the same implications to producers, traders and consumers in the quality of the product. It must have mutually acceptable description. They should reflect commodity characteristics that all types of buyers recognize. The grading should be simple, clear and easy to understand.
- **Improvement in Handling and Packing: -** This refers to the adoption of new techniques for the physical handling of commodities throughout the various phases of marketing, for instance, the use of cold storage (mechanical refrigeration) in handling of perishables, new methods of packing etc. The most appropriate handling and suitable containers among the available ones are meant to use against dust, heat, rain, flies etc., to prevent considerable physical losses and quality deterioration.
- **Provision of Storage Facilities: -** Reduction of physical damage and quality deterioration in the products can be brought about through the application of the scientific techniques and provision of appropriate storage facilities depending on the nature and characteristics of products and the climatic conditions of an area. To this effect, more licensed warehouse are required. A licensed warehouse has the following benefits:
  - Reduces the wastage in storage of various commodities by providing scientific storage facilities
  - Assists the government in orderly marketing of agricultural commodities by introducing standard grade and specifications
  - Issues warehouse receipts, a negotiable instrument in which commercial banks advance finance to the producers and dealers
  - Assists government in the scheme of price support operations.

  However, there would be procedures for storage which are not too bureaucratic. The depositor intending to store the produce in the warehouse would have to present a written requisition in the application prescribed by the warehouse. The commodity meant for storage will be properly packed and delivered at the warehouse. The depositor would have to disclose all details of the commodity including the market value in the application form. The commodity brought for storage will be graded and weighed by trained technical

personnel before the commodity can be stored. Different storage charges would also apply for different commodities and the stocks offered for storage will be insured against possible risks of fire, theft and floods, strikes and civil commotion.

- **Improvement in Transport Facilities: -** Link-up and associated road development is sine qua non for the success of market structure. The availability of efficient transportation encourages the farmers to the markets of their option to derive the price benefits. Rural roads particularly are in bad state during all seasons and more so during rainy season. Investment on roads should be given top priority. Also another problem is that perishables cannot be transported in closed wagons hence there is a need to provide necessary ventilation in whichever means they are to be transported.
- **Market Information: -** As such we have newspapers, price bulletins, reports of the government agencies etc., which provide market information. This information would be much more useful if an educational programme is made available to analyse and interpret the information at the markets. The raw data no doubt provides valuable information but skilful interpretation makes it useful to the farmers.
- **Market Research: -** Market research can be defined as the study of consumer demand by a firm so that it may expand its output and market its product. It centres on consumer's needs, preferences, impressions of a product, accessibility of markets, efficiency of marketing etc. Marketing research needs to be given top priority to improve up on the marketing system.
- **Market Extension: -** This involves the dissemination of needed information on marketing to producers. The farmers will be advised on consumer preferences, grading, packaging, transport, etc., in order to help them to secure better returns.
- **Provision of Agricultural Marketing Training to Farmers: -** Provision of training is of utmost importance in view of the malpractices resorted to by various market functionaries. The farmer needs to be trained in product planning i.e. crops and varieties to be grown, preparation of produce of produce for marketing, malpractices and rules and regulations, market information, promotion of group marketing, etc.
- **Promoting Cooperative Marketing: -** Cooperative marketing is the organized sale of farm products on a non-profit basis in the interests of the individual producer. Cooperative marketing are organized by farmers themselves and the profits are distributed among the farmer-members based on the quantity of the produce marketed by them.

  The agricultural marketing system should basically ensure that the producer is encouraged to increase production, besides assuring the farmer remunerative prices for his produce and supplying the commodities to the customers at reasonable prices. In view of this, cooperative marketing societies should be established for meeting the requirements of the farmer. The benefits of cooperative marketing include:

  - Make arrangement for the sale of produce of the members
  - Provides credit facilities to the members on the security of agricultural produce
  - Provide grading facilities, which would result in better price
  - Make arrangement for scientific storage of the member's produce
  - Arrange the supply off inputs required by the farmers
  - Undertake the system of pooling the produce of the members to enhance the bargaining power through unity of action
  - Arrange for the export of the produce to enable the farmers get better returns
  - Act as an agent of the government in procurement of food-grains, etc.
- **Provisions for Cold Storage Facilities and Refrigerated Transport: -** For perishable commodities like fruits and vegetables, quality losses are enormous and hence it would be necessary to take measures and devise means or methods of controlling and minimizing

losses. Preservation is, thus, a necessary adjunct of production and a vital link between production and consumption. Cold storage is the most important for the proper marketing of horticultural produce, because it had a definite season of production and the quality of the produce deteriorates quickly after harvest. Most fruits and vegetables losses moisture to the surrounding air almost any time in the humidity of the air is less than saturated. It is possible to maintain high humidity of the 80 – 95 per cent in proper cold storages and hence refrigeration is also beneficial in reducing moisture losses. Refrigerated transport for perishables needs to be provided during their movement in marketing channels. Besides road transport, railway wagons should also be suitably modified for transportation of perishables.

- **Development of Physical Market: -** Physical markets handling fruits and vegetables suffer from operational and management inadequacies. A country level plan to identify markets of national importance for fruits and vegetables and provision of need-based infrastructure from export point of view in all these markets is imperative.

1.13. Conclusion

There is no doubt that in any marketing there is a motive towards profit involved and at the same time the marketing is to be based on certain values, principles and philosophies such as offering just and fair prices to the farmers who toil hard to till. Bringing necessary reforms coupled with proper price discovery mechanism through regulated market system will help streamline and strengthen the agricultural marketing.

In order to avoid isolation of small-scale farmers from the benefits of agricultural produce they need to be integrated and informed with the market knowledge like fluctuations, demand and supply concepts which are the core of economy. Marketing of agriculture can be made effective if it is looked from the collective and integrative efforts from various quarters by addressing to farmers, middlemen, researchers and administrators. It is high time we brought out significant strategies in agricultural marketing with innovative and creative approaches to bring fruits of labour to the farmers.

2. Agricultural Transportation: Issues and Related Constraints

2.1. Introduction

An efficient transport system is critically important to efficient agricultural marketing. If transport services are infrequent, of poor quality or are expensive then farmers will be at disadvantage when they attempt to sell their crops. An expensive service will naturally lead to low farm gate prices (the net price the farmer receives from selling his produce). Seasonally impassable roads or slow and infrequent transport services, coupled with poor storage, can lead to losses as certain crops (e.g. milk, fresh vegetables, tea) deteriorate quickly over time. If the journey to market is made over rough roads then other crops (e.g. bananas, mangoes) may also suffer losses from bruising; this will also result in lower prices to the farmer.

Agriculture is best served by consistent high urban, and international, demand. This is best brought about by an efficient, high volume, transport and marketing system where the transporting and marketing unit costs are low. If the margin between what the farmer receives from the sale of his produce and what the urban consumer pays for his produce is high then the effective demand transferred to the farmer will be correspondingly be reduced. Similarly if internal transport costs in a country are particularly high then the scope for agricultural exports will also suffer in comparison with other more efficient countries.

The pattern of agricultural marketing is strongly influenced by the nature of transport services. Many developing countries suffer from monopolistic, low volume and high cost transport and marketing systems. Economies of scale are present in both transport and marketing operations. In the following we will consider transport costs, the impact of roads on rural development, access to markets and the potential use of intermediate means of transport.

