VISION IAS

WORLD GEOGRAPHY

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.

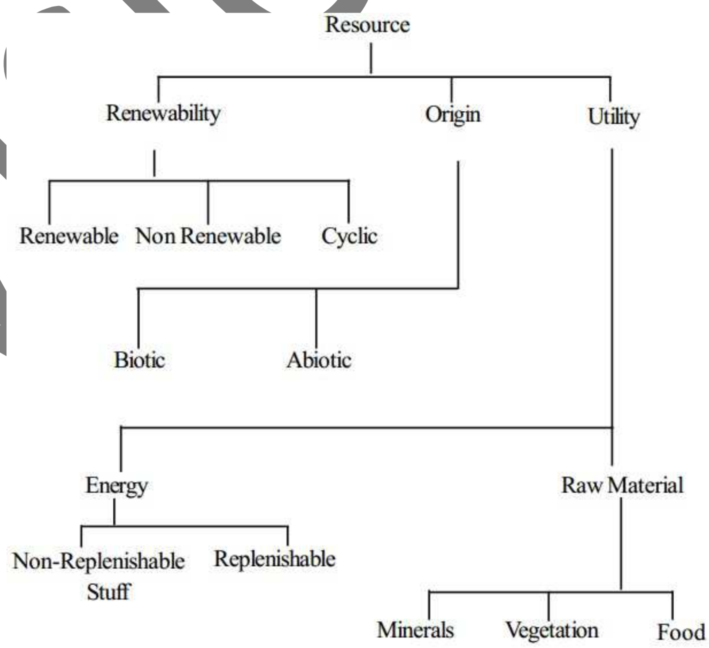


Figure 1: Classification of Resources

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.

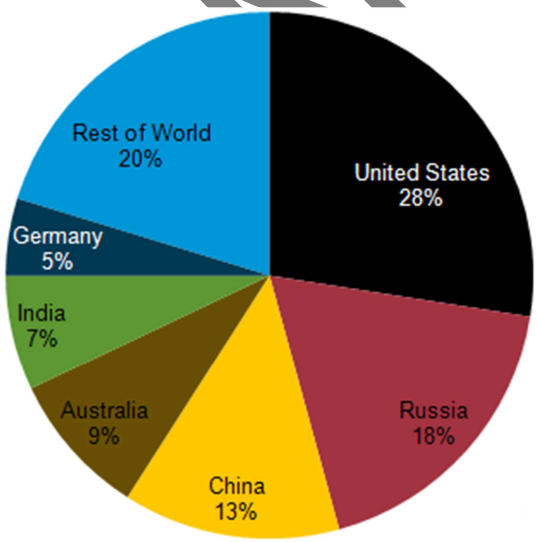


Figure 2: Global share of recoverable coal reserves

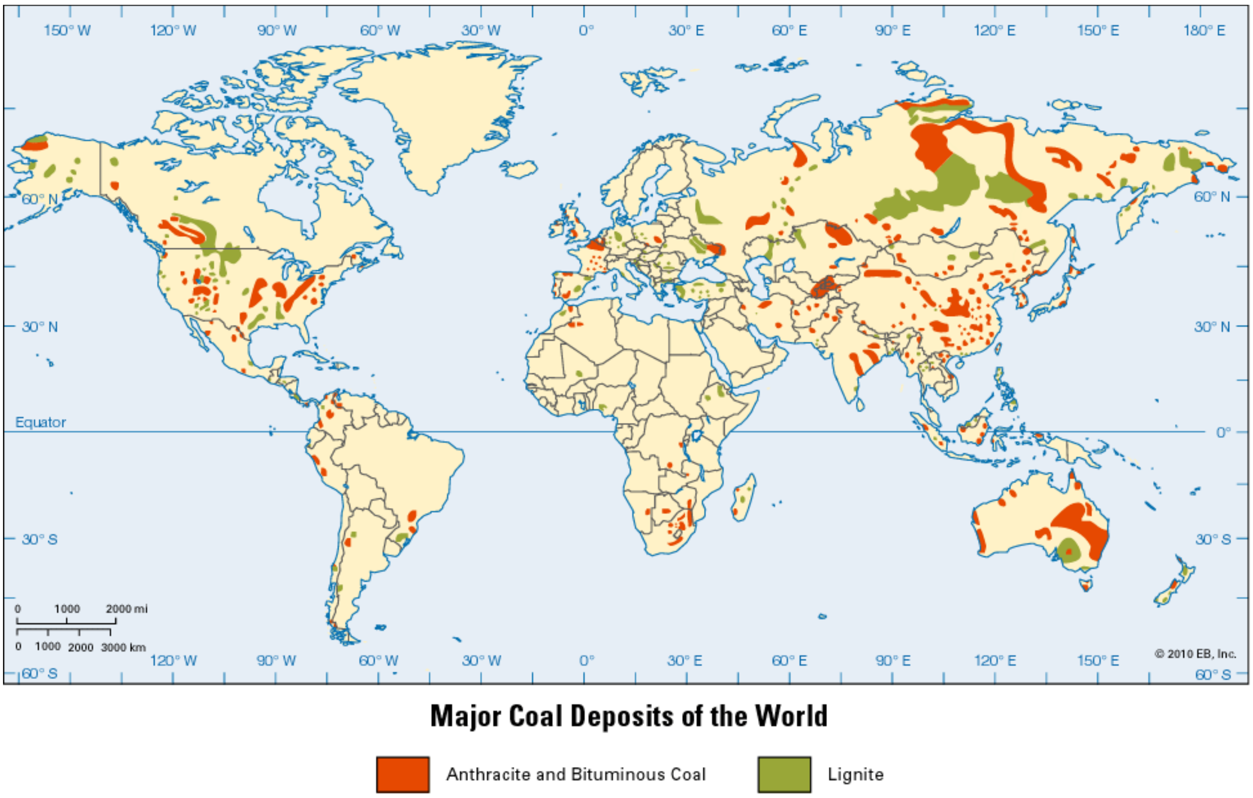


Figure 3: coal deposits of the world

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

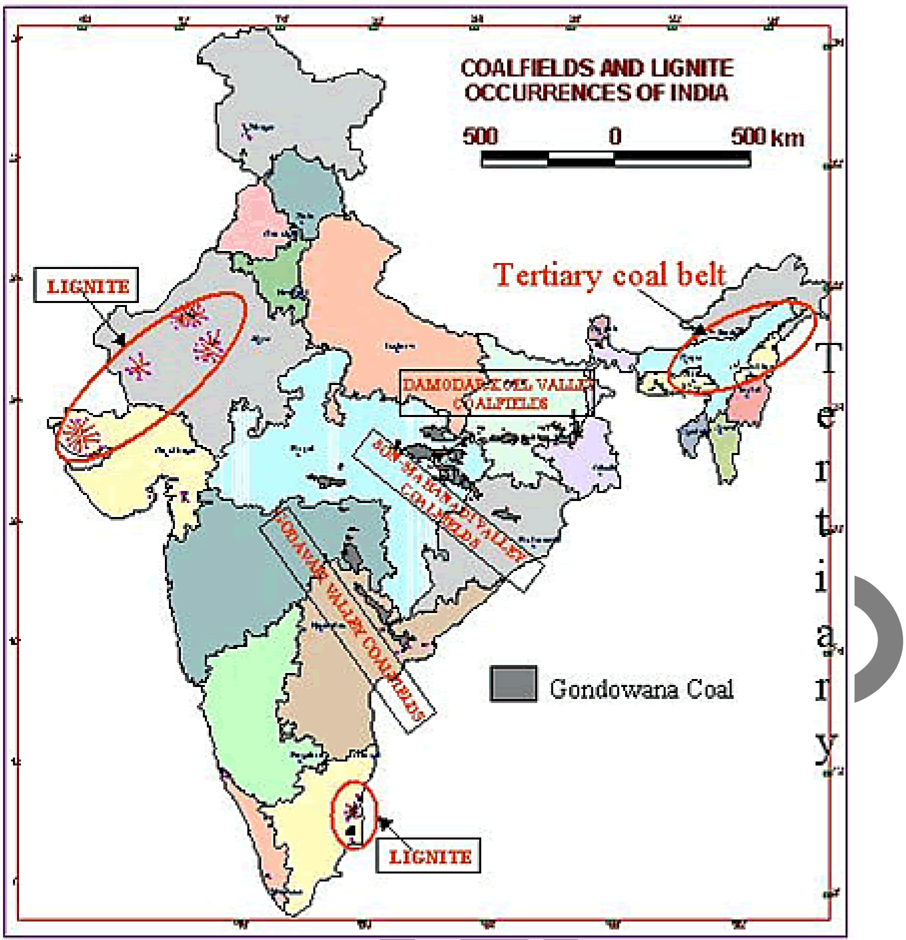


Figure 4: Major coalfields of India

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].

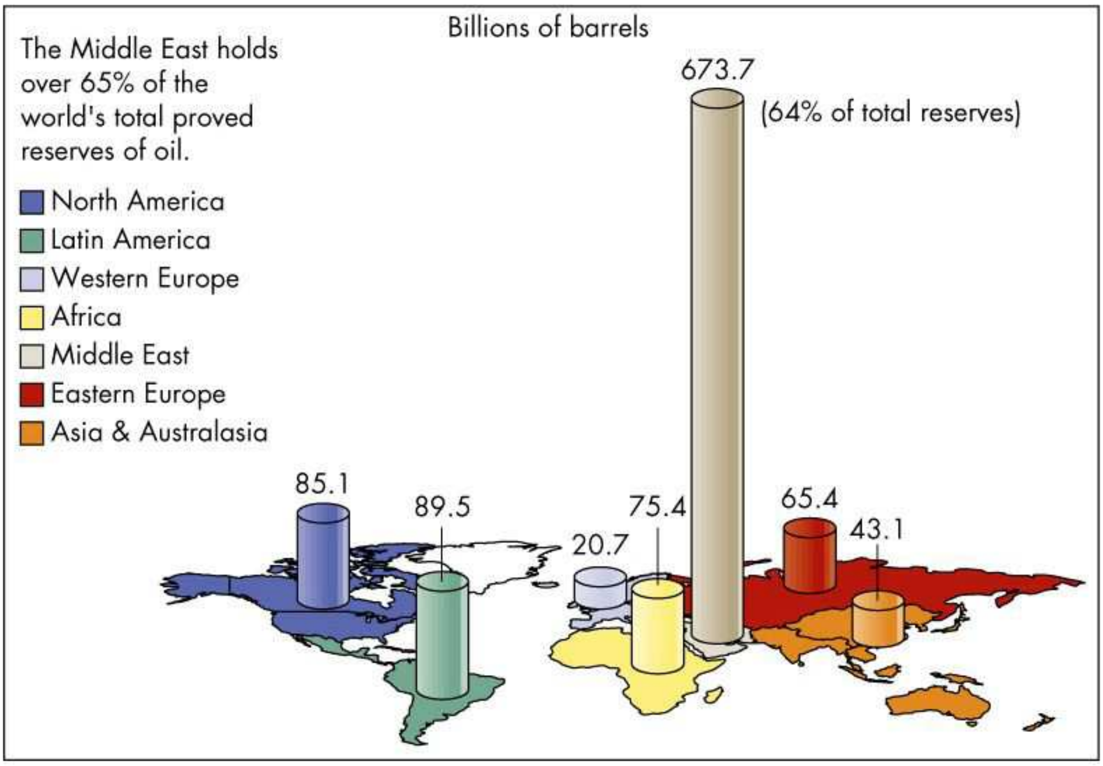


Figure 5: Worldwide Oil Distribution

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:

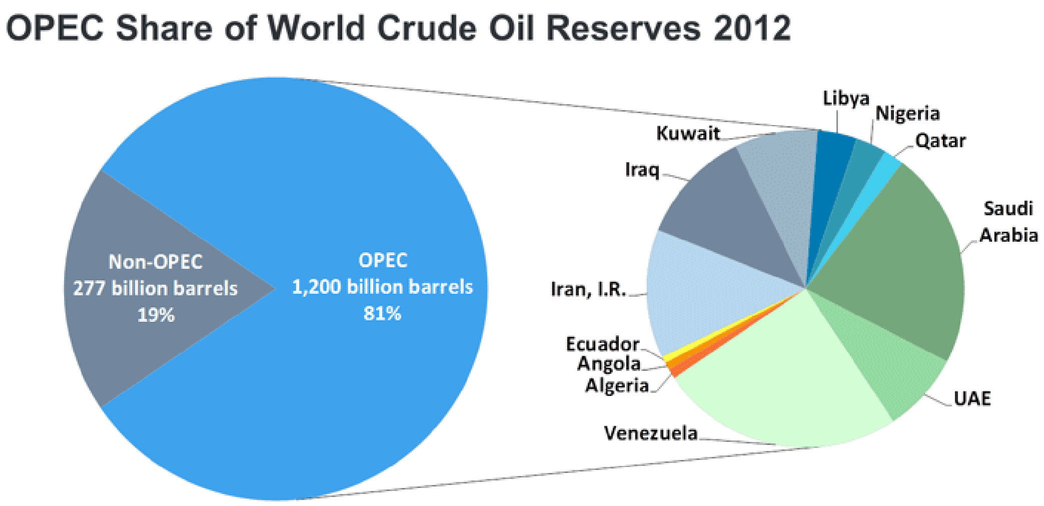
- Ghawar field – Saudi Arabia
- Burgan field – Kuwait
- Azeri-Chirag-Guneshli – Caspian Sea, Azerbaijan
- Ku-Maloob-Zaap – Mexico
- Zakum - UAE
- Ferdows field – Iran

- 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

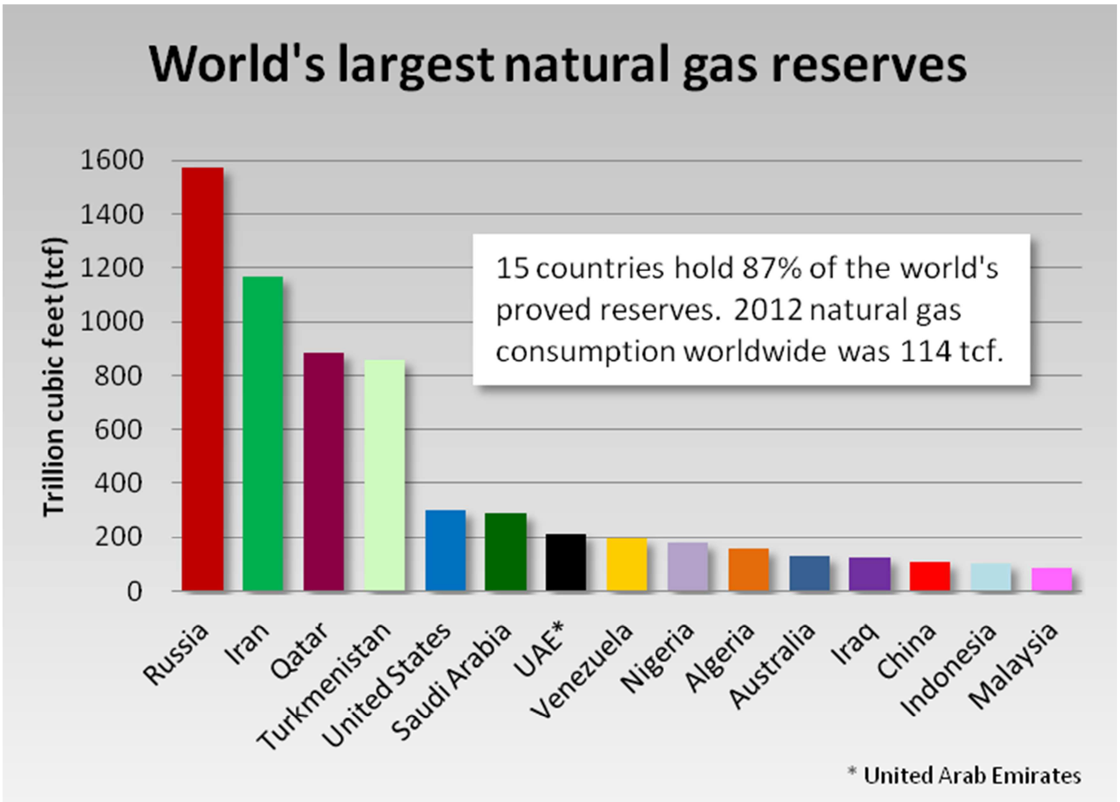


Figure 7: Countries with largest proved natural gas reserves

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 lolotan-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).

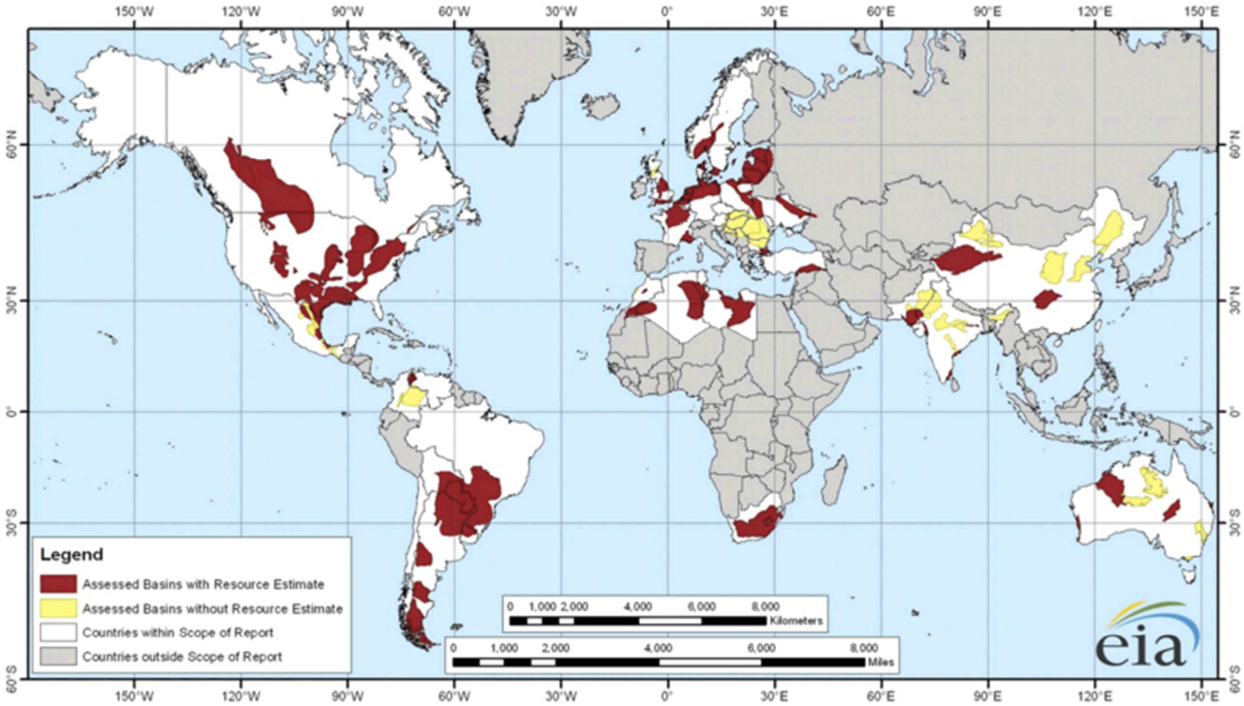


Figure 8: World Shale Gas

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.