2.2. Role of Intermediate Means of Transport in Agriculture

Intermediate Means of Transport or IMTs includes wheelbarrows, bicycles, rickshaws, various animal carts and wagons, motorcycles, motorized three-wheelers, and two-wheel tractors that fill the gap between more expensive motor vehicles and tedious human effort. Intermediate means of transport IMTs can play a useful role in agricultural marketing. Walking, the dominant mode of on-farm transport, can restrict any increase in agricultural production. IMT can improve the efficiency of on-farm agricultural transports by reducing transport costs and time. The effects on agricultural production can be manifold:

- Cultivation of bigger areas
- Utilization of more fertile, but remote, soils
- Production of heavier corps
- Increased utilization of fertilizer and manure
- Reduced pest damage and spoilage at crop harvest time
- Reduction of transport time, partly used for income generation
- Reduced effort and drudgery involved in human porterage
- Spill-over effects if animals are used for ploughing and transport

Thus, IMT enable the farmers to respond better to markets by augmenting or changing their production. Additionally, they reduce losses, save transport costs and time. If markets are within walking distance then head loading is important. Transport efficiency can be significantly increased by improvement of footpaths or the use of IMT. If markets are more than half a day's non-motorized travel, a multimodal transport system is a cost-effective solution. Trucks are unbeatable on long distances, good roads and fully loaded, and IMT operate more efficiently on short distances with small loads and on bad roads making a multimodal approach the best solution for rural transport problems.

2.3. Effect of Markets and Storage Facilities on Agricultural Transportation

The presence of markets and storage facilities play an important role in affecting choice of vehicle. Markets and storage facilities both provide the same role of acting as a place where agricultural produce can be amalgamated. This may be for the purpose of immediate sale or for transportation to the next destination. Access to markets and storage facilities therefore affect vehicle choice in two main ways.

Firstly, the ease of access to these facilities, whether in terms of distance or ability to use the facilities, will dictate the farmer's decision on which vehicle to use. For example, if the storage facility is close he may decide to buy a non-motorised vehicle which would have been of no use if the facility was beyond a certain distance. Similarly, if once the farmer had reached the facility he was unable to use it either because of its expense or because of exclusionist type practises, the need for a vehicle becomes redundant, and the farmer's produce may as well be sold to the village trader. The farmer will only demand a more advanced vehicle if it is the perception that the vehicle will enable an effective increase in farm gate prices.

Secondly, where goods are amalgamated it means that the density of demand for vehicle services increases. The density of demand is of vital importance in determining vehicle choice.

The larger the demand the more an efficient and cost effective vehicle can be justified and hence the unitary costs of transport are reduced. The existence of markets and storage facilities are important at any level. For example, at the village level a small grain store may be able to accumulate enough demand from all the farmers to justify the use of a donkey cart for transportation to market. Without the store individual farmers may only be able to justify head loading their surplus produce to market. Similarly, at the district level a market could attract city traders who bring large trucks to transport the produce bought at the market in bulk.

The ease with which farmers and traders have access to markets and storage facilities will be reflected in their distribution costs (transport and storage). If distribution costs are low this will effectively increase farm gate prices which will give farmers the incentive to increase production.

2.4. Transportation Cost of Agricultural Produce and Farmer's Income

Cost of transportation of agricultural produce from the farm sites to the market has a great impact on production and income of farmers. This is because transport charges on agricultural produce vary with type of crops, the efficiency of the transport and distance travelled. A significant proportion of the farmer's income had gone to transportation and this is as a result of bad roads in these areas. High cost of transportation would translate to high selling price and if the price is too high when compared with other farmers from other areas, customers will not buy and this may result to selling at a loss.

The importance of an efficient and competitive marketing system has been stressed as a complement to rural transport services (RTS) and infrastructure in promoting development. However, the presence of markets in them also constitutes a means by which the effective demand for transport can be increased. A market acts as a point where goods and people are amalgamated together and thereby concentrating the demand for transport. Where populations are dispersed markets are also likely to be dispersed with long average distances to market and people less likely to make the trip. This is an important consideration for the demand for Intermediate means of transports where, if distances become too large, an Intermediate means of transport may not be viable.

In addition, one of the most effective ways that farmers have of getting the best price for their produce is for them to sell it themselves directly to final consumers at rural or urban markets, and thus bypass the normal marketing system. Although farmers do not have the economies of scale of travelling wholesalers it is often recognised by urban dwellers that the keenest prices are often provided by the farmers. Farmers bringing their own produce to market represent a very important way of limiting the power of the marketing cartels. Farmers rely on travelling wholesalers, traders, parastatals or large private marketing companies they all reduce the farmers bargaining power, and critically, it reduces demand for transport services and the supply of vehicles available for rural people. There is usually little support by the authorities for 'unofficial' trading and farmers are frequently harassed as they attempt to sell.

2.5. Transportation Problems and Road Network

Farmers face various transportation problems in the process of transporting their produce from the farm to their houses and markets. These problems included:

- Bad roads,
- High cost of transportation,
- Irregularity of vehicles,
- Insufficiency of vehicles,

- Insufficient means of transportation and
- Long distance from farm to their houses as well as markets.

Road network plays main role among them. This is because it is the major means of transporting agricultural produce from the farms to the markets. Road transport has both positive and negative impact on agricultural development in India.

The impacts of bad road infrastructure on agricultural output and productivity are following: -

- The agricultural sector accounts for a large share of gross domestic product. Poverty is concentrated in rural areas. The relatively low levels of road infrastructure and long average travel time's result in high transaction costs for sales of agricultural inputs and outputs, and this limits agricultural productivity and growth.
- Many farmers are reluctant to grow a marketable surplus second crop because it cannot be sold or because the difficulty and expense of transport significantly reduces the returns to labour.
- Agricultural productivity will be low and there is a lack of innovation because extension information and inputs do not reach the farmers.
- Rural people often are too poor to own their own motorized vehicles and depend on public transport to gain access to locations outside their communities. When rural roads deteriorate public transport becomes more expensive and transport operators eventually decide to stop their business.
- Some of the variables that determine the level of development in a given environment are easy accessibility and mobility.
- A strong relationship between road transportation, underdevelopment and rurality has been identified by various researches.
- When the distance of farm to the market is far and the road is rough perishable crops may be destroyed and farmers may run at a loss.
- With improved roads, transport cost savings occur both through lower costs of existing traffic and lower costs of generated and attracted traffic. The assumption is that traffic will grow as a result of road improvements. A deterioration of the road network on the other hand will gradually reduce traffic levels. Moreover the unit transport cost will increase.
- When the roads become impassable, there will be a shift to less-effective modes of transport, replacing motorized transport by more costly non-motorized transport. The move to non-motorised transport often implies that a lot of transport simply ceases to take place. If motorised transport is not available, bulky goods can only be transported for short sections.
- By the reduction in competition in the transport sector due to lower traffic levels, results in the increased cost of transport and that is passed to the farming households.
- A well maintained road network keeps input and transport prices down and, hence, production costs lower and can lead to improved livelihoods through higher incomes.
- The quality and density of the rural road network makes a significant difference in the cost of agricultural inputs, the quality and value of outputs as well as the delivery of extension services.