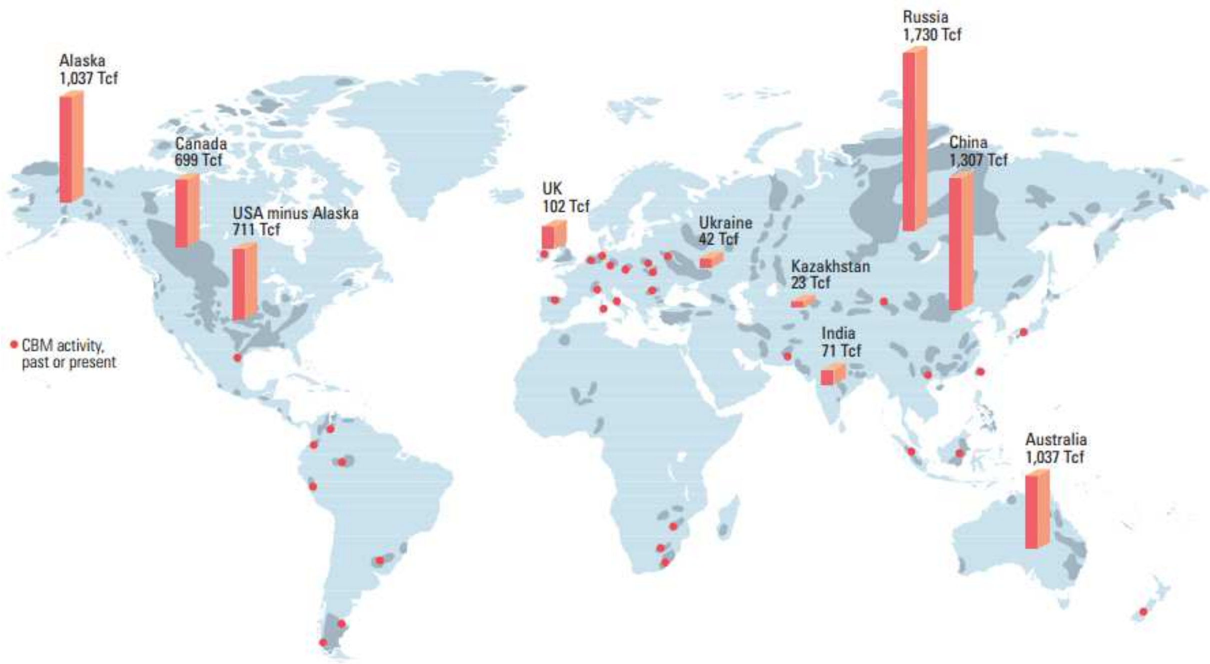


Figure 9: Major coalbed Methane reserves

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.

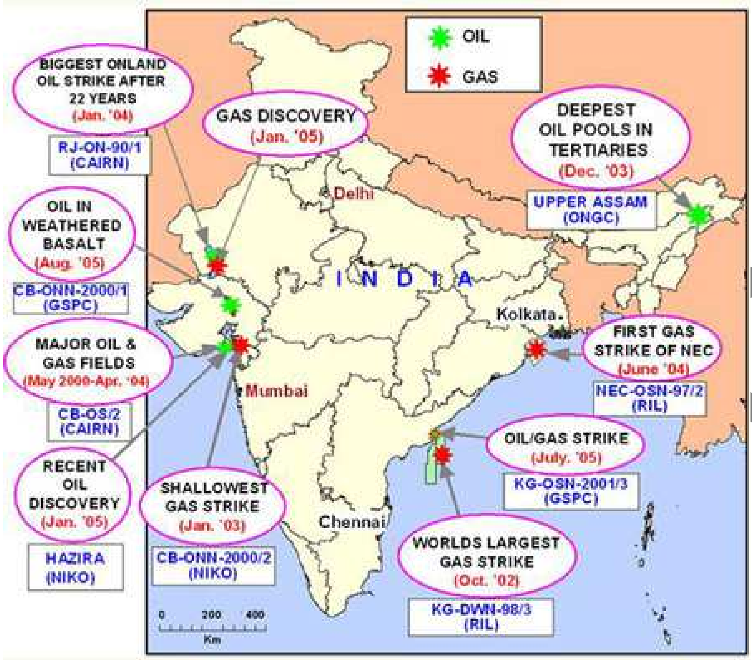


Figure 11: Major Oil and Gas discoveries after 2000

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.

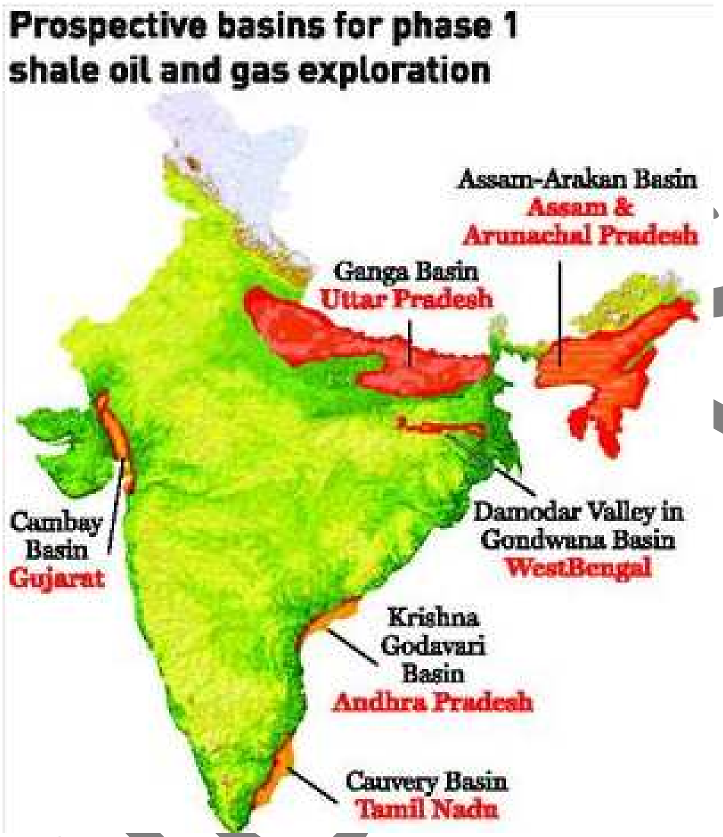


Figure 12: Shale oil and gas basins of India

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.

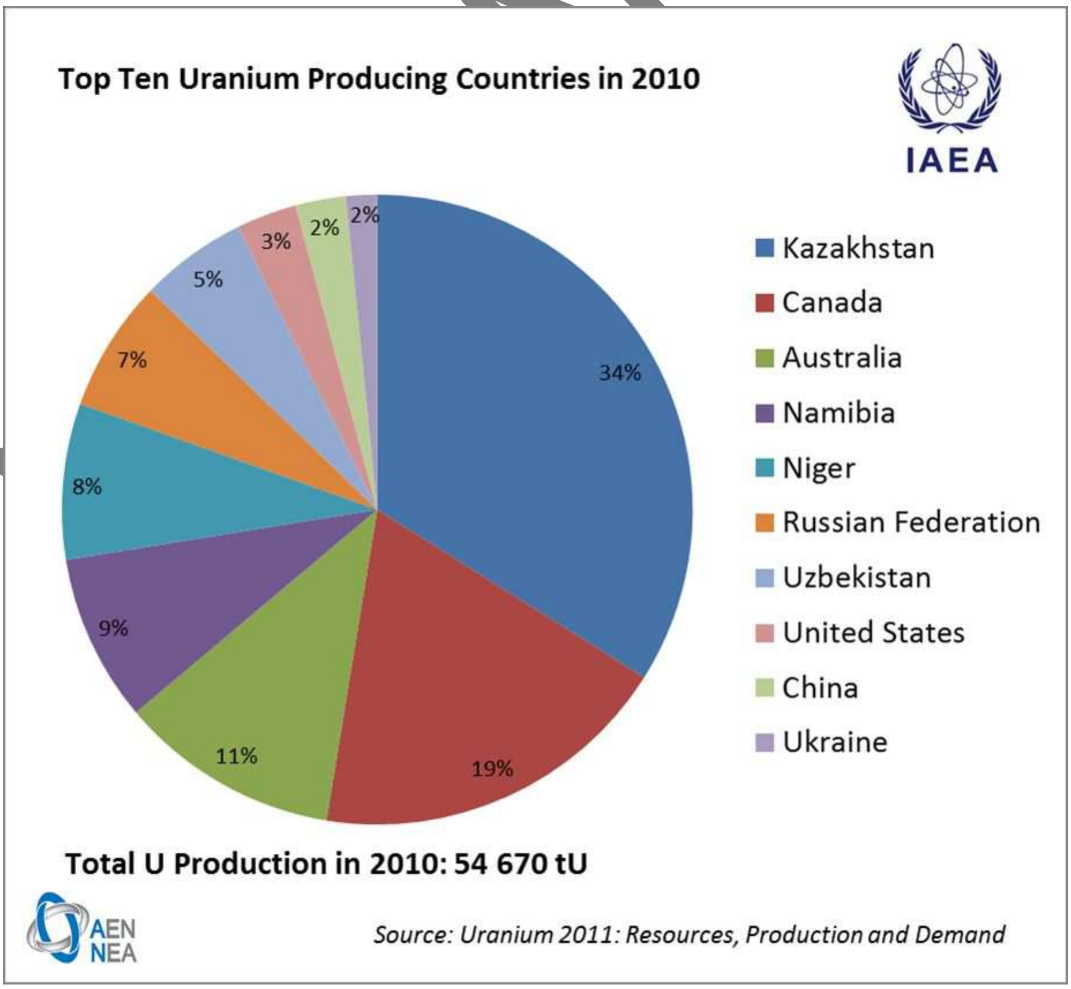


Figure 15: Top 10 Uranium producing countries (2010)

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.

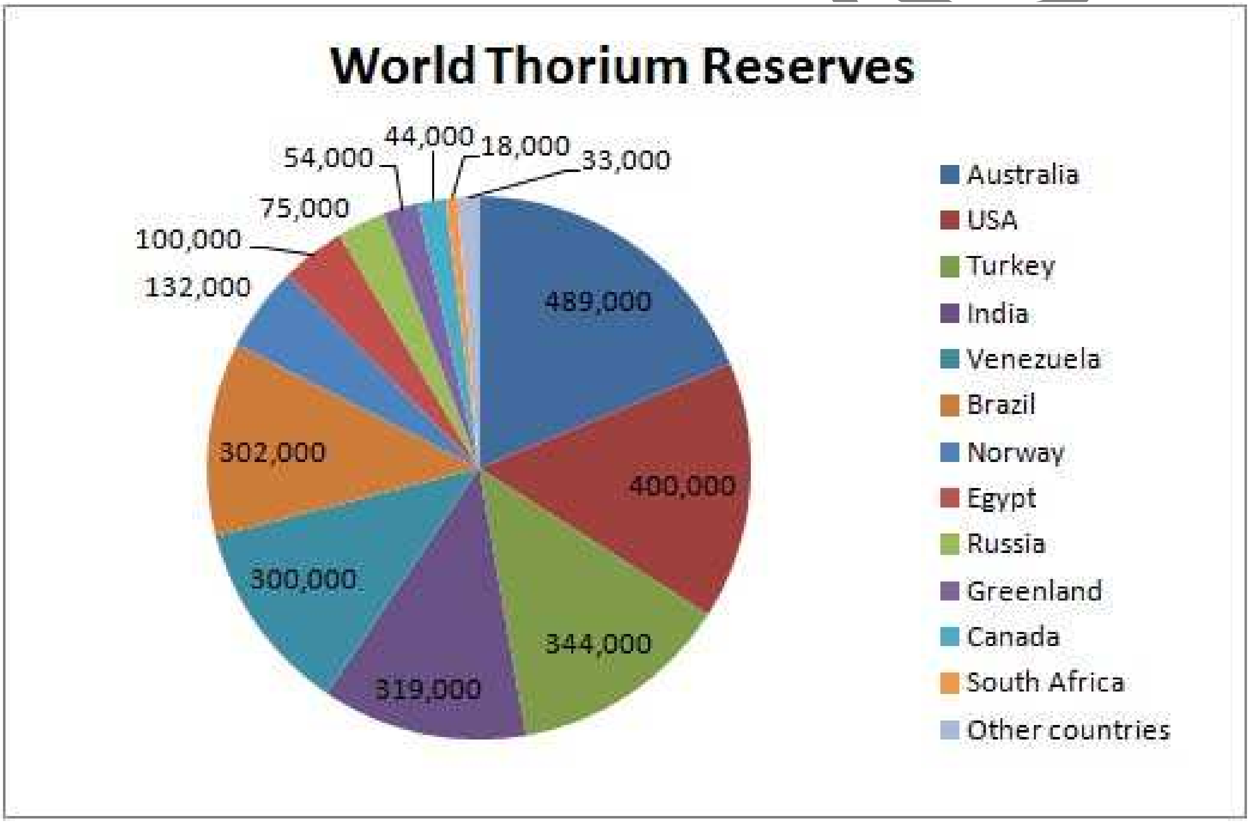


Figure 16: World Thorium reserves (in tonnes) (2005)

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 (ThO_2) in 2009. India Monazite contains about 9-10% of ThO_2 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.

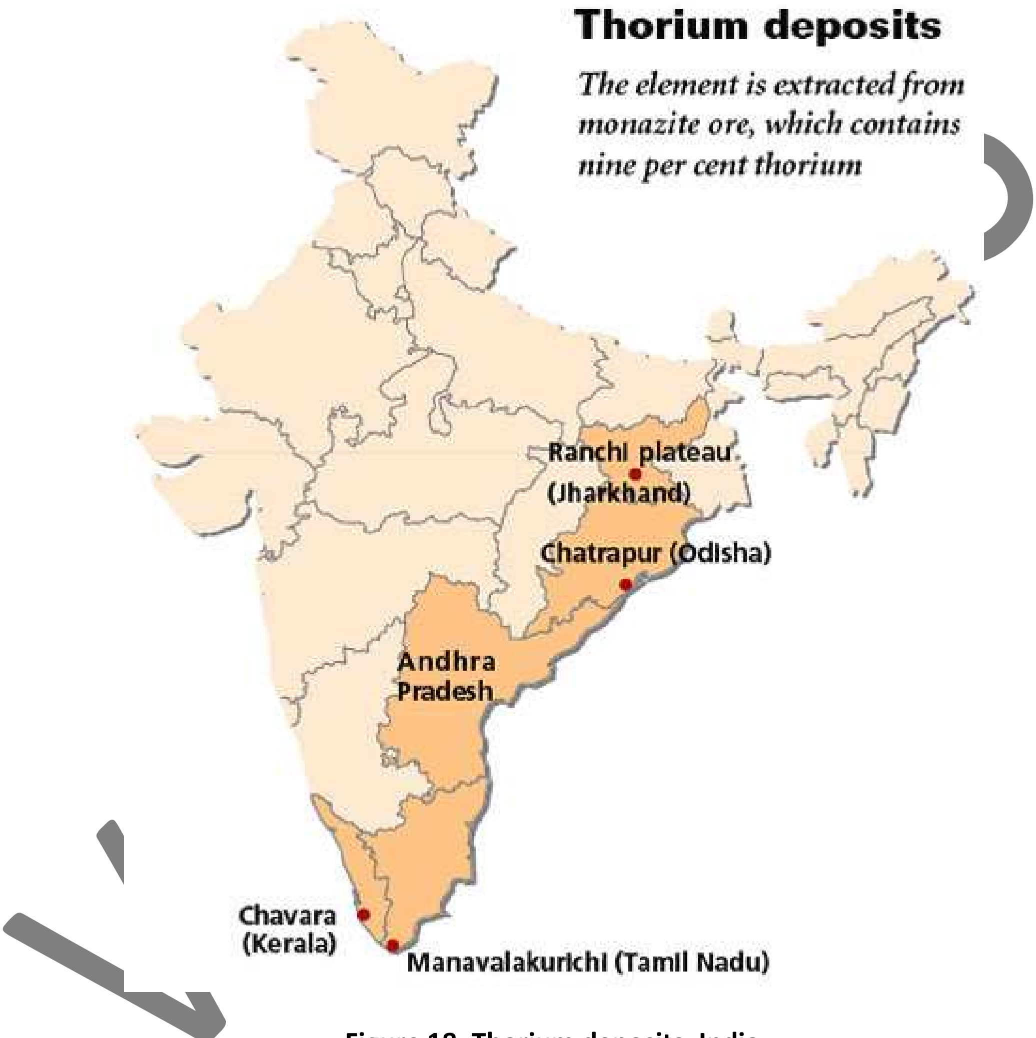


Figure 18: Thorium deposits, India

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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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LOCATION OF INDUSTRIES

Contents

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:

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.

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.

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.

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.

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.

Government Policy

Sometimes Government adopt 'regional policies' to promote 'balanced' economic development and hence set up industries in particular areas.

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.

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.

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.

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.