2.6. Problems of Road Transport in India

Road transport of the country is facing a number of problems. Some of these problems are discussed below:

- Most of the Indian roads are unsurfaced (42.65%) and are not suitable for use of vehicular traffic. The poor maintenance of the roads aggravates the problem especially in the rainy season. According to one estimate there is about per year loss of Rs. 200 crores on the wear

and tear of the vehicles due to poor quality of roads. Less than 0.1 percent of the national income is spent on the maintenance of roads in India.

- Sixty percent of villages are without roads in India. It adversely affects our agriculture and rural economy.
- There is heavy tax burden on motor transport in India. There are multiple check-posts, toll tax and octoroon duties collection points on the roads which bring down the speed of the traffic and waste time. Rate of road taxes vary from state to state and interstate permits are difficult to obtain.
- Way side amenities like repair shops, first aid centers, telephones, clean toilets, restaurants, rest places are lacking along the Indian roads. There is very little attention on road safety and traffic laws are wilfully violated.
- There is little co-operation and co- ordination among different states with regard to motor transport. As such, motor transport faces lot of difficulties.
- According to 'Road Transport Reorganization Committee', 90 per cent of the operators are small operators owning five vehicles or less. Owing to this small number, satisfactory and efficient service is not being provided to the people.
- Due to high prices of petroleum products and diesel operational costs of road transport are rising and making the mode of transport more costly.
- Most of the drivers on the roads are unskilled and untrained.
- One major problem on the Indian roads is the mixing of traffic. Same road is used by high speed cars, trucks, two wheelers, tractors, animal driven carts, cyclists and even by animals. Even highways are not free from this malady. This increases traffic time, congestion and pollution and road accidents.
- In India, roads are not well-maintained as there are no timely repairs. It causes discomfort and quick depreciation of vehicles.
- There is very little participation of private sector in road development in India because of long gestation period and low-returns. The legislative framework for private investment in roads is also not satisfactory. The road engineering and construction are yet to gear themselves up to meet the challenges of the future.
- There has been no stability in policy relating to highway development in the country. It has changed with the change of government. There are a number of agencies which look after the construction and maintenance of different types of roads. Since there is no co-ordination between these agencies their decisions are often conflicting and contradictory.

2.7. Special Problems in the Construction of Rural Roads

Rural roads constitute a special category of roads as regards the type of materials used and construction techniques employed, as compared with roads forming the highway network. As a result, the construction and maintenance problems involved in keeping the rural road network at a satisfactory level of serviceability are of a different quantum and type. Some of these problems are:

- Rural roads are generally built up in stages, extending over a number of years. This practice arises from the inadequate availability of finances, as well as from the fact that the traffic is likely to increase after an initial road link is established, thereby necessitating an upgradation of the pavement.
- One important and significant feature pertaining to the construction of rural roads is the emphasis placed on the utilisation of the local materials, both soil and stone aggregates in the various layers of the pavement. This necessitates that such materials to be utilized after careful evaluation of their properties and affecting the needed improvements by blending or the use of additives as may be required.
- The construction of rural roads is handled by a number of different agencies, varying from state to state. Within the same state different agencies might be building rural roads in different districts.

- The level of expertise available shows great variation from department to department, and it is not unusual to find that trained personnel are not available in the executing department to plan, design and construct a rural road that makes optimal use of the material and financial resources available and build a material and financial resources available manual labour is resorted to, to the maximum extent, since providing employment to the local population also forms one of the essential objectives of the various rural development programmes.
- Rural labour generally does not have the necessary skills associated with the different phases of road construction, nor is any training imparted to them before inducting them into the construction programme. Employment on such construction works is viewed, rather mistakenly, as a relief measure lesson the problem of rural employment. The consequence of such thinking is a finished product of poor quality, i.e., an improperly built road that has only frittered away the meagre resources.
- The lack of adequate quality in the inputs, human as well as material, results in a faster deterioration of the serviceability to a lower than the tolerable level. In turn, these results in greater demands on maintenance, viz, more frequent repairs, involving additional deployment of manpower and materials, all adding upto higher spending on maintenance. If money for maintenance is short, final result will be the deterioration of the roadway leading to the loss of initial capital investment itself.

2.8. Measures Taken for Improving Rural Road Infrastructure by Government

Rural roads connect villages giving access to rural population to the National Highways through Major District Roads and State Highways. Around 59 per cent of the total road length is accounted by rural roads largely built under Jawahar Rojgar Yojna. These roads are of limited value from the point of view of movement of heavy traffic. Some of the government's measures to improve rural road infrastructure are as follows:-

- Pradhan Mantri Gram Sadak Yojana (PMGSY) was launched on 25th December 2000 as a fully funded Centrally Sponsored Scheme to provide all weather road connectivity in rural areas of the country. The programme envisages connecting all habitations with a population of 500 persons and above in the plain areas and 250 persons and above in hill States, the tribal and the desert areas.
- The District Rural Roads Plans (DRRPs) have been developed for all the districts of the country and Core Network has been drawn out of the DRRP to provide for at least a single connectivity to every target habitation. This planning exercise has been carried out with full involvement of the three tier Panchayati Raj Institutions.
- Large scale revision of Rural Roads Manual were carried out by IRC at the special intervention of Ministry of Rural Development. This Manual has established the standards for construction of Rural Roads.
- A three tier quality mechanism has been operationalised to ensure quality of road works during construction.
- There is a provision of two bills of quantities, one for construction and another for routine maintenance on lump-sum basis amount every year for 5 years and the contactor is required to offer not only for construction but also for maintenance separately. This helps in delivery of better quality roads because if the quality of road is compromised by the contractor during construction, much more money would be required during the routine maintenance rendering the contract uneconomical for the contractor.
- A web based online monitoring, management and accounting system has been developed under the PMGSY. The online system and website is being managed and maintained in collaboration with NIC and CDAC.

- The Central Government has created a dedicated fund, called Central Road Fund through collection of cess from petrol and diesel. Presently, Rs. 2/- per litre is collected as cess on petrol and High Speed Diesel (HSD) Oil. The fund is distributed for development and maintenance of National Highways, State Roads and Rural Roads.
- Special construction technology to tackle the construction of roads in the hilly regions would be adopted to ensure quality roads within a specific time frame.
- Promoting participation of private operators on non viable semi urban/rural routes through favourable policy regime. This could be achieved through following options:-
    - Auctioning of combination of routes (which are a mix of profitable and non viable routes) to private operator(s) so as to enable them to compensate their losses on account of operation of non viable routes;
    - Offering non viable routes to bidder asking for lowest subsidy/financial support;
    - Subjecting non viable routes to lower rates of taxation or permit fees and;
    - Allowing alternate competing modes of passenger road transport.