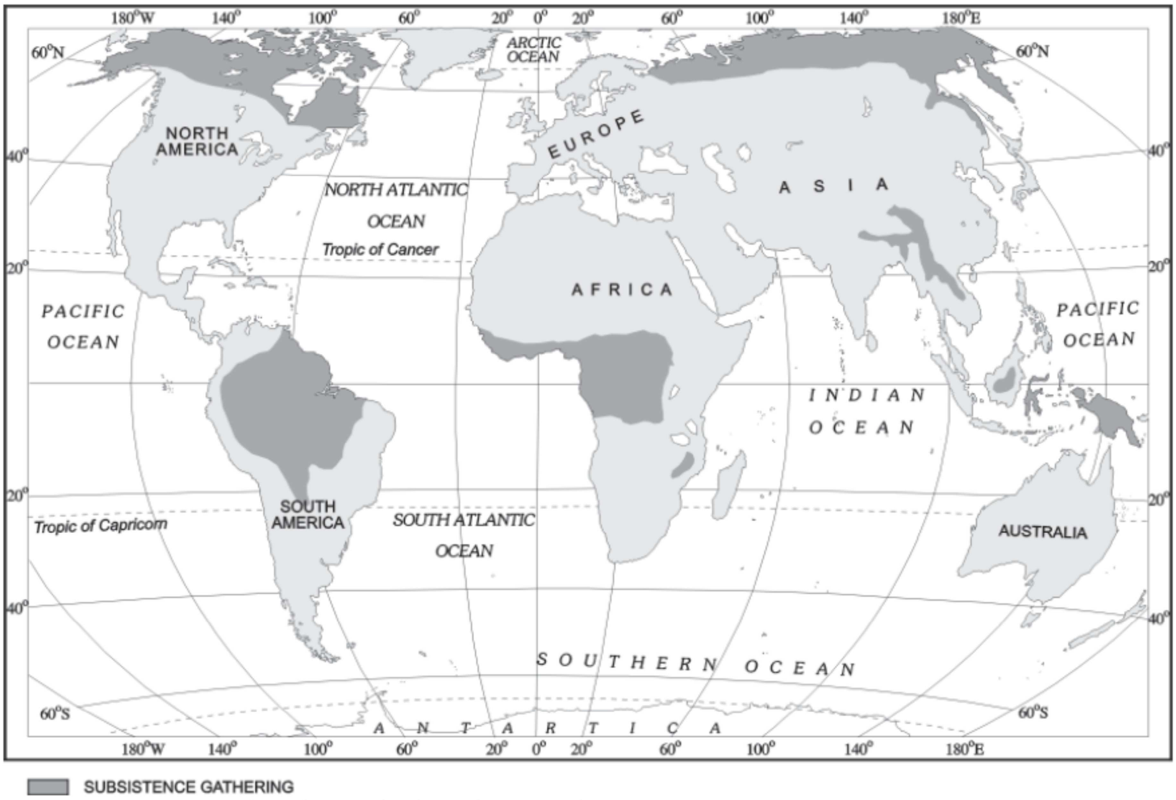

Fig 1. Areas of Gathering

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.

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.

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**.

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.

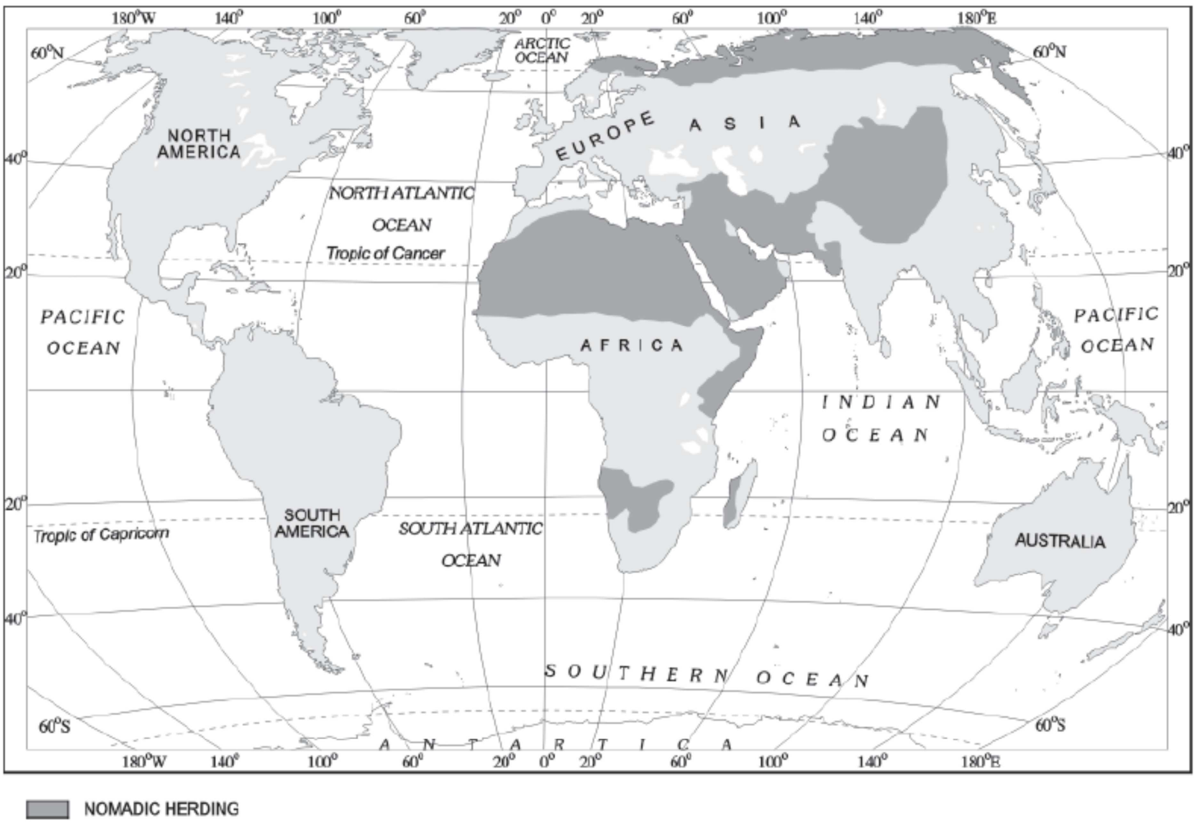

Fig. 2 Areas of Nomadic Herding

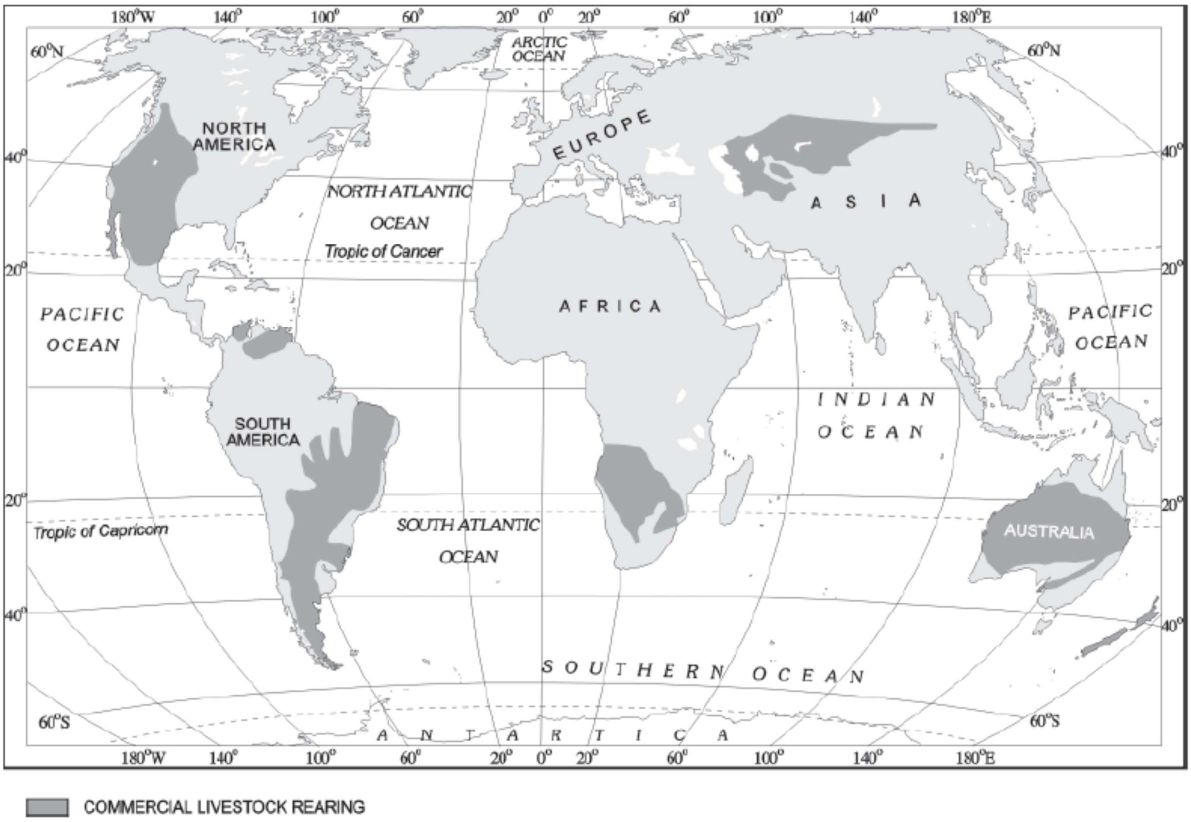

Fig. 3 Areas of Commercial Livestock Rearing

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:

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.

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.

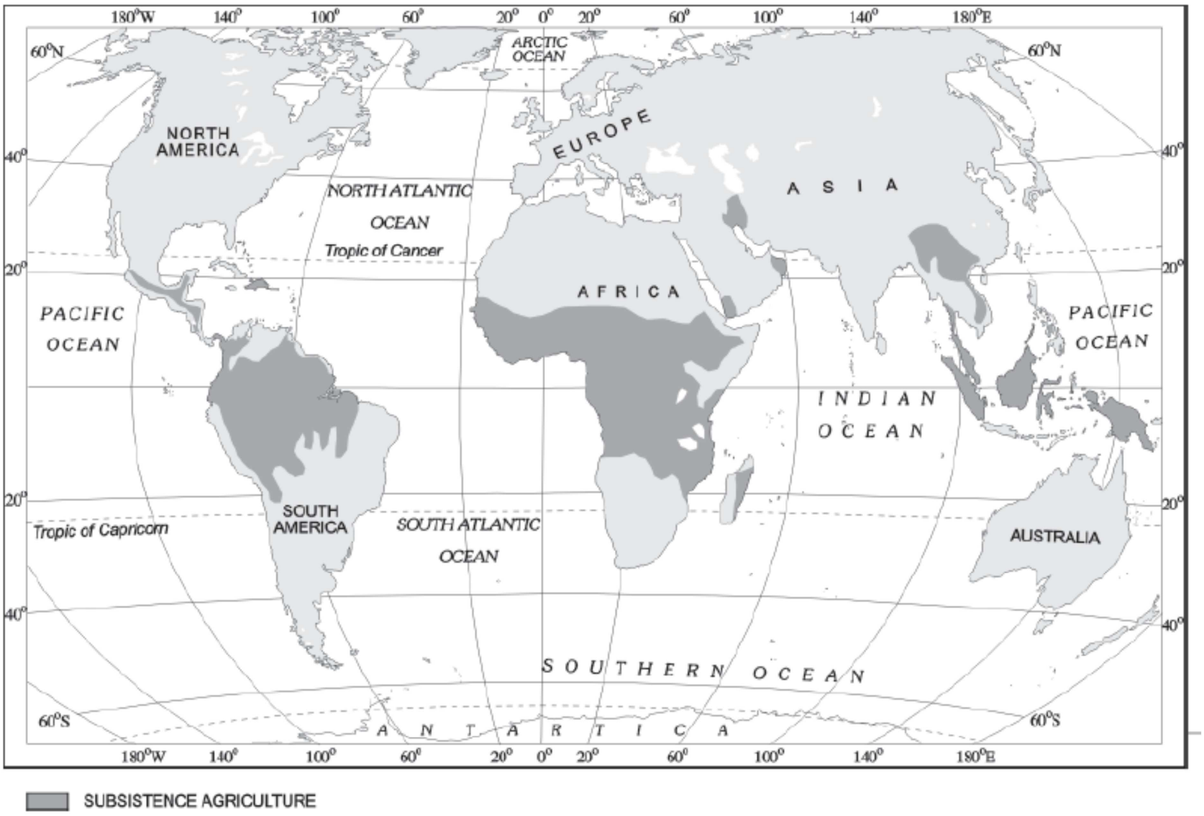

Fig. 4 Areas of Primitive Subsistence Agriculture

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.

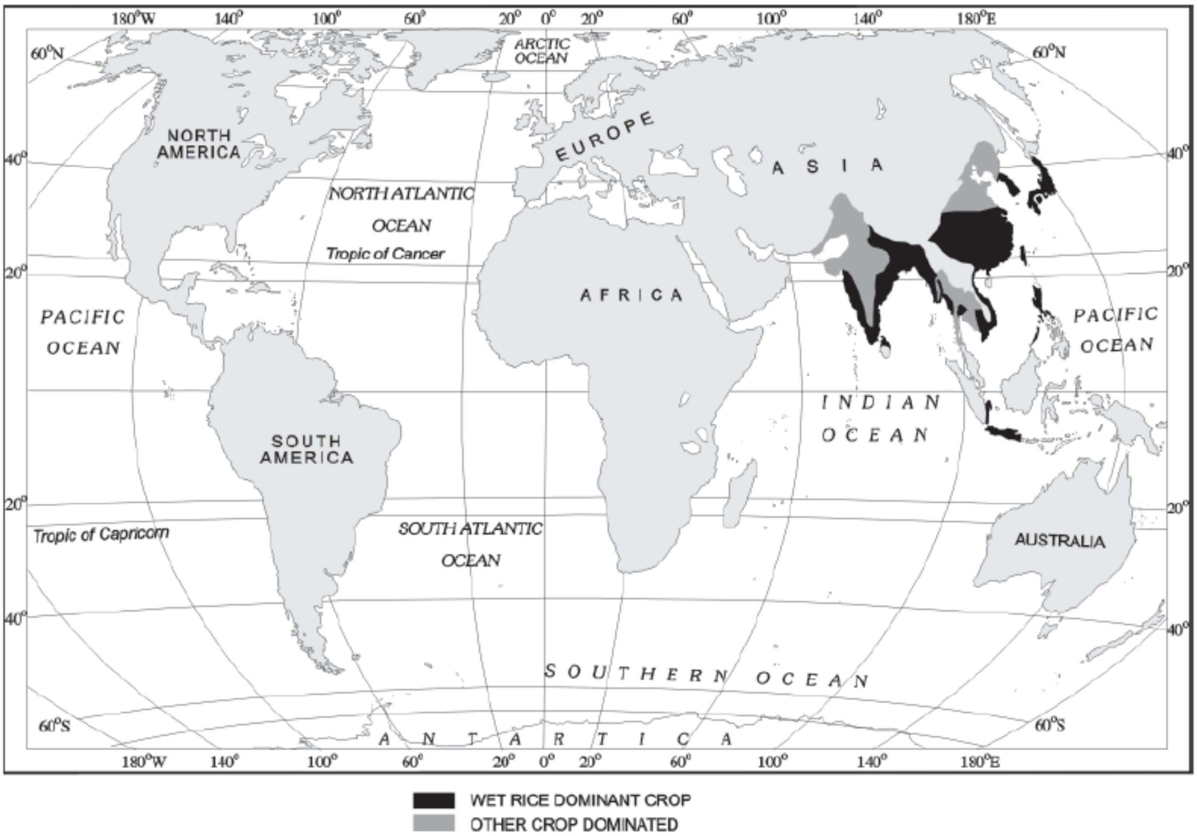

Fig. 5 Areas of Intensive Subsistence Agriculture

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.

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.**

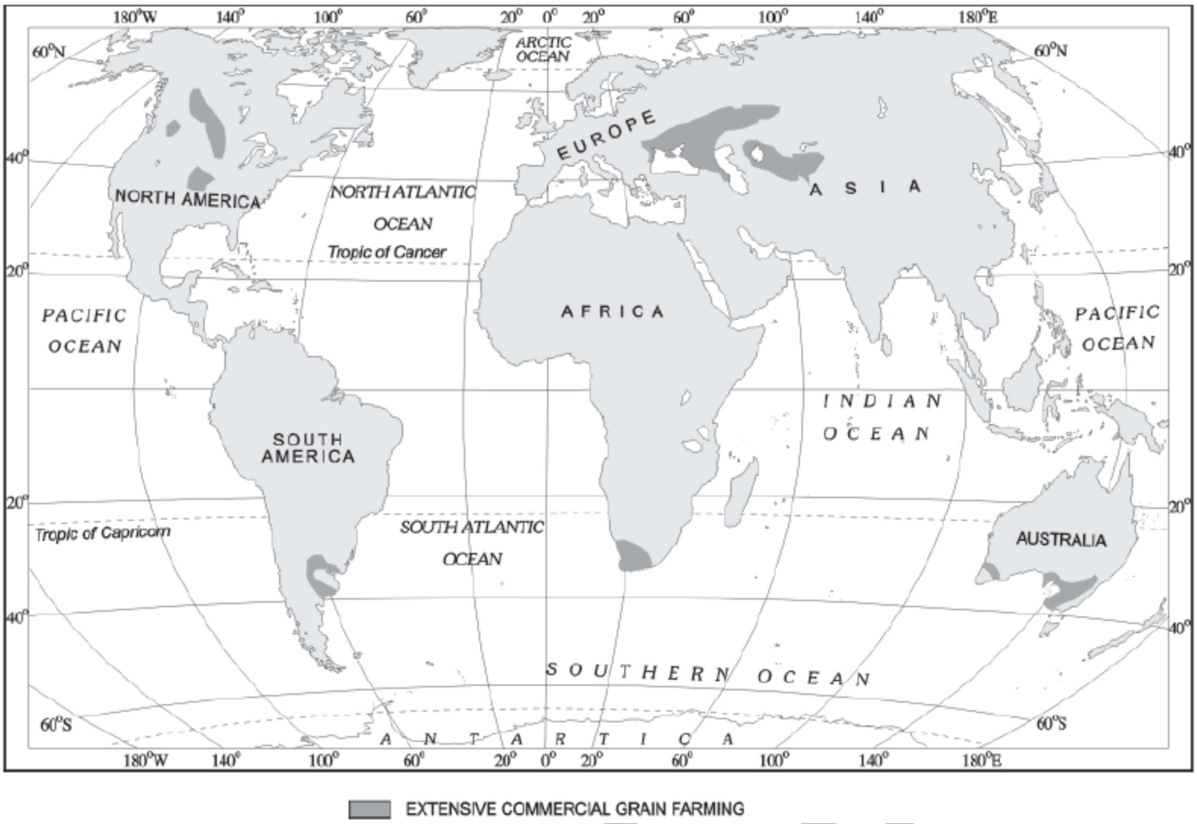

Fig 6. Areas of Extensive Commercial Grain Cultivation

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.

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**.

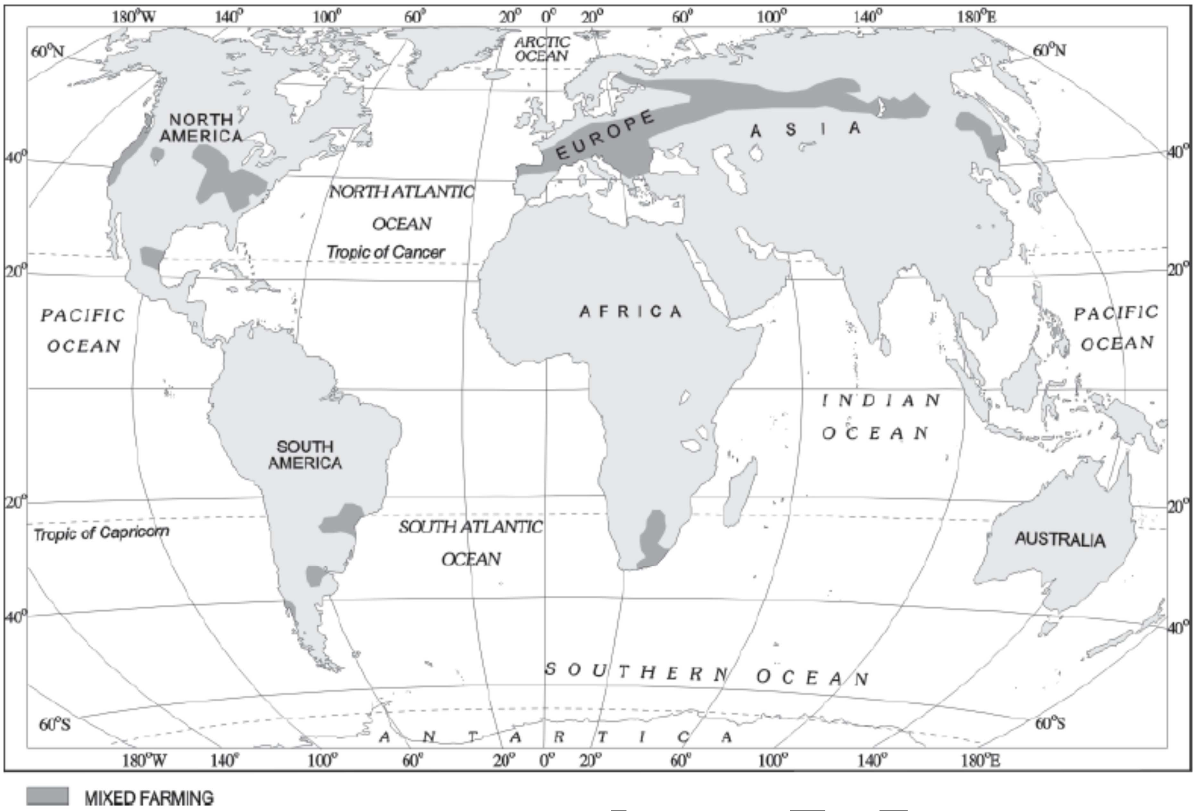

Fig. 7 Areas of Mixed Farming

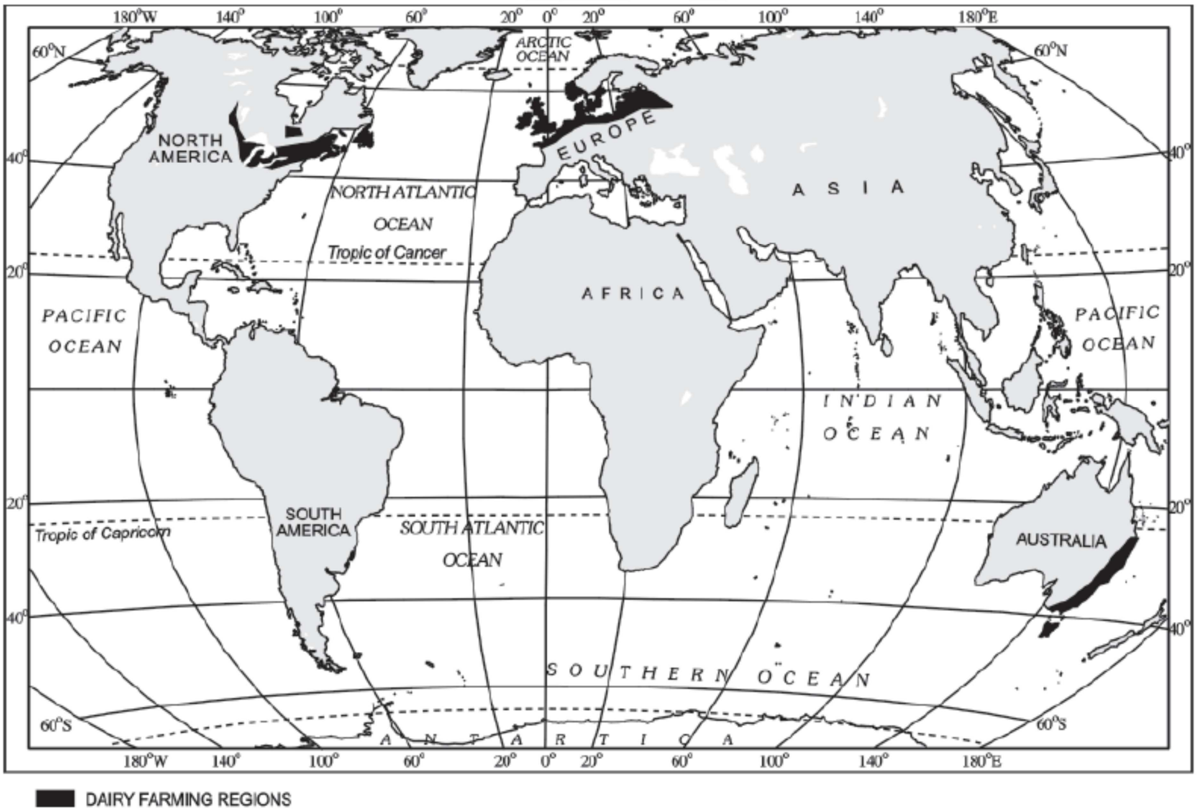

Fig. 8 Areas of Dairy Farming

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.

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.

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.

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.

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.

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.

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:

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.

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.

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.**

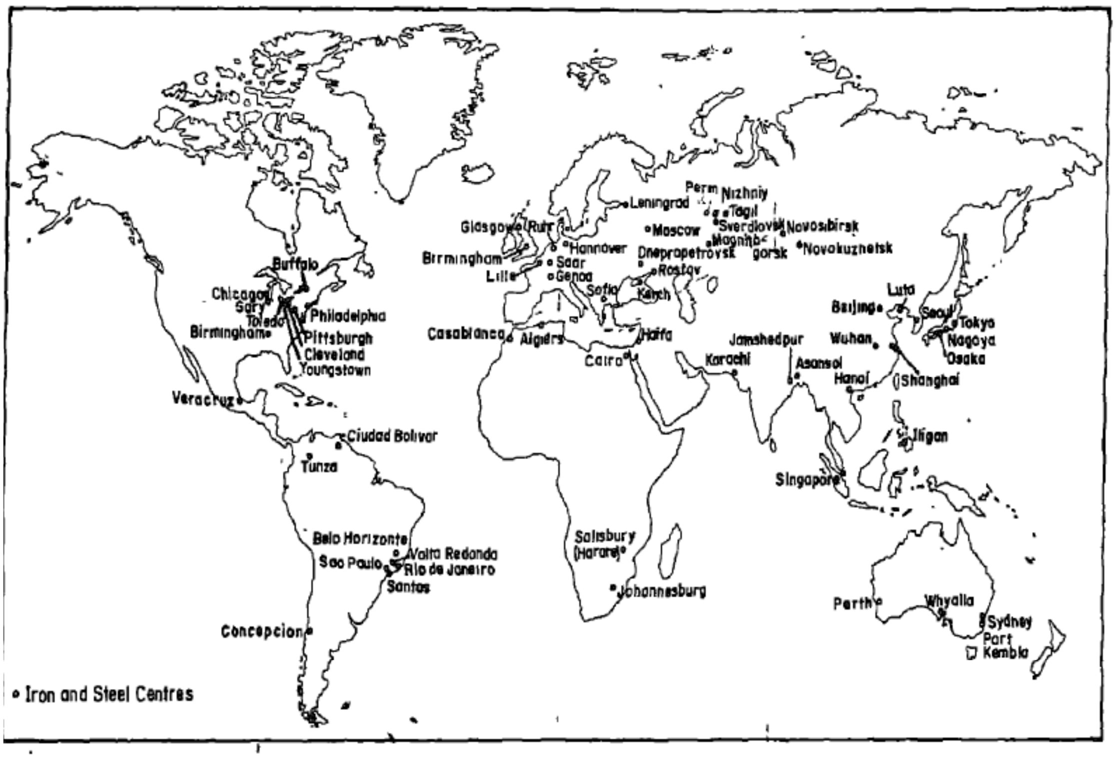

Fig. 9 World- Iron and Steel industry

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..

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**.

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.

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.**

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.**

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.

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**.

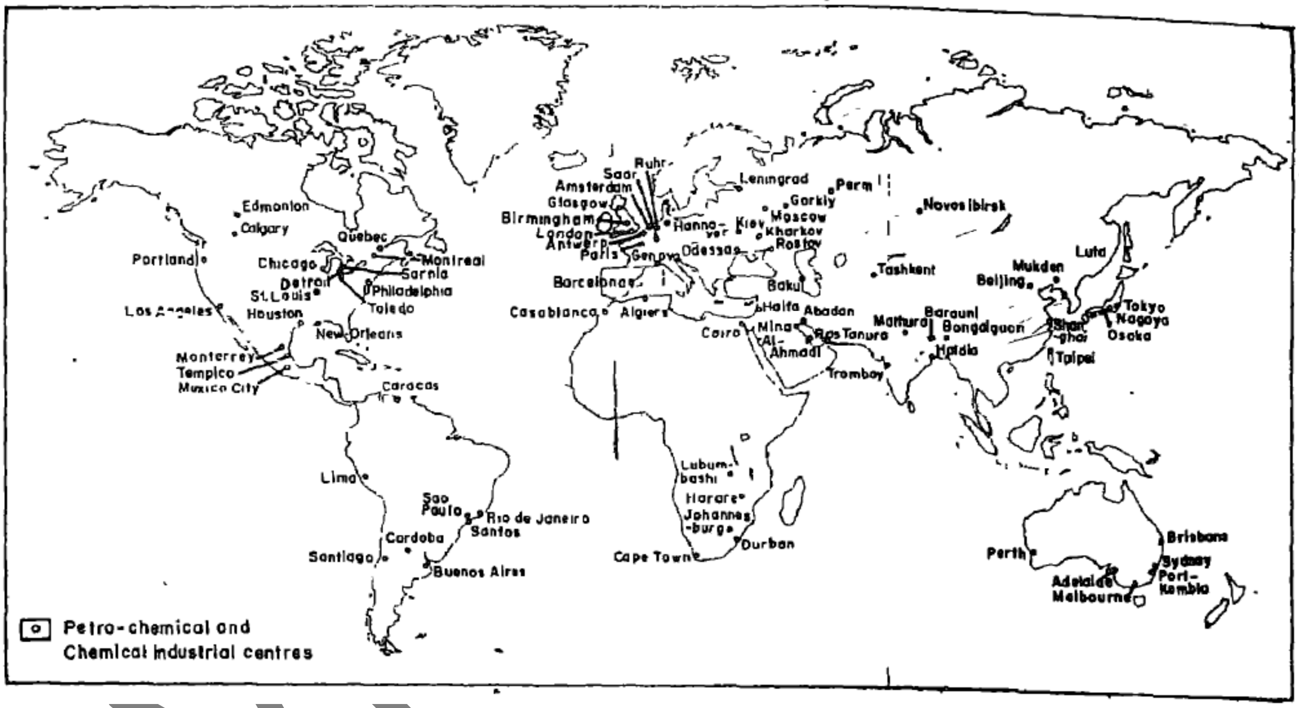

Fig. 10 World-chemical and petrochemical industries

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.

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.

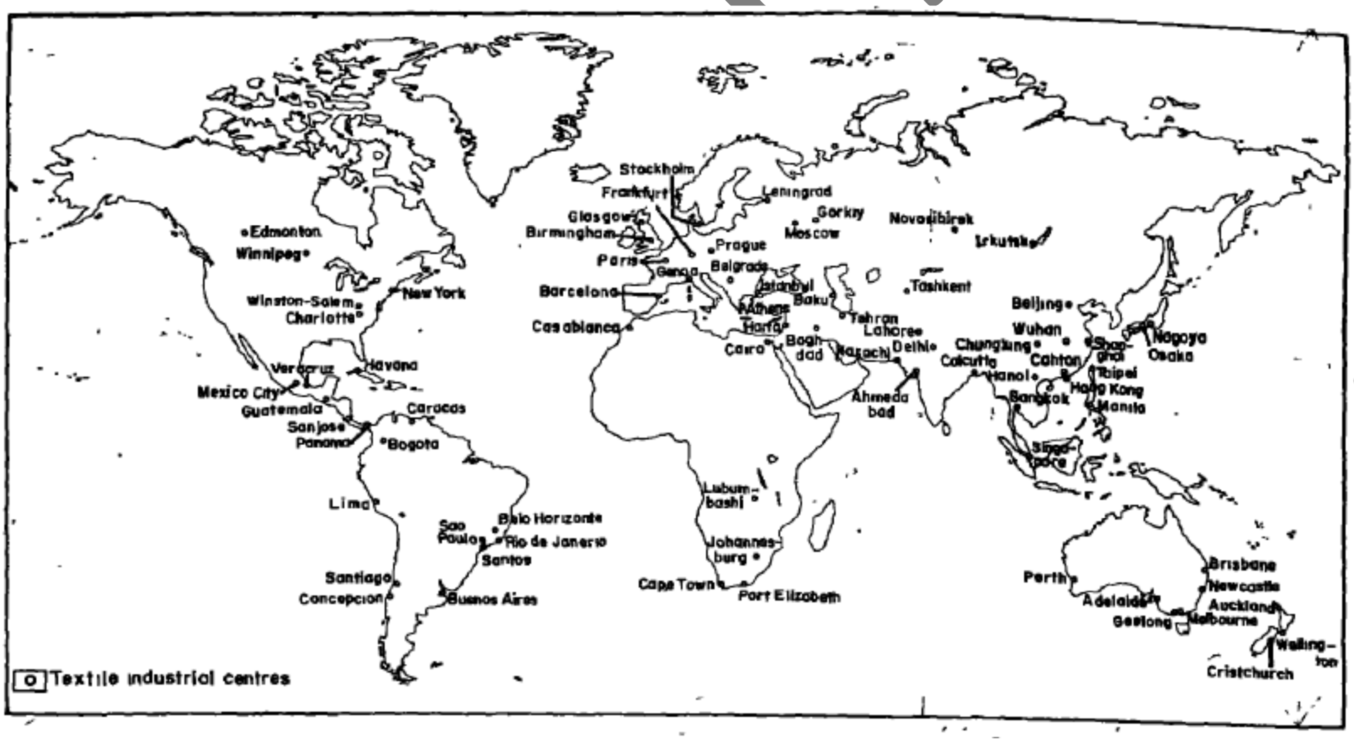

Fig. 11 World-textile industry

EARTHQUAKE TSUNAMI AND VOLCANIC ACTIVITY AND ASSOCIATED LANDFORMS

Contents:

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Earthquakes

An earthquake in simple words is shaking of the earth. It is caused due to release of energy, which generates waves that travel in all directions.

The release of energy occurs along a fault. A fault is a sharp break in the crustal rocks. Rocks along a fault tend to move in opposite directions. As the overlying rock strata press them, the friction locks them together. However, their tendency to move apart at some point of time overcomes the friction. As a result, the blocks get deformed and eventually, they slide past one another abruptly. This causes dissipation of energy, and the energy waves travel in all directions.

The point where the energy is released is called the **focus** of an earthquake, alternatively, it is called the **hypocentre**. The energy waves travelling in different directions reach the surface. The point on the surface, nearest to the focus, is called **epicentre**. It is the first one to experience the waves. It is a point directly above the focus.