2.9. Suggestions for Better Rural Road Network

It is essential that for quick development of rural road network concerted effort is required during planning which should begin at gross root level by associating the concerned village folk and by convincing them that appropriate quality of road constructed with appropriate technology would meet their requirement and this would be maintained and upgraded with their association. All possible resources should be mobilized for raising the necessary funds. Some of the possible suggestions are:

- A feeling has to be created in rural people that they are getting or building an asset for themselves and future generation instead of having a feeling that government is building a road and that the major beneficiaries are the government agencies or the contractor. In other words they should have feeling of belonging instead of detachment.
- If Villagers are made aware about their minimum needs and assured that all assistance will be forthcoming for proper maintenance and continuous upgrading of the road with time and need, they will have a cooperative attitude and would assist in many ways during the initial construction, or subsequent maintenance.
- Land consolidation work can be taken up simultaneously to planning. The land for access road along with raising of the track and proper drainage of the village should also be considered with other facilities for the village during land consolidation. The land for access road on embankment may be considered similar to land reserved for Panchayat land and other common facilities to the village.
- In some cases the village get submerged by the flood of a nearby river. In that case protection of village by bunds/dykes can be considered and these “bunds” will also provide access roads on embankment. But the drainage of village has to be adequately planned in these cases otherwise any opening in the ‘bund’ for cross drainage works, may flood the village by back flow when water level is higher on the other side.
- The quality of road to be constructed has to be planned and will depend upon the subgrade soil properties, level of water table, quantity and quality of anticipated traffic and level of maintenance to be provided. The simplest and first stage of road construction is a properly cambered formation, with reasonable shoulder width and drainage system.
- The road construction work can be taken up in lean farming period, where by free (if managed) or cheap labour could be available. Similarly the timely maintenance of rural roads is essential. This is from the consideration that once damage starts in rural earthen roads it will develop at a much faster pace compared to higher grade roads. Any neglect will totally undo the assets created in past and instead of upgrading at a later date, only in

first stage construction has to be repeated every time afresh. The standard of road should be continuously raised and adequately maintained over the future years.

- At least some part of land revenue collected from the villages could be ploughed back for their development and a minimum percentage of land revenue should be earmarked for rural roads also.
- Another source of raising fund for the rural road development could be, levying a sort of a cess on the saleable produce. This could be collected from the farmers at the market place, sugar mills, rice mills, etc. Many market places (Mandies) do levy a cess on the parked vehicles and produce sold, for the development of market place and for the facilities provided. Even the private wholesale dealers charge commission over the sale. At present most to the farm produce is purchased by the governmental agencies and the price offered s according to the rates fixed by the government, thus the cess to be collected may form a part of the price offered. The cess collected from market place may be distributed amongst the villages feeding the market place.
- Village Panchayats can also collect a type of 'Road Tax' from the vehicles in the village. The rates could be different for different types of vehicles.
- A toll tax can be collected by panchayat from the vehicles visiting the village.
- Banks can also be asked to liberalize their policy and should consider advancing loans to villages at nominal interest for construction of rural roads providing access to the village which would not involve greater risks than that of existing procedure of advancing loans to artisans, etc. for setting up their shop, workshop etc. for increasing the income.
- Industrial houses, commercial undertakings, banks etc. can also be asked to adopt villages for upliftment. Villages selected should be similar to selection of poor families in a village or district for their upliftment. These families are given some fund for raising their means of livelihood.
- The government can also provide matching grant to the funds raised by Panchayat by tax collection, donation, etc. for access road construction to backward villages.
- By proper training and motivation of the personnel involved in the construction and maintenance of these, as well as increasingly adopting appropriate technological methods that have been developed, better rural roads can be built.

2.10. Conclusion

Transport plays a significant role in the structure of food production and marketing and that easy transport to market can make all the difference in the level of rural incomes. An improved transportation will encourage farmers to work harder in the rural areas for increased production, add value to their products, reduce spoilage and wastage, empower the farmers as well as having positive impact on the productivity, income, employment level and reduce poverty level in the rural areas. Finally, transport is also seen as a facilitating factor in the mobilisation of the farmers and other allied workers in the overall national development of the nations.

3. e-Agriculture: e-Technology in The Aid of Farmers

3.1. Introduction

E-Agriculture is an emerging field for enhancing sustainable agriculture and food security through improved processes for knowledge access and exchange using information and communication technologies (ICT).

Agriculture is one of the most important sectors in India, and could benefit tremendously with the applications of ICTs especially in bringing changes to socio-economic conditions of poor in backward areas. Agriculture constitutes a major livelihoods sector and most of the rural poor

depend on rain-fed agriculture and fragile forests for their livelihoods. Farmers in rural areas have to deal with failed crops and animal illness frequently and due to limited communication facilities, solutions to their problems remain out of reach.

The service role of ICTs can enhance rural community's opportunities by improving their access to market information and lower transaction costs for poor farmers and traders. Though India has a strong and fast growing IT industry, access to ICTs remains very low particularly in rural areas. The present indicators of IT penetration in Indian society are far from satisfactory.

The National Policy for Farmers emphasizes the use of Information and Communication Technology (ICT) at village level for reaching out to the farmers with the correct advisories and requisite information. The available satellite data relating to weather news, long-term and short-term weather forecast, production information, market prices policy developments pertaining to agriculture, apart from the number of advisory services in public or private domain that disseminate information should be utilized adequately.

3.2. Information Technology and its Components

Induction of IT as a strategic tool for agricultural development and welfare of rural India requires that the necessary IT infrastructure is in place. The rapid changes and downward trend in prices in various components of IT makes it feasible to target at a large scale IT penetration into rural India. Some of the broad factors to be noted with respect to various components of IT are listed below:

- **Input Devices:** Radical improvements are witnessed with respect to the means of communication by human beings with computers such as key boards, mouse devices, scanners. The advent of touch screen monitors that allow users to give input to computers by touching on the appropriate location of the monitor has made it possible to develop user-friendly interface for farmers which is easy, intuitive, circumvents language barrier and at the same time provides a relaxed environment to the users. The present day digital cameras make it possible to capture and store good quality graphics and large video clips. The small size and low weight of these digital cameras, which are increasingly becoming affordable, open up the possibilities of providing computer based demonstration clips to educate the farmers. The digital cameras can also be used to upload plant stress related images, movie clips which can facilitate an expert residing at a far of location to quickly recommend a solution.
- **Output Devices:** Monitor screens, printers & plotters, data projectors support high resolution and good quality output. The qualities of these output devices have the potential of generating renewed interest in the farmers in using IT based services. The light weight portable data projectors can be easily carried by the agricultural extension personnel for serving larger audience. Similarly, speakers can also be attached to the computers to incorporate voice based trainings for farmers.
- **Processors:** The processing speeds of computers have gone up. At present high speed processorsare available which makes it possible to undertake substantial processing of data at the client side.
- **Storage Devices:** 80GB and even higher hard disk drives have become common in PC range of computers. This makes it possible to store substantial information at the local level which facilitates faster access. Similarly, high capacity pen drives, CDs make it possible to transfer large volumes of data to locations which cannot be connected to networks immediately. These storage devices are also used for backup of crucial data. As a precaution, many corporate store their backups at locations away from the place of work.
- **Software:** Various operating systems are available which act as interface between the user and the machine. The graphic user interface (GUI) has become an accepted prerequisite for

end users. Application software which can support complex user requirements are available. Of the shelf solutions for office automation packages, groupware applications, complex database solutions, communication products, solutions based on remote sensing & geographical information systems are available. In addition, solutions based on some or all of these are also readily available. The present downward trend in the IT industry provides an opportunity get customised application for any specific task developed at an affordable price. Rapid Application Development and Deployment (RADD) is a popular model for quick development and deployment of applications. Development environment itself is simplified with tools that quicken the pace of software specialists. Project management and monitoring software are available that facilitate efficient execution of large and complex applications that are required for rural India.

- **Networking Devices:** The capacity of modems, used to convert the data from digital to analog and vice versa, which are popularly employed to use telephone lines have increased. Internal modems are available integrated into the computer so that they are not exposed to outside environment. The capacities of other networking devices such as routers have also gone up which makes it possible to create large networks with smooth data transmission.
- **Transmission Media:** The media through which the data transfer takes place has also undergone revolutionary change. Telephone lines are still the popular source in India although the reliability and low bandwidth are still major issues. High capacity cables, optical fibre, radio, wireless local loops, satellite transmission and various solutions based on a combination of these are already being used in many parts of the country.
- **Other Accessories:** Uninterrupted Power Supply (UPS) devices are crucial to ensure the durability of the IT equipment as well as provide backup mechanisms. The potential of solar power packs to provide a feasible solution to shortage of power in the rural areas needs to be exploited.

3.3. Role of IT in Agriculture

Applications of IT in support of agricultural and rural development fall into five main areas. These are:

- Economic development of agricultural producers;
- Community development;
- Research and education;
- Small and medium enterprises development; and
- Media networks.

Precision farming, popular in developed countries, extensively uses IT to make direct contribution to agricultural productivity. The techniques of remote sensing using satellite technologies, geographical information systems, agronomy and soil sciences are used to increase the agricultural output. This approach is capital intensive and useful where large tracts of land are involved. Consequently it is more suitable for farming taken up on corporate lines.

The indirect benefits of IT in empowering Indian farmer are significant and remain to be exploited. The Indian farmer urgently requires timely and reliable sources of information inputs for taking decisions. At present, the farmer depends on trickling down of decision inputs from conventional sources which are slow and unreliable. The changing environment faced by Indian farmers makes information not merely useful, but necessary to remain competitive.

Here are some agricultural development services that can be provided in the developing world using ICT:

- Online services for information, education and training, monitoring and consultation, diagnosis and monitoring, and transaction and processing;

- E-commerce for direct linkages between local producers, traders, retailers and suppliers;
- The facilitation of interaction among researchers, extension (knowledge) workers, and farmers;
- Question-and-answer services where experts respond to queries on specialised subjects ICT services to block- and district-level developmental officials for greater efficiency in delivering services for overall agricultural development;
- Up-to-date information, supplied to farmers as early as possible, about subjects such as packages of practices, market information, weather forecasting, input supplies, credit availability, etc.;
- Creation of databases with details of the resources of local villages and villagers, site-specific Information systems, expert systems, etc.;
- Provision of early warning systems about disease/ pest problems, information regarding rural development programmes and crop insurances, postharvest technology, etc.;
- Facilitation of land records and online registration services;
- Improved marketing of milk and milk products;
- Services providing information to farmers regarding farm business and management;
- Increased efficiency and productivity of cooperative societies through the computer communication network and the latest database technology;
- Tele-education for farmers;
- Websites established by agricultural research institutes, making the latest information available to extension (knowledge) workers and obtaining their feedback.

3.4. E-Agriculture Ecosystem

E-Agriculture initiatives bring together a wide array of local and regional stakeholders to form a mutually beneficial value chain:

- **Grameen Intel and other social businesses:** Information and expertise, consulting services, technology, and programs to reach rural and impoverished markets.
- **Governments and multilateral development agencies:** Program support to enable and increase rural outreach, improve food security, create jobs, and develop partner-ships with local businesses and community organizations.
- **Banks and other financial institutions:** Credit, capital, and other financial instruments (crop insurance, subsidies, etc.) for entrepreneurs and farmers.
- **Universities and agriculture extension systems:** Technology to strengthen extension systems; advice and technical support for farming communities; training and capacity-building for entrepreneurs; research and development projects designed to solve problems faced by farming communities.
- **Supply chain (e.g., suppliers, commodity markets, aggregators):** Best-of-class products and services for farmers that improve returns to all stakeholders, including farmers.
- **Technology companies:** Internet connectivity, hardware, and software solutions that create access to new markets, value chains, and business models.
- **Community organizations (e.g., farmer cooperatives, rural telecenters, government and NGO-run agriculture service centers):** Help entrepreneurs; provide grassroots agriculture domain and business support, and enable programs to scale efficiently.

3.5. ICT Initiatives for Agricultural Development in India by Various Agencies

Some initiatives in India that use ICT for agricultural development are:

- Gyandoot project (Madhya Pradesh);
- Warana Wired Village project (Maharashtra);

- Information Village project of the M S Swaminathan Research Foundation (MSSRF) (Pondicherry);
- iKisan project of the Nagarjuna group of companies (Andhra Pradesh);
- Automated Milk Collection Centres of Amul dairy cooperatives (Gujarat);
- Land Record Computerisation (Bhoomi) (Karnataka);
- Computer-Aided Online Registration Department (Andhra Pradesh);
- Online Marketing and CAD in Northern Karnataka (Karnataka);
- Knowledge Network for Grass Root Innovations-Society for Research and Initiatives (SRISTI) (Gujarat);
- Application of Satellite Communication for Training Field Extension Workers in Rural Areas (Indian Space Research Organisation);

In addition to the above, a few non-governmental organisations (NGOs) have initiated ICT projects such as:

- Tarahaat.com by Development Alternatives (Uttar Pradesh and Punjab);
- Mahitiz-samuha (Karnataka);
- VOICES – Madhyam Communications (Karnataka);
- Centre for Alternative Agriculture Media (CAAM);

Some exclusive agricultural portals are also available, such as:

- haritgyan.com
- krishiworld.net
- toeholdindia.com
- agriwatch.com
- itc's soyachoupal.com
- acquachoupal.com
- plantersnet.com

3.6. Case Studies

These are some of the few examples of ICT enabled services for Indian farmers:-

3.6.1. Agropedia

- Agropedia is a peer-group tool for interaction among the farmers.
- This is a comprehensive, integrated model for digitalized content of agricultural domain. This e-initiative intends to bring together a community through ICT enabled knowledge creating and organising platform with an attempt to leverage the current agricultural extension system.
- IIT Kanpur (agropedia platform), IIT Bombay and IIITM Kerala (multi-model delivery) are the three key partner organizations who are in charge of different projects and responsibilities along with ICRISAT- Hyderabad, NAARM- Hyderabad, GBPUAT- Pantnagar, UAS- Raichur under the aegis of the National Agricultural Innovation Project (NAIP).
- ICRISAT is the consortium leader, which is responsible for the outputs and deliverables.
- Agropedia has been labelled as one stop solution for the Indian agro-sphere. Defining and developing the Knowledge-Model for understanding of the crop has been done first time ever in the world in order to accumulate codified and approved information about the crops with the support of Food and Agriculture Organisation (FAO), Rome.
- These models are essentially the structural representation by using symbols for tagging a particular piece of information and relationships between them. Following this, Chickpea, Pigeon pea, Sorghum and Groundnut.
- Knowledge-Models are developed at ICRISAT, Wheat, Sugarcane, Litchi and Vegetable pea are developed at GBPUAT and Rice is developed at IITK.