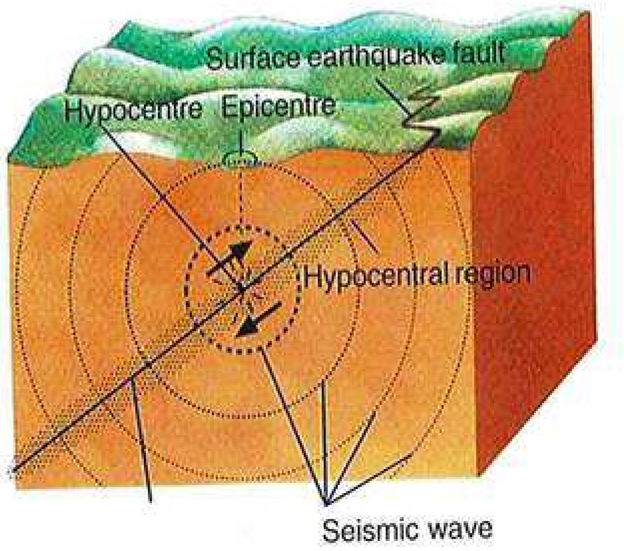

Figure 1: Hypocentre and Epicentre

Types of Earthquakes

1. **Tectonic Earthquakes**: These are generated due to sliding of rocks along a fault plane. This movement causes imbalance in the crustal rocks which results in earthquakes of varying magnitude, depending upon the nature of dislocation in the rock strata.
2. **Volcanic Earthquakes:** Volcanic activity is considered to be one of the main causes of earthquakes. In fact, volcanic activity and seismic events are so intimately related to each other that they become cause and effect for each other. Each volcanic eruption is followed by an earthquake and many of the severe earthquakes can cause volcanic eruptions.
   The explosive violent gases during the process of volcanic activity try to escape upward and hence they push the crustal surface from below with great force. This leads to severe tremors of high magnitude, which depend upon the intensity of volcanic eruptions.
3. **Collapse Earthquakes:** In areas of intense mining activity, sometimes the roofs of underground mines collapse causing minor tremors.

4. **Explosion Earthquakes:** Ground shaking may also occur due to the explosion of chemical or nuclear devices.
5. The earthquakes that occur in the areas of large reservoirs are referred to as **reservoir induced earthquakes**.
   Above may also be referred as various causes of earthquakes with one and two being the **natural causes** of earthquakes while three, four and five represent **anthropogenic** or **man-made** causes of earthquakes.

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Seismic waves

The waves generated by an earthquake are called the 'seismic waves' or 'earthquake waves'. These are recorded by an instrument called the **seismograph** or the **seismometer**. For further understanding of earthquake waves, refer to the portion of the notes on 'Interior of Earth'.

Depth of Earthquakes

Earthquake focus depth is an important factor in shaping the characteristics of the waves and the damage they inflict. The focal depth can be **deep** (from 300 to 700 km), **intermediate** (60 to 300 km) or **shallow** (less than 60 km). Deep focus earthquakes are rarely destructive because the wave amplitude is greatly attenuated by the time it reaches the surface. Shallow focus earthquakes are more common and are extremely damaging because of their close proximity to the surface

Measurement of Earthquakes

The earthquake events are scaled either according to the magnitude or intensity of the shock.

Magnitude Scale

Magnitude is the amount of energy released and is based on the direct measurement of the size of seismic waves. The magnitude scale is known as the **Richter Scale**.

The **Richter magnitude scale** was developed in 1935 by Charles F. Richter as a mathematical device to compare the size of earthquakes. The magnitude of an earthquake is determined from the *logarithm of the amplitude* of waves recorded by seismographs. Because of the logarithmic basis of the scale, each whole number increase in magnitude represents a *ten fold increase* in measured amplitude; as an estimate of energy, each whole number step in the magnitude scale corresponds to the release of about 31 times more energy than the amount associated with the preceding whole number value.

Intensity Scale

Intensity of an earthquake is measured in terms of its effects on human life. The intensity of an earthquake at a specific location depends on a number of factors. Some of them are:

- the total amount of energy released,
- the distance from the epicentre,
- the types of rocks and the degree of consolidation.

The **Mercalli intensity scale** is a scale used for measuring the intensity of an earthquake. The scale quantifies the effects of an earthquake on the Earth's surface, humans, objects of nature, and man-made structures on a scale of **I** through **XII**, with I denoting 'not felt', and XII 'total destruction'. Data is gathered from individuals who have experienced the quake, and an intensity value will be given to their location.

Characteristic	Mercalli Scale	Richter Scale
Measures	The effects caused by earthquake	The energy released by the earthquake
Measuring Tool	Observation	Seismograph
Calculation	Quantified from observation of effect on earth's surface, human, objects and man-made structures	Base-10 logarithmic scale obtained by calculating logarithm of the amplitude of waves.
Scale	I (not felt) to XII (total destruction)	From 2.0 to 10.0+ (never recorded). A 3.0 earthquake is 10 times stronger than a 2.0 earthquake.
Consistency	Varies depending on distance from epicentre.	Varies at different distances from the epicentre, but one value is given for the earthquake as a whole.

Table 1: Comparison between Richter and Mercalli Scale

Classification of Earthquakes

Category	Magnitude on Richter Scale
Slight	Upto 4.9
Moderate	5.0 to 6.9
Great	7.0 to 7.9
Very Great	8.0 and more

Table 2: classification of earthquakes based on magnitude

Distribution of Earthquakes

Most earthquakes in the world are associated with the following:

- the zones of young fold mountains,
- the zones of faulting and fracturing,
- the zones representing the junctions of continental and oceanic margins,
- the zones of active volcanoes, and
- along the different plate boundaries.

Seismic Belts of the world

The main seismic belts are as under:

1. **Circum-Pacific Belt:** The Belt includes the coastal margins of North America, South America and East Asia. These are as represent the eastern and western margins of the

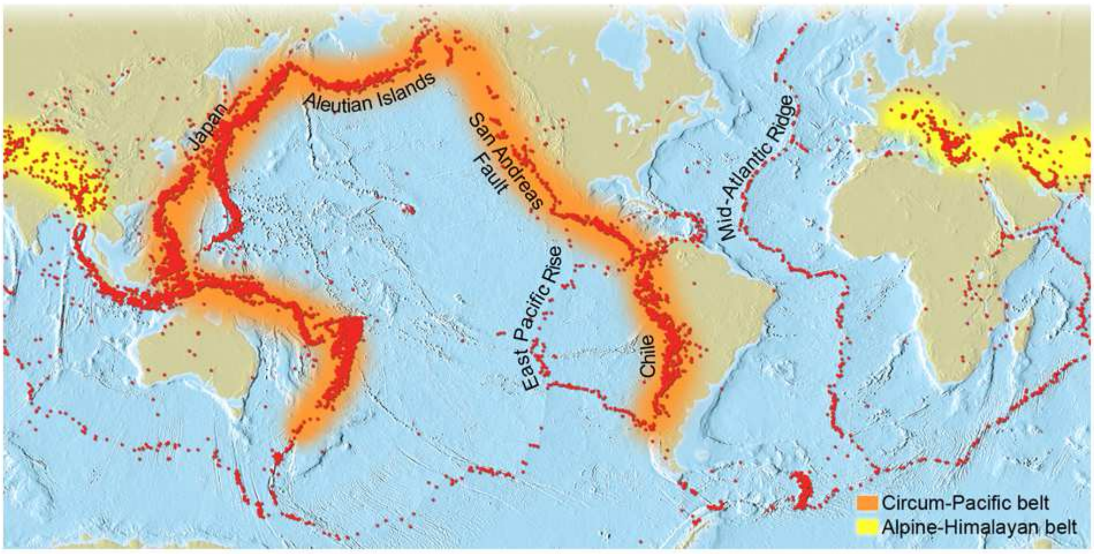
Student Notes:

Pacific Ocean respectively, and account for about 65 per cent of the total earthquakes of the world.

The **western marginal zones** are represented by the Rockies and the Andes mountain chains. These are also the zones of convergent plate boundaries where the Pacific oceanic plate is subducted below the American plates.

The **eastern marginal zones** are represented by the island arcs of Kamchatka, Sakhalin, Japan and Philippines. The earthquakes are caused due to collision of the Pacific and the Asiatic plates and the consequent volcanic activity. Japan records about 1500 seismic shocks every year.

2. **Mid-Continental Belt:** The Mid-Continental Belt includes the Alpine mountains and their off shoots in Europe, Mediterranean Sea, northern Africa, eastern Africa and the Himalayas.
   The Mid-Continental Belt extends through Sulaiman and Kirthar zones in the west, the Himalayas in the north and Myanmar in the east. This belt represents the weaker zone of Fold Mountains. About 21 per cent of the total seismic events are recorded in this belt.
3. **Mid-Atlantic Ridge Belt:** The Mid-Atlantic Ridge Belt includes the Mid-Atlantic ridge and several islands near the ridge. It records moderate earthquakes which are caused due to the moving of plates in the opposite directions. Thus the seafloor spreading and the fissure type of volcanic eruptions cause earthquakes of moderate intensity in this region.



Distribution of nearly 15,000 earthquakes with magnitudes equal to or greater than 5 for a 10-year period.

Figure 2: Distribution of Earthquake belts

Seismic Zones of India

The Indian sub-continent is highly prone to multiple natural disasters including earthquakes, which is one of the most destructive natural hazards with the potentiality of inflicting huge loss to lives and property. Earthquakes pose a real threat to India with 59% of its geographical area vulnerable to seismic disturbance of varying intensities including the capital city of the country.

The varying geology at different locations in the country implies that the likelihood of damaging earthquakes taking place at different locations is different. Thus, a seismic zone map is required so that buildings and other structures located in different regions can be designed to withstand different level of ground shaking. The current zone map divides India into four zones – II, III, IV and V.

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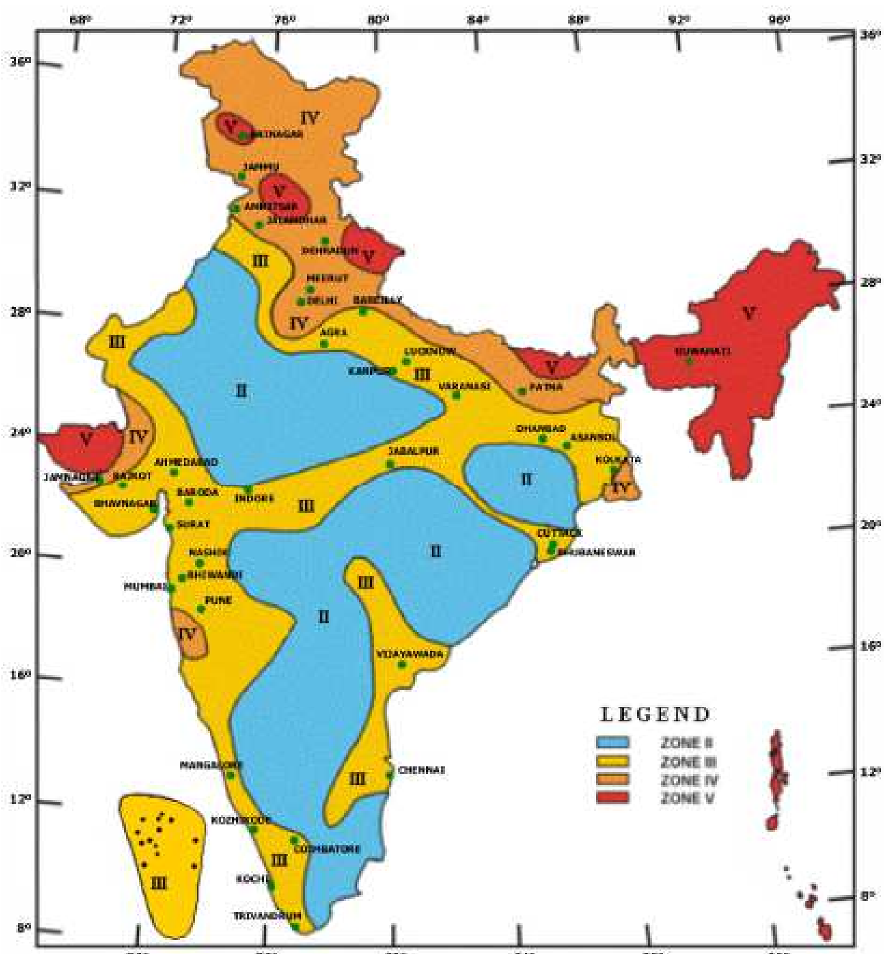

Figure 3: Seismic Zones of India

The following table gives the distribution of various regions of the country into various seismic zones:

Zone	Damage risk	Region
Zone V	Very high damage risk zone	The entire North-east, including the seven sister states, the Kutch district, parts of Himachal and Jammu & Kashmir, and the Andaman and Nicobar islands.
Zone IV	High damage risk zone	Parts of the Northern belt starting from Jammu and Kashmir to Himachal Pradesh. Also including Delhi and parts of Haryana. The Koyna region of Maharashtra is also in this zone.
Zone III	Moderate damage risk zone	A large part of the country stretching from the North including some parts of Rajasthan to the South through the Konkan coast, and also the Eastern parts of the country.
Zone II	Low damage risk zone	These two zones are contiguous, covering parts of Karnataka, Andhra Pradesh, Orissa, Madhya Pradesh, and Rajasthan, known as low risk earthquake zones.

Table 4: Region falling in various zones of the country

Effects of Earthquakes

The direct and indirect effects of an earthquake includes:

1. **Deformed Ground Surface:** The earthquake tremors and the resultant vibrations, result in the deformation of the ground surface, due to the rise and subsidence of the ground surface and faulting activity. The alluvium filled areas of the flood plains may get fractured at several places.
2. **Damage to man-made structures:** Man-made structures such as buildings, roads, rails, factories, dams, bridges, etc., get severely damaged.
3. **Damage to towns and cities:** The towns and cities are the worst affected due to a high density of buildings and population. Under the impact of tremors, large buildings collapse and men and women get buried under the debris. Ground water pipes are damaged and thus water supply is totally disrupted.
4. **Loss of human and animal life:** The destructive power of an earthquake depends upon the loss it can cause in terms of loss of life arid property. The Bhuj earthquake of India in 2001 (8.1 on the Richter Scale) caused over one lakh human casualties.
5. **Devastating fires:** The strong vibrations caused by an earthquake can cause fire in houses, mines and factories due to the bursting of gas cylinders, contact with live electric wires, churning of blast furnaces, displacement of other electric and fire related appliances.
6. **Landslides:** The tremors in hilly and mountainous areas can cause instability of unconsolidated rock materials. This ultimately leads to landslides, which damage settlements and transport systems.
7. **Flash floods:** Very strong seismic events result in the collapse of dams and cause severe flash floods. Floods are also caused when the debris produced by tremors blocks the flow of water in the rivers. Sometimes the main course of the river is changed due to the blockage.
8. **Tsunamis:** When the seismic waves travel through sea water, high sea waves are generated, which can cause great loss to life and property, especially in the coastal areas.

Tsunami

Tsunami is a Japanese word which means 'harbour wave'. It is a series of traveling ocean waves of extremely long length generated by disturbances associated primarily with earthquakes occurring below or near the ocean floor. Underwater volcanic eruptions and landslides can also generate tsunamis. Tsunamis are a threat to life and property to anyone living near the ocean. Large tsunamis have been known to rise over 100 feet, while tsunamis 10 to 20 feet high can be very destructive and cause many deaths and injuries.

Causes

Tsunamis generally are caused by earthquakes. Not all earthquakes generate tsunamis. To generate tsunamis, earthquakes must occur underneath or near the ocean, be large and create movements in the sea floor. All oceanic regions of the world can experience tsunamis, but in the Pacific Ocean there is a much more frequent occurrence of large, destructive tsunamis because of the many large earthquakes along the margins of the Pacific Ocean.

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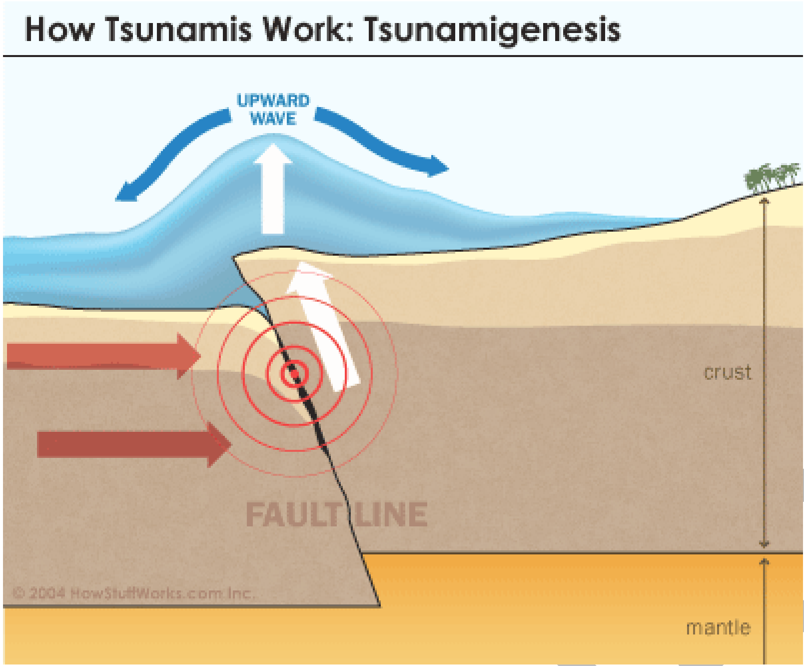

Figure 4: Generation of Tsunami

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Other less common causes of earthquakes are **submarine landslides**, **submarine volcanic eruptions** and very rarely a **large meteorite impact in the ocean**.

Propagation

In the open ocean a tsunami is less than a few feet high at the surface, but its wave height increases rapidly in shallow water. Tsunamis wave energy extends from the surface to the bottom in the deepest waters. As the tsunami attacks the coastline, the wave energy is compressed into a much shorter distance creating destructive, life-threatening waves.

Where the ocean is over 20,000 feet deep, unnoticed tsunami waves can travel at the speed of a commercial jet plane, nearly 600 miles per hour. They can move from one side of the Pacific Ocean to the other in less than a day. This great speed makes it important to be aware of the tsunami as soon as it is generated. Scientists can predict when a tsunami will arrive since the speed of the waves varies with the square root of the water depth. Tsunamis travel much slower in shallower coastal waters where their wave heights begin to increase dramatically.