3.6.2. e-Choupal

- e-Choupal is an initiative from ITC's Agri Business Division to face the challenges of India's agricultural uncertainty.
- Indian agriculture is characterised by fragmented farms, weak infrastructure and the involvement of numerous intermediaries. e-Choupal aims at bringing out the Indian farmers from vicious circle of low risk taking ability.
- To increase the competitiveness of the Indian agricultural sector and enhance productivity, ITC has developed this market-led business model. It is assumed and expected that a growth in rural incomes will also result in the overall growth of Indian economy.
- e-Choupal operates in three layers. This three-layered infrastructure allows ITC to provide a complete end-to-end solution to suit the needs of both the farmers and consumers at village as well as in global level.
- The first layer consists of ICT kiosks (Village Level) with internet access, managed by an ITC trained local farmer called the Sancalak. The second layer is known as hubs managed by the traditional intermediary who has local knowledge /skills called Samyojak. The final layer is a network of companies (consumers of farmers‟ products and providers of products and services to the farmers) orchestrated by ITC is known as Choupal Sagar, which has a pan-Indian presence.
- With this model, ITC is able to deliver the same benefits as vertical integration does in matured agricultural economies like USA.
- e-Choupal is the largest initiative among all Internet-based programmes in rural India. It reaches to over 4 million farmers of more than 400000 villages through 6500 kiosks. It operates across ten states, namely Madhya Pradesh, Haryana, Uttarakhand, Karnataka, Andhra Pradesh, Uttar Pradesh, Rajasthan, Maharashtra, Kerala and Tamil Nadu in the cultivation of soybeans, coffee, wheat, rice, pulses, and shrimp.

3.6.3. Kissan Kerala

- Kissan Kerala is an Agriculture Information Services system to provide information and advisory to the farmers of Kerala. This is accessible by all concerned anytime in the day and from any parts of the state.
- The objective of this programme is to empower the farmers by providing them useful information and required knowledge; this would lead the farmers to take better decision.
- To disseminate the message and to answer farmer's queries, various channels are used like Television, Internet, Telephone, and Mobile. The farmers are free to choose any medium of their choice.
- The quintessential feature of this ICT enabled service delivery model is to ensure that the farmers get the expert's assistance on time and agricultural organisations provide necessary help to the farmers.
- This has helped the cultivators to better the crop production, enhanced crop protection, value addition to the existing practices, opening up new avenues and improves the overall life of the farming community.
- Children, Youth, women, men and seniors are the target group of this programme, who are somewhat related to the agricultural activities.
- Kissan Kerala focuses on five broad areas.
    - Online Agri advisory service: Portal based online Advisory services for the farmers (www.kissankerala.net)
    - Kissan Krishideepam: Agriculture based weekly Television program in vernacular language
    - Online Agri video Channel: In collaboration with the You Tube, online agricultural video channel was brought in the country

- Tele Advisory Services: Farmers are just a call away from getting solutions to their problems. AQ dedicated phone number is there to address their need
- The mobile based Agri Advisory services: Through text, voice or video message, farmers can get their answers on mobile phones

3.6.4. AgmarkNet

- In order to bring the farmers in a better bargaining position and to promote a culture of good agricultural marketing practices in the country, Directorate of Marketing and Inspection (DMI) , Ministry of Agriculture has embarked upon an ICT Project – NICNET based Agricultural Marketing Information System Network (AGMARKNET) as part of the Central Sector Scheme : "Marketing Research and Information Network".
- Objectives:
  - To establish a nation-wide information network for speedy collection and dissemination of market information and data for its efficient and timely utilization.
  - To facilitate collection and dissemination of information related to better price realization by the farmers by facilitating:
    - Market related information such as market fee, market charges, costs, method of sale, payment, weighment, handling, market functionaries, development programmes, market laws, dispute settlement mechanism, composition of Market Committees, income and expenditure, etc.;
    - Price-related information such as minimum, maximum and modal prices of varieties and qualities transacted, total arrivals and dispatches with destination, marketing costs and margins, etc.;
    - Infrastructure related information comprising facilities and services available to the farmers with regard to storage and warehousing, cold storage, direct markets, contract farming, buy-back arrangements, grading, re-handling and repacking etc.;
    - Promotion related information covering accepted standards and grades, labelling, sanitary and phyto-sanitary requirements, pledge finance, marketing credit and new opportunities available in respect of better marketing;
  - To sensitize and orient farmers to respond to new challenges in agricultural marketing by using ICT as a vehicle of extension.
  - To improve efficiency in agricultural marketing through regular training and extension for reaching region-specific farmers in their own language.
  - To provide assistance for marketing research to generate marketing information for its dissemination to farmers and other marketing functionaries at grass-root level to create an ambience of good marketing practices in the country.
- Under the project, 199 market nodes are computerized and are reporting daily prices of commodities reaching these markets noted. The training to the officials of the department has been conducted.

3.6.5. eMojani

- eMojani is a software to distributed to land and city survey offices.
- One can now apply online for his request for measuring his land. All Fees are calculated and displayed by the application.
- The application allocates the cases to registered Measurement Surveyors of the department. Now the system decides the Surveyors for doing the measurement and not the individual from the department.
- The application generates the necessary Challan's, Receipts and prints the Date of Measurement, Name of Surveyors for doing the measurement along with their contact details.

- This application has been implemented throughout the state. Department has banned the manual maintenance of Measurement case register. Manual applications are no more accepted.
- The manual calculation of the fees and assigning the cases to the individual Surveyors has been stopped.
- The eMojani Application is Integrated with Govt. Receipts and Accounts System (GRAS) for on line transfer and accounting of citizen payments towards various fees. The application has been awarded with the "eGovernance Public Jury Award by the State Government" for the year 2012.

3.6.6. Agri - Subsidy

- An online application that automates the subsidy distribution operation under various schemes of Agriculture department.
- The application is entered online from block level, forwarded to district office Online & the same is sanctioned at District level Online.
- While sanctioning the subsidy, it is taken care that necessary funds are available at district office that was allocated from state level office.
- The subsidies are granted for 11 different schemes of central & state.
- The details of payment of subsidy are also entered online & SMS is sent to the farmer on every event of his application. Various kinds of reports are available for monitoring and evaluation of the project.

3.6.7. Kisan Call Centers

- The Kisan Call Centre (KCC) initiative aims to provide information to the farming community through toll-free telephone lines.
- Under this project, call centre facilities have been extended to the farmers through call centres located in different states so that farmers can get the information in their own language.
- Recently KCCs have been further revamped by consolidation and appointing a new service provider for KCC to set up state of the art KCCs at 14 identified locations.

3.6.8. National e-Governance Plan in Agriculture (NeGP-A)

- The Mission Mode Project has been introduced during last phase of the 11th plan to achieve rapid development of agriculture in India through the use of ICT for ensuring timely access to agriculture related information for the farmers of the country.
- There are a number of current IT initiatives/schemes undertaken or implemented by DAC which are aimed at providing information to the farmers on various activities in the agriculture value chain.
- These initiatives will be integrated so that farmers would be able to make proper and timely use of the available information.
- Such information is intended to be provided to farmers through multiple channels including Common Service Centers, Internet Kiosks and SMSs. 12 clusters of services have been identified and the project has been sanctioned for implementation in 7 States i.e. Assam, Himachal Pradesh, Karnataka, Jharkhand, Kerala, Madhya Pradesh and Maharashtra.
- The services include Information on Pesticides, Fertilizers & Seeds, Soil Health; Information on crops, farm machinery, training and Good Agricultural Practices (GAPs); Weather advisories; Information on prices, arrivals, procurement points, and providing interaction platform; Electronic certification for exports & import; Information on marketing infrastructure; Monitoring implementation / evaluation of schemes & program; Information on fishery inputs; Information on irrigation infrastructure; Drought Relief and Management; Livestock Management.

3.6.9. Bhoomi

- The land records management system is the first e-Governance project successfully implemented for the benefits of the common man, jointly by the Government of Karnataka & NIC Karnataka.
- It has been providing service to more than 70 lakh farmers of Karnataka since the last five years.
- BHOOMI has become the model for replication in many other States. It has received wide spread recognition from the public and also won the international award, Silver of CAPAM 2002.
- Salient features are Kiosk setup in each taluk to issue the land records documents to public on demand, Finger print (Bio-metrics) authentication to ensure fool proof system, PKI enabled BHOOMI & integration with Sub-Registrar's data, Mutation requests processed on First-in First-out Basis.

3.6.10. TARAhaat

- This project, named "TARAhaat" after the all-purpose haat (meaning a village bazaar), comprises a commercially viable model for bringing relevant information, products and services via the Internet to the unserved rural market of India from which an estimated 50% of the national income is derived.
- TARAhaat combines a mother portal, TARAhaat.com, supported by franchised networks of village cybercafes and delivery systems to provide a full range of services its clients.

3.6.11. Warana Wired Villages

- The key objective of the project has been to utilise IT to increase the efficiency and productivity of the existing sugar cane cooperative enterprises by setting up of a state-of-the-art computer communications network.
- This provides agricultural, medical, and educational information in the local language to villages around Warana Nagar in the Kolhapur and Sangli Districts of Maharashtra.

3.6.12. Dairy Information Services Kiosk

- The DISK application targeted at the booming dairy sector has been tested for two milk collection societies by the Indian Institute of Management Ahmedabad's e-governance center.
- The project consists of two basic components—an application running at the rural milk collection society that could be provided Internet connectivity and a portal at the district level serving transactional and information needs of all members.
- DISK has helped in the automation of the milk buying process at 2,500 rural milk collection societies and has been tested in two co-operative villages of Amul dairy in Kheda district.
- Software called AkashGanga has been developed with special features to enable speedier collection of milk and faster disbursement of payments to dairy farmers.

3.6.13. GramSampark

- 'Gramsampark' is a flagship ICT product of the state of Madhya Pradesh.
- A complete database of available resources, basic amenities, beneficiaries of government programmes and public grievances in all the
- 51,000 villages of Madhya Pradesh can be obtained by accessing the website.
- Gramsampark has three sections-Gram Paridrashya (village scenario), Samasya Nivaran (grievance redress) and Gram Prahari (village sentinel). An eleven-point monitoring system has been put in place whereby programmes are monitored village-wise every month.

- Four more programmes are under the monitoring system, which includes untouchability-eradication, women's empowerment, water conservation and campaigns for sanitation.

3.6.14. Digital Gangetic Plane

- One of the first few long-distance Wi-Fi projects in the world, the Digital Gangetic Plane (DGP) connects few villages in Uttar Pradesh to internet using wireless network.
- Media Lab Asia (MLA) and Indian Institute of Technology (IIT), Kanpur started creating the DGP wireless network.
- The even terrain of Gangetic plain allows unhindered line-of-sight signal transmission for wireless networks despite the presence of tall telecom or power supply towers.
- Applications developed intervene on education, health and livelihoods.
- Bimari Jankari or disease information portal offers healthcare information in Hindi.
- Digital Mandiis a one-stop agro-commodities prices shop for rural farming communities.
- The portal serves as agricultural knowledge base in Hindi.
- DGP is largely limited by its approach of being a technological research focused on innovation, experimentation and deployment of Wi-Fi enabled internet connectivity.

3.6.15. Gyandoot

- Gyandoot is a rural infokiosk-based e-governance service delivery model initiated by the state government of Madhya Pradesh in Dhar district.
- The project aims to create a cost-effective, sustainable and replicable rural internet delivery model for improving government services for the poor, involving citizen's cooperatives, government and the community.

3.7. IT and Indian Agriculture in the Future

Technologically it is possible to develop suitable systems, as outlined in the previous sections, to cater to the information needs of Indian farmer. User friendly systems, particularly with content in local languages, can generate interest in the farmers and others working at the grassroots. It is possible to create dedicated networks or harnesses the powers of Internet to make these services are available to all parts of the country.

The task of creating application packages and databases to cater to complete spectrum of Indian agriculture is a giant task. The Long Term Agriculture Policy provides an exhaustive list of all the areas that are to be covered. This can be taken as a guiding list to evolve design and develop suitable systems catering to each of the specified areas. Our country has the advantage of having a large number of specialised institutions in place catering to various aspects of Indian agriculture. These institutions can play a crucial role in designing the necessary applications & databases and services. This will facilitate modularisation of the task, better control and help in achieving quick results. As it is, several institutions have already developed systems related to their area of specialisation. For quick results, it may be useful to get the applications outsourced to software companies in India. This will facilitate quick deployment of applications and provide boost to the software industry in India. In order to avoid duplication of efforts, it may be useful to consider promoting a coordinating agency which will have an advisory role to play in evolving standard interface for users, broad design and monitoring of the progress.

In the post WTO regime, it is suggested that it is useful to focus more on some agricultural products to maintain an unquestionable competitive advantage for exports. This will call for urgent measures to introduce state of the art technologies such as remote sensing, geographical information systems (GIS), bio-engineering, etc. India has made rapid strides in satellite technologies. It is possible to effectively monitor agricultural performance using remote sensing and GIS applications. This will not only help in planning, advising and

monitoring the status of the crops but also will help in responding quickly to crop stress conditions and natural calamities. Challenges of crop stress, soil problems, natural disasters can be tackled effectively through these technologies. A beginning in precision farming can be encouraged in larger tracts of land in which export potential can be tilted in our country's favour.

While developing these systems it is necessary to appreciate that major audience that is targeted is not comfortable with computers. This places premium on user friendliness and it may be useful to consider touch screen technologies to improve user comfort levels. It is often observed that touch screen kiosks, with their intuitive approach, provide a means for quick learning and higher participation. It is also necessary to provide as much content as possible in local languages.

Once the required application packages & databases are in place, a major challenge is with respect to dissemination of the information. The Krishi Vigyan Kendras, NGOs and cooperative societies may be used to set up information kiosks. Private enterprise is also required to be drawn into these activities. These kiosks should provide information on other areas of interest such as education, information for which people have to travel distances such as those related to the government, courts, etc. Facilities for email, raising queries to experts, uploading digital clips to draw the attention of experts to location specific problems can be envisaged.

3.8. Constraints and Remedies for Effective Dissemination

Educating and catering to the information needs of farmers across nearly seven lakh villages in India indeed sounds unrealistic as this would require immense financial investment. A one-time major investment in establishing communication technologies in the required places restricts the government's objective of covering more people regularly because of insufficient power availability in rural areas, poor ICT infrastructure, ICT illiteracy, non-availability of timely relevant content, non-integration of services, poor advisory services and lack of localization, and in particular non availability of agricultural information kiosks/ knowledge centers at the grass root level.