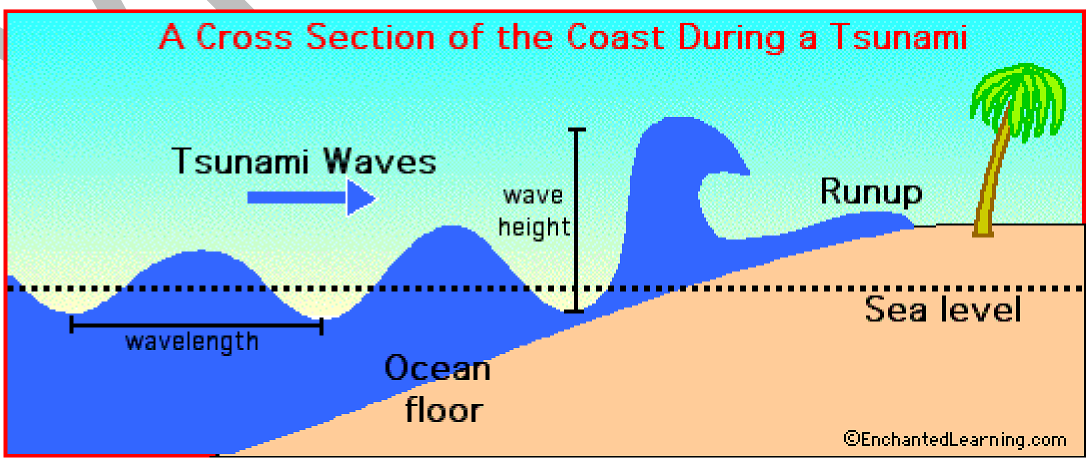

Figure 5: Rise in Tsunami amplitude near the coast

Offshore and coastal features can determine the size and impact of tsunami waves. Reefs, bays, entrances to rivers, under sea features and the slop of the beach all help to modify the tsunami as it attacks the coastline. When the tsunami reaches the coast and moves inland, the water level can rise many feet. In extreme cases, water level has risen to more than 50 feet for tsunamis of distant origin and over 100 feet for tsunami waves generated near the earthquake's epicentre.

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Consequences

The consequences vary from loss of livelihood for fishermen to unknown damages to coral reefs and flora and fauna. It may take years for the coral reefs to get back the balance and mangrove stands and coastal tree plantations get destroyed or severely affected.

With so much sea water coming inland, salination is another effect that not only makes the soil less fertile to support vegetation but also increases vulnerability to erosion, the impacts of climate change and food insecurity. For humans, on the other hand, fisheries, housing and infrastructure are the worst affected.

Early Warning and Mitigation

Major tsunami warning centres are:

1. **Pacific Tsunami Warning Center (PTWC):** The Tsunami Warning System (TWS) in the Pacific, comprised of 26 participating international Member States, has the functions of monitoring seismological and tidal stations throughout the Pacific Basin to evaluate potentially tsunami genic earthquakes and disseminating tsunami warning information. The Pacific Tsunami Warning Center is the operational center of the Pacific TWS. Located near Honolulu, Hawaii, PTWC provides tsunami warning information to national authorities in the Pacific Basin.

2. **The Alaska Tsunami Warning Center (ATWC):** in Palmer, Alaska, serves as the regional Tsunami Warning Center for Alaska, British Columbia, Washington, Oregon, and California.
3. **Indian Tsunami Early Warning System (ITEWS):** The Indian Tsunami Early Warning System has the responsibility to provide tsunami advisories to Indian Mainland and the Island regions. Acting as one of the Regional Tsunami Advisory service Providers (RTSPs) for the Indian Ocean Region, ITEWS also provide tsunami advisories to the Indian Ocean Rim countries along with Australia and Indonesia.

In order to confirm whether the earthquake has actually triggered a tsunami, it is essential to measure the change in water level as near to the fault zone with high accuracy. There are two basic types of sea level gages: **coastal tide gages** and **open ocean buoys**.

Tide gages are generally located at the land-sea interface, usually in locations somewhat protected from the heavy seas that are occasionally created by storm systems. Tide gages that initially detect tsunami waves provide little advance warning at the actual location of the gage, but can provide coastal residents where the waves have not yet reached an indication that a tsunami does exist, its speed, and its approximate strength.

Open ocean tsunami buoy systems equipped with **bottom pressure sensors** are now a reliable technology that can provide advance warning to coastal areas that will be first impacted by a tsunami, before the waves reach them and near by tide gages. Open Ocean buoys often provide a better forecast of the tsunami strength than tide gages at distant locations.

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Apart from technology, we can also use **natural barriers** to mitigate the effect of tsunamis. **Coral reefs** act as natural breakwaters, providing a physical barrier that reduces the force of a wave before it reaches the shore, while **mangrove forests** act as natural shock absorbers, also soaking up destructive wave energy and buffering against coastal erosion.

Volcanoes

The word **volcano** is derived from the name of 'Vulcano', a volcanic island in the *Aeolian Islands* of Italy whose name in turn originates from 'Vulcan', the name of a god of fire in *Roman mythology*.

Volcano is a **vent** or an opening through which heated materials consisting of *water*, *gases*, *liquid lava* and *rock fragments* are erupted from the highly heated interior to the surface of the Earth. The layer below the solid crust of earth is **mantle**. It has higher density than that of the crust. The mantle contains a weaker zone called **asthenosphere**. It is from this that the molten rock materials find their way to the surface. The material in the upper mantle portion is called **magma**. Once it starts moving towards the crust or it reaches the surface, it is referred to as **lava**.

'*Volcanology'* or '*vulcanology'* is the term given to the study of volcanoes, and the scientists who study them are called the '*volcanologists*' or '*vulcanologists*'.

Vulcanicity

Vulcanicity includes all those processes in which molten rock material or magma rises to the crust to solidify as crystalline or semi-crystalline rocks. Some scientists use '*vulcanism*' as a synonym for vulcanicity.

Vulcanicity has two components; one of them operates below the crustal surface and the other above the crust, i.e. the endogenetic mechanism and the exogenous mechanism. The **endogenetic mechanism** includes the creation of hot and liquid magma and gases in the mantle and the crust, their expansion and upward ascent, their intrusion and cooling and solidification in various forms below the crustal surface. The **exogenous mechanism** includes the process of the appearance of lava, volcanic dust and ashes, fragmental materials, mud, smoke, etc., in different forms on the earth's surface.

Causes of Vulcanism

The mechanism of vulcanism and the volcanic activity are associated with several processes, such as:

1. A gradual increase of temperature with increasing depth at the rate of 1 degree Celsius for every 32 m.
2. Magma is formed due to the lowering of melting point, which in turn is caused by the reduction in pressure of the overlying material.
3. Gases and vapour are formed due to heating of water, which reaches underground through percolation.
4. The ascent of magma forced by vast volume of gases and water vapour.
5. The occurrence of volcanic eruption.

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Components of a Volcano

The volcanoes of explosive type have a **volcanic cone**, which is formed when the erupted material accumulates around the vent. The **vent** is an opening of circular or nearly circular shape at the centre of the cone. The vent is connected to the interior of the earth by a **narrow pipe**. The volcanic materials erupt through this pipe. A funnel-shaped hollow at the top of the cone is called the **crater**.

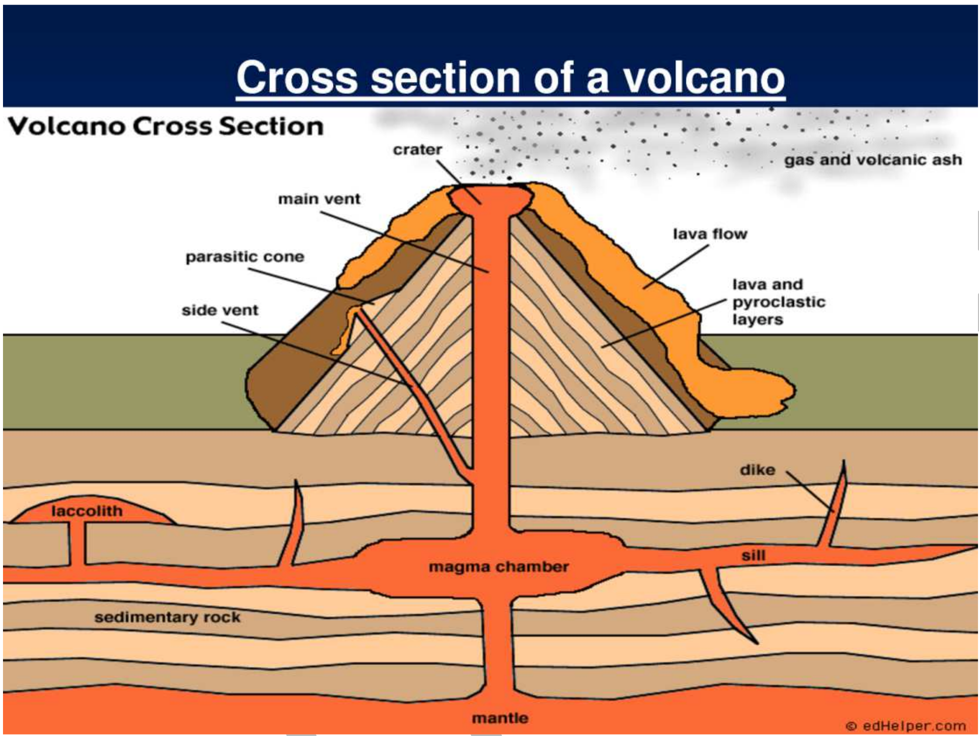

Figure 6: Components of a volcano

Types of lavas

There are two main types of lavas:

1. **Basic Lavas:** These are the hottest lavas and are *highly fluid*. They are dark coloured like *basalt*, rich in iron and magnesium but poor in silica. They flow quietly and are not very explosive. They affect extensive areas, spreading out as thin sheets over great distances before they solidify. The resultant volcano is gently sloping with a wide diameter and forms a flattened *shield* or *dome*.

2. **Acid Lavas:** These lavas are highly viscous with a high melting point. They are *light coloured*, of low density and have a high percentage of silica. They flow *slowly* and seldom travel far before solidifying. The resultant volcano is therefore *steep-sided*. The rapid cooling of lava in the vent obstructs the flow of the outpouring lava, resulting in loud explosions throwing out many *volcanic bombs* or *pyroclasts*.

Note: Pyroclasts are any volcanic fragment that was hurled through the air by volcanic activity.

Student Notes:

Types of volcanoes

There is a wide variation in the mode of volcanic eruption and their periodicity. Accordingly the volcanoes can be classified on the basis of the mode of eruption and their periodicity of eruption.

Classification on the basis of mode of eruption: The volcanoes are classified into two groups on the basis of their *mode* of eruption:

1. **Violent or Explosive type:** The eruption of violent or explosive type is so rapid that huge quantities of volcanic materials are ejected thousands of metres in the sky. On falling, these materials accumulate around the volcanic vent and form volcanic cones. Such volcanoes are very destructive. They are generally associated with acidic lavas.

2. **Effusive or Fissure type:** The eruption of the fissure type of volcanoes-occurs along a long fracture, fault or fissure. Magma ejects slowly and the resultant lava spreads on the surface. The speed of the lava flow depends on the nature and volume of magma, slope of the ground and the temperature conditions.

Classification on the basis of periodicity of eruption: The volcanoes are divided into three types on the basis of the periodicity of their eruption:

1. **Active Volcanoes:** Volcanoes are said to be active when they frequently erupt or at least when they have erupted within recent time. Etna and Stromboli are typical examples.
2. **Dormant Volcanoes:** Volcanoes that have been known to erupt and show signs of possible eruption in future are described as dormant. Mt. Vesuvius is the best example.
3. **Extinct Volcanoes:** Volcanoes that have not erupted at all in historic times but retain the features of volcanoes are termed extinct. Ship rock in Netherlands is one such example.

All volcanoes pass through active, dormant and extinct stages but it is impossible to be thoroughly sure when a volcano has become extinct.

Volcanic Landforms

Various landforms are created due to the cooling and solidification of magma (below the Earth's surface) and lava (on the Earth's surface). Some relief features are formed due to the accumulation of volcanic materials. The volcanic landforms are grouped into two broad categories: **Extrusive** landforms and **Intrusive** landforms.

Extrusive Landforms

Extrusive landforms are determined by the nature and composition of the lava. Major extrusive landforms are as under:

1. **Cinder or ash cones** are formed due to the accumulation of loose particles around the vent. Its size increases due to the continuous accumulation of volcanic material minus lava. The larger particles are arranged near the crater and the finer particles are deposited at the outer margins of the cone. The lava flows are so viscous that they solidify after a short distance.
2. **Composite cones** are the highest and are formed by the accumulation of various layers of volcanic material. They have alternate layers of lava and fragmented

material, wherein lava acts as the cementing material. These are mainly associated with cooler and more viscous lava and the volcanoes associated with them are called **composite volcanoes**.

3. **Shield Volcanoes** are built almost entirely of fluid lava flows**.** They are named for their large size and low profile, resembling a warrior's shield lying on the ground. Barring the basalt flows, the shield volcanoes are the largest of all the volcanoes on the earth. These volcanoes are mostly made up of basalt, a type of lava that is very fluid when erupted. For this reason, these volcanoes are not steep.
4. **Craters** are depressions formed at the mouth of the volcanic vent, which is usually funnel-shaped. Some volcanoes may have greatly enlarged depressions called **calderas**. These are the result of violent eruptions accompanied by the subsidence of much of the volcano into the magma beneath. Water may collect in the crater or the caldera forming crater or caldera lakes.
5. **Flood Basalt Provinces** are formed when volcanoes outpour highly fluid lava that flows for long distances. Some parts of the world are covered by thousands of sq. km of thick basalt lava flows. There can be a series of flows with some flows attaining thickness of more than 50 m. Individual flows may extend for hundreds of km. The *Deccan Traps* from India, presently covering most of the Maharashtra plateau, are a much larger flood basalt province.

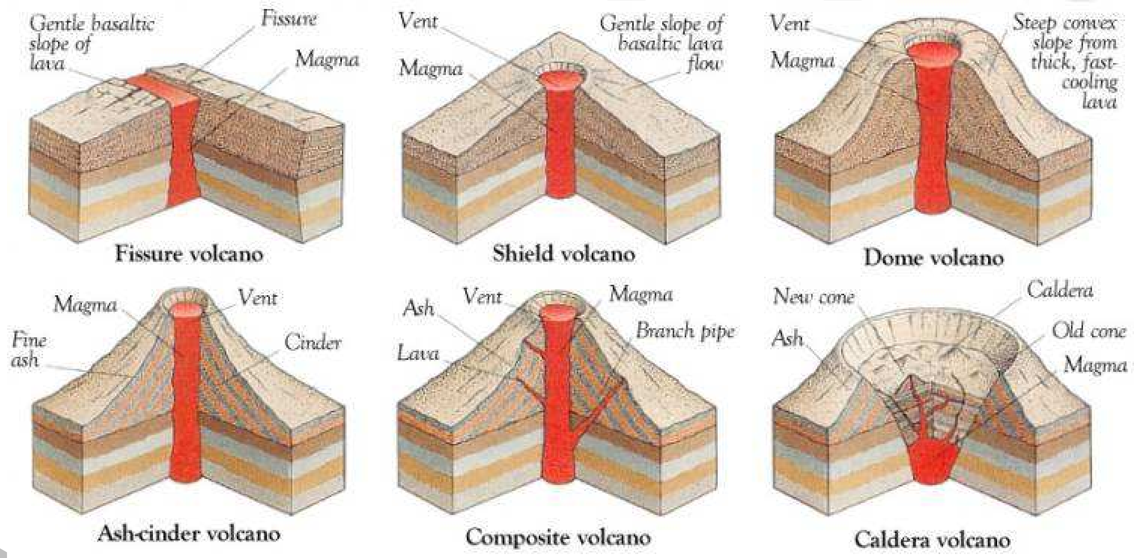

Figure 7: Volcanoes based on extrusive landforms

Intrusive Landforms

The lava that cools within the crustal portion assumes different forms called intrusive forms. Some of these forms are:

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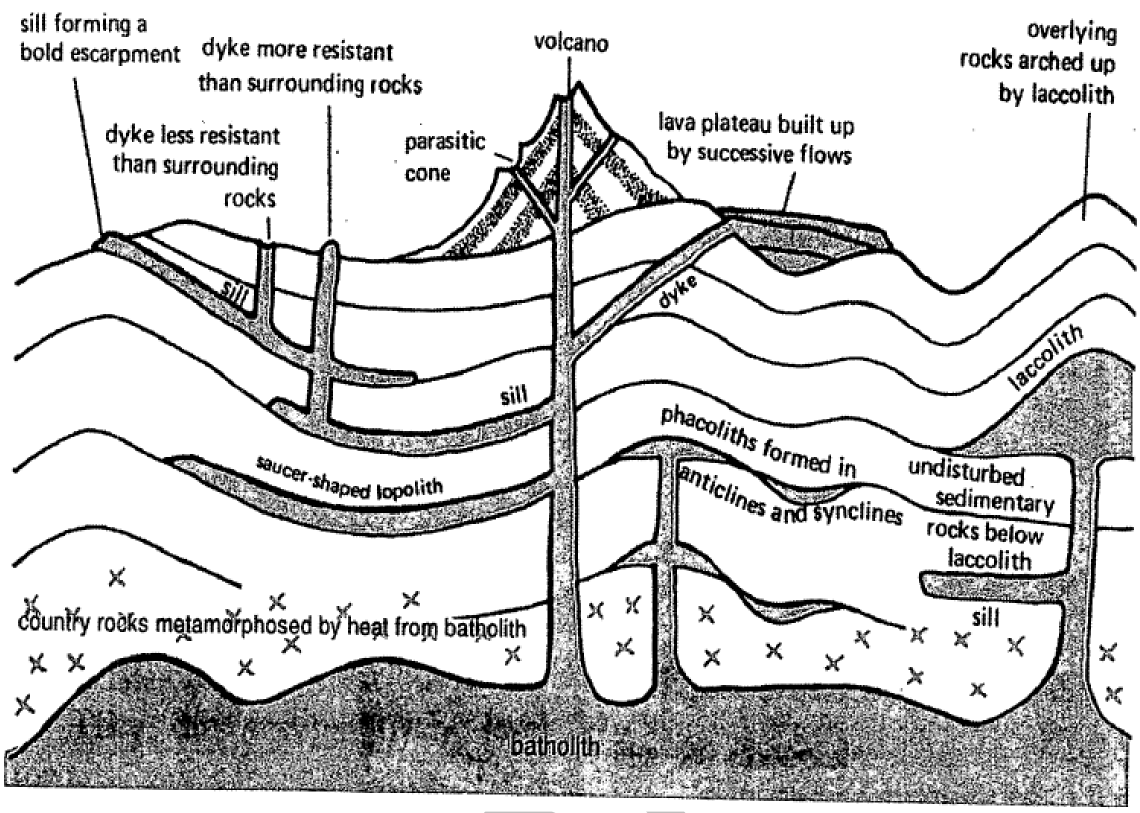

Figure 8: Various intrusive landforms formed in volcanic regions

1. **Batholiths** are long, irregular, undulating and dome-shaped features. They are a large body of magmatic material that cools in the deeper depth of the crust and develops in the form of large domes. They appear on the surface only after the denudational processes remove the overlying materials. They cover large areas, and at times, assume depth that may be several km. These are granitic bodies. Batholiths are the cooled portion of magma chambers.
2. **Laccoliths** are formed due to the intrusion of magma along the bedding planes of horizontal sedimentary rocks. They are usually mushroom or dome shaped.
3. **Phacoliths** are formed due to the intrusion of acidic magma along the anticlines and synclines in the region of fold mountains.
4. **Lapoliths** are formed when magma solidifies in shallow basins into a saucer shape.
5. **Sills** and **Sheets** are intrusive igneous rocks usually parallel to the bedding planes of sedimentary rocks. Depending on the thickness of deposits, thinner ones are called **sheets** while thick horizontal deposits are called **sills.**
6. **Dykes** are wall-like formation of solidified magma. These are vertical to the bed of sedimentary rocks. The thickness ranges from a few centimetres to several hundred metres, but the length can be several kilometres.

Distribution of Volcanoes

The volcanoes are mostly associated with the weaker zones of the Earth's crust which are also zones of seismic activities like the earthquakes. The weaker zones are mostly found in the areas of fold mountains. They are also associated with the meeting zones of oceans and continents, or with the mountain building activity.

Most of the world's active volcanoes are associated with the plate boundaries. About 15 per cent of the volcanoes are associated with the divergent plate boundaries and about 80 per cent

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with the convergent plate boundaries. Some volcanoes are also found in the intra-plate regions.

The main volcanic belts are as under:

1. **Circum-Pacific Belt:** It includes the volcanoes of the eastern and western coastal areas of the Pacific Ocean. This belt is also known as the **Ring of Fire** of the Pacific Ocean.

   It begins from Erebus mountains of Antarctica and runs northwards through Andes of South America and Rockies of North America to reach Alaska. From there, it turns eastwards along the coast of Asia to include the volcanoes of Sakhalin and Kamchatka, Japan and Philippines respectively. This belt finally merges with the Mid-continental Belt in Indonesia.

   Most of the high volcanic cones and volcanic mountains are found in the Circum-Pacific Belt. *Cotopaxi* in Andes (5896 m) is the highest volcanic mountain in the world. The other famous volcanoes are *Fujiyama* (Japan), *Shasta*, *Rainier*, *Mt St Helena* (USA).

2. **Mid-Continental Belt:** It includes the volcanoes of the Alpine mountains and the Mediterranean Sea. The volcanic eruptions are caused due to the convergence and collision of the Eurasian Plates and the African and Indian Plates. Some of the famous volcanoes of the Mediterranean Sea such as the *Stromboli*, *Vesuvius*, *Etna*, etc., are in this belt. This belt is not continuous and has several volcanic free zones such as the Alps and the Himalayas. The important volcanoes in the fault zone of eastern Africa are *Kilimanjaro*, *Meru*, *Elgon*, *Rungwe*, etc.

3. **Mid-Atlantic Belt:** It includes the volcanoes along the mid-Atlantic ridge which is the divergent plate zone. They are mainly of the fissure eruption type. Iceland, is the most active volcanic area.

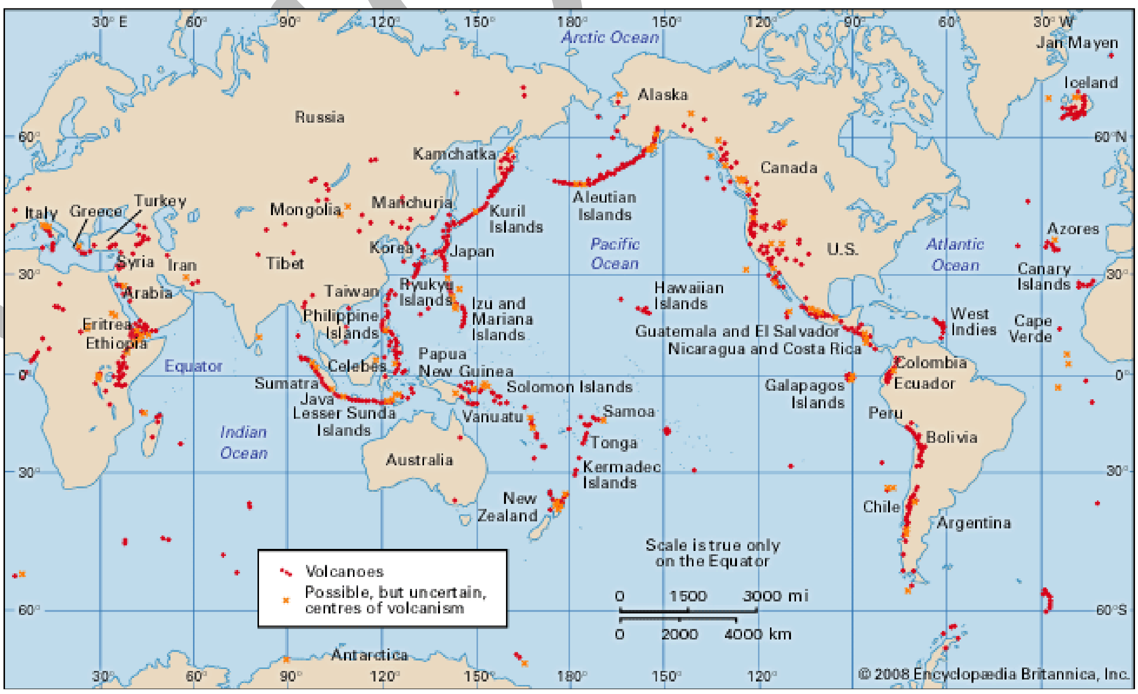

Figure 9: Distribution of volcanoes

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Effects of volcanic eruptions

Volcanic eruption causes heavy damage to human life and property. Some of them are as under:

- Large volumes of hot lava moving at a fast speed can bury man-made buildings, kill people and animals, destroy agricultural farms and pastures, burn and destroy forests.
- The fall out of large quantities of fragmented materials, dust, ash, smoke, etc., creates health hazards due to poisonous gases emitted during eruption. It also causes **acid rain**.
- If the explosive eruption has occurred suddenly, the human beings get no time to escape to safer places. Heavy rains mixed with volcanic dust and ash cause enormous mud-flow on the steep slopes of the cones.
- Earthquakes caused due to explosive eruptions can generate destructive tsunamis, seismic waves, etc. These can cause loss of life and property in the affected coastal regions.
- The volcanic eruptions can change the heat balance of the Earth and the atmosphere, causing climatic changes.

But there are many **positive effects** also. Some of them are:

- Lava can give rise to fertile soils. Most of the precious stones are formed due to volcanic activity.
- Geysers and springs are tourist attraction and are also important from the medical point of view due to the chemicals dissolved in them.
- Some crater lakes are source of rivers and often offer scenic attraction for tourists.
- Most of the volcanic rocks when exposed on the surface are a storehouse of metals and minerals.

Geysers

Geysers are *fountains of hot water* and superheated steam that may spout up to a height of 150 feet from the earth beneath. The phenomena are associated with a thermal or volcanic region in which the water below is being heated beyond boiling point. The jet of water is usually emitted with an explosion, and is often triggered by gases seeping out of the heated rocks.

Almost all the world's geysers are confined to three major areas: Iceland, New Zealand and Yellowstone park of U.S.A.

Hot Springs

Hot springs or thermal springs are more common, and may be found in any part of the earth where water sinks deep enough beneath the surface to be heated by the interior forces. The water rises to the surface without any explosion. Such springs contain dissolved minerals which have medical value.

Iceland has thousands of hot springs. Hot springs are common in many parts of India, especially in the hilly and mountainous parts. Some of them are in Manikaran (Kulu), Tattapani (Shimla), Jwalamukhi (Kangra), Rajgir (Patna), Sitakund (Munger) and in Yamunotri and Gangotri.

Fumaroles

A fumarole is a vent in the Earth's surface which emits gases and water vapour. Sometimes the emission is continuous, but in majority of cases emission occurs after intervals. It is widely believed that gases and water vapour are generated due to cooling and contraction of magma after the eruption. Fumaroles are the last signs of the activeness of a volcano.

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NATURAL VEGETATION

Contents:

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1] Natural vegetation

Nature has gifted our country with a large variety of natural resources. Natural vegetation is an important natural resource which refers to a plant community that has grown naturally without human aid and has been left undisturbed by humans for a long time. The natural vegetation adapts to the constraints of natural environment in size, structure and requirements. As India is situated in tropical latitudes and has diverse temperature and rainfall regimes, Indian climate and relief has made natural vegetation and animal life interdependent on each other and they form a single ecosystem which has evolved through thousands of years. The overall climate of India is suitable for the growth of forests[1]. The natural vegetation in India ranges from the one that is found in the tropical region to that found in the Arctic region. However, in the past thousand years, various types of human activities have altered these natural climatic formations in the country to a large extent.

On the basis of climate and relief the natural vegetation of India can be divided in the following types:

i. Tropical Evergreen and Semi Evergreen forests
ii. Tropical Deciduous forests
iii. Tropical Thorn forests
iv. Montane forests
v. Littoral and Swamp forests

1.1 Tropical Evergreen and Semi Evergreen Forests

Tropical Evergreen and Semi Evergreen Forests are found mainly in the areas where the annual rainfall is more than 200 cm, with a short dry season. The average annual temperature should be above 22 °C. The relative humidity should also be high, approx around 70 percent. The general climatic conditions should be hot and humid.

The trees in these regions are generally evergreen and do not shed their leaves. These forests are very dense and composed of tall trees reaching upto the height of about 60 metres. The trees have a multi-storeyed structure with good canopy. Due to dense growth of trees, the sunlight cannot reach the ground. Thus, the undergrowth mainly consists of canes, bamboos, ferns, climbers, etc.

The semi evergreen forests are found in the less rainy parts of these regions. Such forests have a mixture of evergreen and moist deciduous trees. The under-growing climbers provide an evergreen character to these forests. These forests are less dense and can be easily exploited.

The timber from the tropical evergreen and semi- evergreen a forest is **hard, durable, fine-grained and of high economic value**. The important trees of these forests are **rosewood, ebony, mahogany, rubber, cinchona, bamboo, coconut, palms, canes, lianas, etc**. The main species in the semi-evergreen forests are **cedar, hillock, kail**, etc. The true evergreen forests are mostly found along the **western side of the Western Ghats, in the northern states and in the Andaman and Nicobar Islands**. The semi-evergreen forests which are more gregarious are found along the lower slopes of eastern Himalaya Mountains, Assam, Orissa coast, Western coast and neighbouring hills.

[1] The original natural vegetation, which are purely native are called the endemic plants, but those which have come from outside are called the exotic plants.

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1.2 Tropical Deciduous Forests

Tropical Deciduous Forests are the monsoon forests and are found mainly in the areas where the average annual rainfall ranges between 70 cm and 200 cm, with mean annual temperature of about 27 °C. The average annual relative humidity should be 60 to 75 per cent. The tropical deciduous forests are most widespread in India.

On the basis of availability of water, these forests are further divided into *moist and dry deciduous* forests. The moist deciduous forests are found in areas receiving rainfall between 100 cm and 200 cm, while the dry deciduous forests are found in areas having 70 cm to 100 cm of average annual rainfall.

The trees in the deciduous forests shed their leaves for about 6 to 8 weeks during the spring and early summer seasons (March-April). During this period sufficient moisture is not available for the leaves. Enough light reaches the ground to permit the growth of grasses and climbers.

The tropical deciduous forests are commercially most important as they yield valuable timber and a variety of other forest products. The important trees in the moist deciduous forests are **teak, sal, shisham, sandalwood, khair, kusum, arjun, mahua, mulberry**, etc. The dry deciduous forests are more open stretches and also have **pipal, neem, tendu, bamboo**, apart from those in the moist deciduous forests.

The tropical deciduous forests are commercially most exploited. Large tracts of these forests have been cleared to provide more land for agricultural purposes and have also suffered from severe biotic factors, such as over-cutting, overgrazing, fires, etc.

The moist deciduous forests are found mainly in the north-eastern states, along the foothills of the Himalaya Mountains, Jharkhand, west Orissa, Chhattisgarh and on the eastern slopes of the Western Ghats. The dry deciduous forests are found mainly in the rainier parts of the peninsular plateau and the plains of Bihar and Uttar Pradesh.

1.3 Tropical Thorn Forests

Tropical Thorn Forests are found mainly in those areas where the average annual rainfall is less than 50 cm, with a long dry season. The average annual temperature ranges between 25 °C and 30 °C and the relative humidity is low, i.e. less than 50 per cent. The natural vegetation is **thorny trees and bushes.** There is not much scope for thick and tall forests due to the shortage of moisture. The trees are **scattered and have long roots**. The roots penetrate deep into the soil to get moisture. The leaves are mostly thick and small, which retards evaporation. The trees have thick bark and their wood is generally used as fuel.

The main trees found in the tropical thorn forests are acacias, palms, euphorbias and cacti. Other important trees include khair, babul, neem, kheijra, kanju, palas, nirmali, dharman, khagri, etc. The tropical thorn forests are found in the northwestern parts of the country, including semi-arid areas of Gujarat, Rajasthan, Madhya Pradesh, Uttar Pradesh, southwestern Punjab and western Haryana. These forests also grow on the leeward side of Western Ghats, covering large areas in Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu.

1.4 The Montane Forests

The natural vegetation in the mountains is greatly influenced by the decrease in temperature with increase in height above sea level. The mountain forests can be broadly classified into *two major categories* the forests in the Himalayan ranges and the forests in the peninsular plateaus and hill ranges.

Student Notes:

In *the Himalaya Mountains,* one can notice a succession of natural vegetation belts, as we see in the tropical to the tundra region. Between the height of 1000 m and 2000 m, the evergreen broad-leaf trees such as oak and chestnut predominate. Between the height of 1500 m and 3000 m, the coniferous trees, such as pine, deodar, silver fir, spruce and cedar are found. The coniferous forests cover the southern slopes of Himalayas and parts of northeast India. At higher elevations (about 3600 m above sea level) temperate grasslands are common. At attitudes above 3600 m, coniferous forests and grasslands give way to the alpine vegetation. Silver firs, junipers, pines and birches are common varieties of trees.

Ultimately these forests merge into alpine grasslands, through the shrubs and scrubs. The grasslands are extensively used by the nomadic tribes like the Gujjars and the Bakarwals for grazing livestock. The southern slopes of the Himalaya Mountains have denser forests than the north facing areas. This is due to relatively higher precipitation. At higher altitudes, mosses and lichens form part of vegetation.

In *the peninsular India,* the mountain forests are found in the three district areas—the Western Ghats, the Vindhyas and the Nilgiris. As they are closer to the tropics, and only 1,500 m above the sea level, vegetation is **temperate in the higher regions and subtropical on the lower regions** of the Western Ghats, especially in Kerala, Tamil Nadu and Karnataka. The temperate forests are called ***Sholas*** in the Nilgiris, Annamalai and Palani hills. The word 'shola' is probably derived from the Tamil language word 'colai' meaning grove. The shola-forest and grassland complex has been described as a climatic climax vegetation. Some of the other trees of this forest of economic significance include magnolia, laurel, cinchona and wattle. Now the tea plantations have been developed and many useful trees have been planted in recent years. As a result of these efforts the former bare areas today have vegetal cover.

1.5 Littoral and Swamp Forests

These forests are found in and around the deltas of the Ganga, Mahanadi, Godavari, Krishna and Kaveri rivers. These areas are prone to tidal influences. They also occur in tidal creeks and coastal areas where mud, silt and saline water have accumulated. Mangroves grow along the coasts in the salt marshes, tidal creeks, mud flats and estuaries. They are highly developed in the Andaman and Nicobar Islands and the Sunder bans of West Bengal. These forests too, are being encroached upon, and hence, need conservation.

Mangrove ecosystem acts as Buffer Zone between the land and sea. Mangroves protect the coast against erosion due to wind, waves, and water currents and protect coral reefs, sea-grass bed and shipping lanes against siltation. They are also known to absorb pollutants. Mangroves host a number of threatened or endangered species, different animal species- mammals, reptiles, amphibians and bird- offer nutrients to the marine food web and provide spawning grounds to a variety of fish and shellfish, including several commercial species. Mangrove forests are also important in terms of aesthetics and tourism. Many people visit these areas for sports fishing, boating, bird watching, snorkelling, and other recreational pursuits.

Wetlands

Wetlands are lands transitional between terrestrial and aquatic system where the water table is usually or near the water surface and land is covered by shallow water.

Identification of wetlands can be attributed to the following three main factors, viz., (i) When an area is permanently or periodically inundated; (ii) When an area supports hydrophytic vegetation; (iii) When an area has hydric soils that are saturated or flooded for a sufficiently long period to become anaerobic in the upper layers.

Student Notes:

On these criteria, Ramsar Convention defines Wetlands as areas of marsh or fen, peat-land or water, whether artificial or natural, permanent or temporary, with the water that is static or flowing, a fresh brackish or salt including areas of marine water, the depth of which at low tide does not exceed six meter. Mangroves, corals, estuaries, bays, creeks, flood plans, sea grasses, lakes, etc., are covered under this definition.