Some of the major constraints delaying the spread of e-revolution to rural India are listed below:

- **Haphazard development:** It is observed that some initiatives have already been made to provide IT based services to rural community. However, duplication of efforts are witnessed as most of the services revolve around limited subjects. Keeping in view the giant task involved, it is necessary to form a coordination mechanism to strive for a concerted effort to support farming community in the country. Such a coordination agency may only have advisory powers such as user interface, broad design, delivery mechanism of the content and standards for setting up kiosks.
- **User friendliness:** The success of this strategy depends on the ease with which rural population can use the content. This will require intuitive graphics based presentation. Touch screen kiosks are required to be set up to encourage greater participation.
- **Awareness about the Benefits of ICT:** Farmers sometimes become averse to adopting technology as they think that it might result in their losing their traditional methods of cropping practices. They simply do not want to use such systems, even if the cost incurred is negligible. Therefore, the attitude and mindset of farmers needs to be changed first. There is a need to win their confidence and create awareness about the benefits of ICT in agriculture.
- **Local languages:** Regional language fonts and mechanisms for synchronisation of the content provides a challenge that needs to be met with careful planning.

- **Restrictions:** Information content based on remote sensing and geographical information systems can provide timely alerts to the farmers and also improve the efficiency of administration. These applications can have a major impact on the farmers and help them to appreciate the potential of information technology. However, government's map restriction policies often threaten to stifle the optimal utilisation of these tools.
- **Power Supply:** In most of the rural India, power supply is not available for long hours. This will reduce the usefulness of the intended services. Since almost entire country receives sunshine for most part of the year, it is useful to explore solar power packs for UPS as well as for supply of power. The Ministry of Non-conventional Energy Sources may pay special attention in this area which can be a major contributor to the growth of IT in villages.
- **Connectivity:** Despite the phenomenal progress made in the recent years, the connectivity to rural areas still requires to be improved. Reliable connectivity is a prerequisite for a successful penetration of IT into rural areas. Many private ISPs are setting up large networks connecting many major towns and cities. Since some of these networks pass through rural areas, it is possible to provide connectivity to a large number of villages. Several technologies exist that can be utilised for connecting rural areas. Cable network is a possible medium for providing the last mile connectivity to villages.
- **Bandwidth:** Even in areas where telephone and other communication services exist, the available bandwidth is a major constraint. Since internet based rural services require substantial use of graphics, low bandwidth is one of the major limitations in providing effective e-services to farmers. As already stated, networks with high bandwidth are being set up by several companies passing through rural segments which can be utilised. Until this materialises, a two pronged strategy of storing static information at the kiosks and providing dynamic information from remote locations can be examined. The graphic oriented content which does not change frequently, such as, demonstration clips for farmers, can be stored on the local drives at the kiosks and arrange for periodic updation of this information over the network during non-peak hours. The dynamic information which changes more frequently can be accessed from remote locations to obtain the latest status.
- **Dissemination Points:** Mass deployment of information kiosks is critical for effective use of the Internet based content and services. In order to ensure that the information kiosks are economically feasible, it is necessary to make the proposition sustainable and viable. This requires a major focus on a viable revenue model for such kiosks. In the new information era, the kiosks should be designed to become electronic super markets that can, in addition to being information sources, handle other services of use to the people living in rural areas. The revenue available through such sources can make a kiosk attractive for prospective investors. The Government can provide finance facilities to unemployed rural agricultural graduates who can be expected to have greater commitment and at the same time act as an efficient interface for less educated rural visitors. The objective should be to transform rural information kiosks into 'clicks and mortar' gateway to rural India for 'Bricks and mortar' industry. Some of the sources that can generate revenue for rural kiosks are :
    - **Distance Education:** A large number of people travel substantial distances to attend educational courses. It is possible to set up virtual classrooms right in their villages.
    - **Training:** People living in rural areas require training and a means for upgrading their skills in their area of work. It is possible to provide quality education right at their door steps with facilities for online interaction with experts. For example, a village teacher or a paramedical staff can keep abreast latest developments without disturbing his/her routine. Similarly, training can be imparted on various aspects of agriculture such as correct practices, irrigation practices, efficient utilisation of tools used in farming such as tractors.
    - **Insurance:** The advent of private players into insurance has brought about advanced IT

systems that can render services over networks. The kiosks can be insurance agents for insurance firms which, in turn, can compensate the kiosk operators for online transactions for new business as well as maintaining the old.

- **Local Agent:** Many companies have difficulty in working out logistics for their supplies to rural outlets. A rural kiosk can act as conduit for such 'bricks and mortar' companies. This has the potential of transforming a rural kiosk into a profitable venture.
- **Rural Post Office:** The kiosks can facilitate sending and receiving emails, facilitate 'chats' with experts. Several successful rural kiosks are already available in many states which run essentially on this model.
- **E-Governance:** Rural kiosks are the stepping stones for effective implementation of e-governance. Details related to central / state / local governments, formats and procedures, status verification such as case listings in courts, filing of applications in electronic format where admissible, etc. are some of the areas where kiosks can be of major use.
- **Online Examinations:** Online certification examinations are 'in things' with many organisations and certification agencies. Many people are forced to stay at metros to take the examinations. Eventually it should be possible to conduct these examinations through the rural kiosks.

- **Stake Holders:** At present, several initiatives have been taken in the form of websites / portals targeting rural India. These are at best sketchy information sources catering to pockets of rural India. It is to be noted that strong inter-linkages exist within entire rural India and concerted and coordinated effort is required for carrying the benefits of IT to rural India. The magnitude of the task is such that no single institution or organisation can accomplish it. It is necessary for stake holders in rural India, such as fertiliser industry, to come together to provide adequate thrust to the effort initially. The fertiliser industry distributes more than 15 million tonnes of nutrients per annum in the country involving complex production, logistics and storage operations. A small savings made possible through better management of information up to the point of delivery to farmers can mean significant savings. The success of e-powering Indian agriculture is high if fertiliser industry makes a concerted and coordinated effort to set up Business to Business (B-B) market place with dealer / cooperative networks. The consumer industry also benefits from efficient operations in rural India. The corporate India may be willing to participate in a joint effort that proves beneficial to them as well as the rural India. The Government of India may, as outlined above, initiate a coordinating agency where various stake holders can join hands to spread e-culture to rural India and at the same time benefit from efficient operations.

3.9. Conclusion

The Indian farmer and those who are working for their welfare need to be e-powered to face the emerging scenario of complete or partial deregulation & reduction in government protection, opening up of agricultural markets, fluctuations in agricultural environment and to exploit possible opportunities for exports. The quality of rural life can also be improved by quality information inputs which provide better decision making abilities. IT can play a major role in facilitating the process of transformation of rural India to meet these challenges and to remove the fast growing digital devides.

The rapid changes in the field of information technology make it possible to develop and disseminate required electronic services to rural India. The existing bottlenecks in undertaking the tasks need to be addressed immediately. A national strategy needs to be drawn for spearheading IT penetration to rural India. A national coordinating agency with an advisory role can act as a catalyst in the process.

Student Notes:

No single institution or organisation alone can succeed in the task of e-powering farmers and rural India. At the same time, scattered and half hearted attempts cannot be successful in meeting the objective. Industries with major stake in villages, such as fertiliser sector, should come together to provide the initial impetus. The success of any IT based service to rural India hinges on evolving a proper revenue model for the dissemination points. The information kiosks can draw revenue from the industry by providing and disseminating required services. Once these dissemination points prove to be economically viable, the IT revolution in rural India will require no crusaders.