Wetlands in India: The country's wetlands have been grouped into eight categories, viz. (i) the reservoirs of the Deccan Plateau in the south together with the lagoons and other wetlands of the southern west coast; (ii) the vast saline expanses of Rajasthan, Gujarat and the Gulf of Kachchh; (iii) freshwater lakes and reservoirs from Gujarat eastwards through Rajasthan (Keoladeo National Park) and Madhya Pradesh; (iv) the delta wetlands and lagoons of India's east coast (Chilika Lake); (v) the freshwater marshes of the Gangetic Plain; (vi) the floodplains of the Brahmaputra; the marshes and swamps in the hills of northeast India and the Himalayan foothills; (vii) the lakes and rivers of the Montane region of Kashmir and Ladakh; and (viii) the mangrove forest and other wetlands of the island arcs of the Andaman and Nicobar Islands. Two sites — Chilika Lake (Odisha) and Keoladeo National Park (Bharatpur) are protected as water-fowl habitats under the Convention of Wetlands of International Importance (Ramsar Convention).

Wetlands are **essential ecological features** in any landscape. They are primary **habitat for hundreds of species** of waterfowl as well as many other birds, fish, mammals and insects. Wetlands naturally filter **and recharge the water** that later comes out of our faucets downstream. They **act like giant sponges**, slowing the flow of surface water and reducing the impact of flooding. Wetlands also **prevent soil erosion**, and they **buffer water bodies** from potentially damaging land use activities such as agriculture. And wetlands can **remove and store greenhouse gases** from the Earth's atmosphere, slowing the onset of global warming. Apart from that, they are valuable for their educational and scientific interest and provide durable timber, fuelwood, protein rich fodder for cattle, edible fruits, vegetables and traditional medicines.

2] Forest Cover in India

According to the records of the Government of India, the forest area covers 23.81[2] per cent of the total land area of the country, which is much below the average of about 30.4 per cent for the world. The forest area is the area notified and recorded as the forest land irrespective of the existence of trees, while the actual forest cover is the area occupied by forests with canopy. While the former is based on the records of the State Revenue Department, the latter is based on aerial photographs and satellite imageries.

Both forest area and forest cover varies from state to state. India has only 2% of the total world's forest. The state of Madhya Pradesh has the largest forest cover in the country at 77,700 square km followed by Arunachal Pradesh at 67, 410 square km. In terms of percentage of forest cover in relation to total geographical area, Mizoram tops with 90.68% followed by Lakshadweep with 84.56%.

[2] India State of Forest Report 2011 **Forest Cover (21.05%) + Tree Cover(2.76%)**

Student Notes:

India State of Forest Report 2011 Released

The Forest Survey of India (FSI) has been publishing a series of biennial assessment report the forest cover in the country since 1987. As per the present assessment, the Forest and Tree cover of the country is 78.29 million ha, which is 23.81% of the geographical area of the country. In comparison to the 2009 assessment, after taking into account the interpretational changes, there is a **decrease of 367 square km** in country's forest cover. 15 states have registered aggregate increase of 5000sqkm in their forest cover with Punjab leading with increase of 100sqkm. 12 states/UTs (mainly the NE states) have shown decrease to the extent of 867sqkm. Decline of 281 sqkm in Forest cover of Andhra Pradesh is mainly attributed to harvesting of mature plantation of Eucalyptus & other species. Decline in Forest cover of NE is particularly due to prevailing practice of shifting cultivation in this region. The state of Madhya Pradesh has the largest forest cover in the country at 77,700 square km followed by Aruncachal Pradesh at 67, 410 square km. In terms of percentage of forest cover in relation to total geographical area, Mizoram tops with 90.68% followed by Lakshadweed with 84.56%. The total growing stock of India's forests and trees outside forests is estimated as 6047.15 million cu m i.e. 4498.73 million cu m inside the recorded forest area and 1548.42 million cu m outside the recorded forests.

On the basis of the percentage of the actual forest cover, the states have been grouped into four regions:

The Region and Percentage Cover of the Forest	States
(i) The region of high concentration > 40	Mizoram (90.68%), Lakshadweep (84.56%), A & N Islands (81.51%), Arunachal Pradesh (80.5%), Nagaland (80.33%), Meghalaya (77.02%), Manipur (76.54%) Tripura (76.04%), Goa (59.94%), Sikkim (47.34%), Uttarakhand (45.8%), Kerala (44.52%), Dadra & Nagar Haveli (42.97%), Chhattisgarh (41.18%)
(ii) The region of medium concentration 20-40	Assam (35.28%), Orissa (31.41%), Jharkhand (28.82%), Himachal Pradesh (26.37%), Madhya Pradesh (25.21%)
(iii) The region of low concentration 10-20	Karnataka (18.87%), Tamil Nadu (18.16%), Andhra Pradesh (16.86%), Maharashtra (16.46%), Chandigarh(14.72%) West Bengal (14.64%), Delhi (11.88%), Puducherry (10.43%), Jammu & Kashmir (10.14%)
(iv)The region of very low concentration < 10	Gujarat (7.46%), Bihar (7.27%), Uttar Pradesh (5.95%), Daman & Diu (5.49%), Rajasthan (4.7%), Haryana (3.64%), Punjab (3.5%)

Student Notes:

3] Forest Conservation

Forests have an intricate interrelationship with life and environment. These provide numerous direct and indirect advantages to our economy and society. Hence, conservation of forest is of vital importance to the survival and prosperity of humankind.

4] National Forest Policy 1988

India adopted a forest policy in 1952, which was further modified in 1988.The ***forest policy of the Government of India*** aims at: (i) bringing **33 per cent** of the geographical areas under forest cover; (ii) maintaining environmental stability and to restore forests where ecological balance was disturbed; (iii) conserving the natural heritage of the country, its biological diversity and genetic pool; (iv) checks soil erosion, extension of the desert lands and reduction of floods and droughts; (v) **increasing the forest cover** through social forestry and afforestation on degraded land; (vi) increasing the **productivity** of forests to make timber, fuel, fodder and food available to rural population dependant on forests, and encourage the substitution of wood; (vii) creating of a massive peoples movement involving women to encourage planting of trees, stop felling of trees and thus, reduce pressure on the existing forest.

5] Social Forestry:

Social forestry means the management and protection of forests and afforestation on barren lands with the purpose of helping in the environmental, social and rural development. The *National Commission on Agriculture* (1976) has classified social forestry into three categories. These are **urban forestry, rural forestry and Farm forestry**.

Urban forestry pertains to the raising and management of trees on public and privately owned lands in and around urban centres such as green belts, parks, roadside avenues, industrial and commercial green belts, etc. Rural forestry lays emphasis on promotion of agro-forestry and community-forestry. Agro-forestry is the raising of trees and agriculture crops on the same land inclusive of the waste patches. It combines forestry with agriculture, thus, altering the simultaneous production of food, fodder, fuel, timber and fruit.

6] Community forestry:

It involves the raising of trees on public or community land such as the village pasture and temple land, roadside, canal bank, strips along railway lines, and schools etc. Community forestry programme aims at providing benefits to the community as a whole. Community forestry provides a means under which the people of landless classes can associate themselves in tree raising and thus, get those benefits which otherwise are restricted for landowners.

7] Farm Forestry:

It is a term applied to the process under which farmers grow trees for commercial and non-commercial purposes on their farm lands. Forest departments of various states distribute seedlings of trees free of cost to small and medium farmers.

Student Notes:

8] Wildlife and Its Conservation

About 4-5 per cent of all known plant and animal species on the earth are found in India. The main reason for this remarkable diversity of life forms is the great diversity of the ecosystem which this country has preserved and supported through the ages. Over the years, their habitat has been disturbed by human activities and as a result, their numbers have dwindled significantly. There are certain species that are at the brink of extinction.

Some of the important reasons of the declining of wildlife are as follows:

(i) Industrial and technological advancement brought about a rapid increase in the exploitation of forest resources.

(ii) More and more lands were cleared for agriculture, human settlement, roads, mining, reservoirs, etc.

(iii) Pressure on forests mounted due to lopping for fodder and fuel wood and removal of small timber by the local people.

(iv) Grazing by domestic cattle caused an adverse effect on wildlife and its habitat.

(v) Hunting was taken up as a sport by the elite and hundreds of wild animals were killed in a single hunt. Now commercial poaching is rampant.

(vi) Incidence of forest fire.

9] Protected Area Network in India

A National Board for Wildlife (NBWL), chaired by the Prime Minister of India provides for policy framework for wildlife conservation in the country. The National Wildlife Action Plan (2002-2016) was adopted in 2002, emphasizing the people's participation and their support for wildlife conservation. India's conservation planning is based on the philosophy of identifying and protecting representative wild habitats across all the ecosystems. The Indian Constitution entails the subject of forests and wildlife in the Concurrent list. The Federal Ministry acts as a guiding torch dealing with the policies and planning on wildlife conservation, while the provincial Forest Departments are vested with the responsibility of implementation of national policies and plans.

A network of 668 Protected Areas (PAs) has been established, extending over 1,61,221.57 sq. kms. (4.90% of total geographic area), comprising 102 National Parks, 515 Wildlife Sanctuaries, 47 Conservation Reserves and 4 Community Reserves. 39 Tiger Reserves and 28 Elephant Reserves have been designated for species specific management of tiger and elephant habitats. UNESCO has designated 5 Protected Areas as World Heritage Sites. As the ecosystems and species do not recognise political borders, the concept of Trans- boundary Protected Areas has been initiated for coordinated conservation of ecological units and corridors with bilateral and/or multilateral cooperation of the neighbouring nations. There are 4 categories of the Protected Areas viz, National Parks, Sanctuaries, Conservation Reserves and Community Reserves.

Sanctuary is an area which is of adequate ecological, faunal, floral, geomorphological, natural or zoological significance. The Sanctuary is declared for the purpose of protecting, propagating or developing wildlife or its environment. Certain rights of people living inside the Sanctuary could be permitted. Further, during the settlement of claims, before finally notifying the

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Sanctuary, the Collector may, in consultation with the Chief Wildlife Warden, allow the continuation of any right of any person in or over any land within the limits of the Sanctuary.

National Park is an area having adequate ecological, faunal, floral, geomorphological, natural or zoological significance. The National Park is declared for the purpose of protecting, propagating or developing wildlife or its environment, like that of a Sanctuary. The difference between a Sanctuary and a National Park mainly lies in the vesting of rights of people living inside. Unlike a Sanctuary, where certain rights can be allowed, in a National Park, no rights are allowed. No grazing of any livestock shall also be permitted inside a National Park while in a Sanctuary, the Chief Wildlife Warden may regulate, control or prohibit it. In addition, while any removal or exploitation of wildlife or forest produce from a Sanctuary requires the recommendation of the State Board for Wildlife, removal etc., from a National Park requires recommendation of the National Board for Wildlife (However, as per orders of Hon'ble Supreme Court dated 9th May 2002 in Writ Petition (Civil) No. 337 of 1995, such removal/ exploitation from a Sanctuary also requires recommendation of the Standing Committee of National Board for Wildlife).

Conservation Reserves can be declared by the State Governments in any area owned by the Government, particularly the areas adjacent to National Parks and Sanctuaries and those areas which link one Protected Area with another. Such declaration should be made after having consultations with the local communities. Conservation Reserves are declared for the purpose of protecting landscapes, seascapes, flora and fauna and their habitat. The rights of people living inside a Conservation Reserve are not affected.

Community Reserves can be declared by the State Government in any private or community land, not comprised within a National Park, Sanctuary or a Conservation Reserve, where an individual or a community has volunteered to conserve wildlife and its habitat. Community Reserves are declared for the purpose of protecting fauna, flora and traditional or cultural conservation values and practices. As in the case of a Conservation Reserve, the rights of people living inside a Community Reserve are not affected.

Regulations/ laws relating to Protected Areas (PAs):

The PAs are constituted and governed under the provisions of the Wild Life (Protection) Act, 1972, which has been amended from time to time, with the changing ground realities concerning wildlife crime control and PAs management. Implementation of this Act is further complemented by other Acts viz. Indian Forest Act, 1927, Forest (Conservation) Act, 1980, Environment (Protection) Act, 1986 and Biological Diversity Act, 2002 and the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006. The Wildlife Crime Control Bureau of the Central Government supplements the efforts of provincial governments in wildlife crime control through enforcement of CITES and control of wildlife crimes having cross-border, inter- state and international ramifications. In order to strengthen and synergise global wildlife conservation efforts, India is a party to major international conventions viz. Convention on International Trade in Endangered Species of wild fauna and flora (CITES), International Union for Conservation of Nature (IUCN), International Convention for the Regulation of Whaling, UNESCO-World Heritage Committee and Convention on Migratory Species (CMS).

Main issues concerning the management of Protected Areas: Wildlife conservation and management in India is currently facing a myriad of complex challenges that are both ecological and social in nature. Issues such as habitat loss/fragmentation, overuse of biomass resources in the context of biotic pressures, increasing human-wildlife conflicts, livelihood dependence on forests and wildlife resources, poaching and illegal trade in wildlife

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parts and products, need for maintaining a broad base of public support for wildlife conservation exemplify and characterize the contemporary wildlife conservation scenario in India. The government and the civil society are taking several measures to address these issues. Improved synergies and better coordination amongst the wide array of stakeholders are needed to meet the challenges of conserving India's diverse wilderness resources.

10] Biosphere Reserves

The origin of Biosphere Reserves goes back to the "Biosphere Conference" organized by UNESCO in 1968. **A Biosphere Reserve is a unique and representative ecosystem of terrestrial and coastal areas which are internationally recognised within the framework of UNESCO's Man and Biosphere (MAB) Programme**. Collectively, biosphere reserves form a world network: the World Network of Biosphere Reserves (WNBR).

10.1 Functions of biosphere reserve

Each biosphere reserve is intended to fulfil 3 basic functions, which are complementary and mutually reinforcing:

1. conservation function - to contribute to the conservation of landscapes, ecosystems, species and genetic variation;
2. development function - to foster economic and human development which is socio-culturally and ecologically sustainable;
3. logistic function - to provide support for research, monitoring, education and information exchange related to local, national and global issues of conservation and development.

10.2 Structure and Design of Biosphere Reserves

In order to undertake complementary activities of biodiversity conservation and development of sustainable management aspects, Biosphere Reserves are demarcated into three inter-related zones. These are (I) natural or core zone (ii) manipulation or buffer zone and (iii) a transition zone outside the buffer zone.

The Core Zone: The core zone is kept absolutely undisturbed. Only the core area requires legal protection and hence can correspond to an existing protected area such as a nature reserve or a national park. It must contain suitable habitat for numerous plant and animal species, including higher order predators and may contain centres of endemism. Core areas often conserve the wild relatives of economic species and also represent important genetic reservoirs. Management and research activities that do not affect natural processes and wildlife are allowed inside core zone.

The Buffer Zone: In the Buffer Zone, which adjoins or surrounds core zone, uses and activities are managed in ways that protect the core zone. These uses and activities include restoration, demonstration sites for enhancing value addition to the resources, limited recreation, tourism, fishing and grazing, which are permitted to reduce its effect on core zone. Research and educational activities are to be encouraged. Human activities, if natural within Biosphere Reseve, are likely to be permitted to continue if these do not adversely affect the ecological diversity.

The Transition Zone: The Transition Zone is the outermost part of a Biosphere Reserve. This is usually not delimited one and is a zone of cooperation where conservation, knowledge and

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management skills are applied and uses are managed in harmony with the purpose of the Biosphere Reserve. This includes settlements, crop lands, managed forests and area for intensive recreation, and other economic uses characteristic of the region.

10.3 Difference between Biosphere reserve and Protect Area(National Park, Sanctuary etc.)

Biosphere reserve and Protected Areas are complementary concepts. However, the Biosphere Reserves differ from protected areas due to their emphasis on Conservation of overall biodiversity and landscape (rather than some specific flagship species) to allow natural and evolutionary processes to continue without any hindrance, and enhancement of local people's participation and their Training.

10.4 Difference between Biosphere reserve and a natural World Heritage site?

UNESCO designates Natural World Heritage sites status to natural sites having outstanding universal value in accordance with the UNESCO Convention on the Protection of the World Cultural and Natural Heritage (1972). Efforts to enhance local development and to promote scientific understanding are means to ensure the protection of the natural World Heritage values.

In some instances, a core area of a biosphere reserve can meet World Heritage criteria: the usually larger biosphere reserve can therefore serve as a complementary means to protect the integrity of the World Heritage site.

10.5 Benefits of biosphere reserves

The designation of a site as a biosphere reserve can raise awareness among local people, citizens and government authorities on environmental and development issues. It can help to attract additional funding from different sources. At the national level, biosphere reserves can serve as pilot sites or 'learning places' to explore and demonstrate approaches to conservation and sustainable development, providing lessons which can be applied elsewhere. In addition, they are a concrete means for countries to implement Agenda 21, the Convention on Biological Diversity (for example the Ecosystem Approach), many Millennium Development Goals (for example on environmental sustainability), and the UN Decade of Education for Sustainable Development. In the case of large natural areas which straddle national boundaries, trans boundary biosphere reserves can be established jointly by the countries concerned, testifying to long-term cooperative efforts.

There are eighteen biosphere reserves in India. **Nine** of the eighteen biosphere reserves are a part of the World Network of Biosphere Reserves, based on the UNESCO Man and the Biosphere (MAB) Programme list.

Year	UNESCO Recognition in	Name	Location	States	Type	Key Fauna
1986	**2000**	**Nilgiri Biosphere Reserve**	**Part of Waynad, Nagarhole, Bandipur and Mudumalai, Nilambur, Silent Valley and Anaimalai Hills**	**Tamil Nadu, Kerala and Karnataka**	**Western Ghats**	**Nilgiri Tahr, Lion-tailed macaque**

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1988	**2001**	**Nanda Devi National Park & Biosphere Reserve**	**Parts of Chamoli District, Pithoragarh District & Bageshwar District**	**Uttarakhand**	**Western Himalayas**	
1988	**2009**	**Nokrek**	**Part of Garo Hills**	**Meghalaya**	**East Himalayas**	**Red Panda**
1989	**2001**	**Gulf of Mannar**	**Indian part of Gulf of Mannar extending from Rameswaram island in the North to Kanyakumari in the South of Tamil Nadu and Sri Lanka**	**Tamil Nadu**	**Coasts**	**Dugong or Sea Cow**
1989	**2001**	**Sundarbans**	**Part of delta of Ganges and Barahamaputra river system**	**West Bengal**	**Gangetic Delta**	**Royal Bengal Tiger**
1989		Manas	Part of Kokrajhar, Bongaigaon, Barpeta, Nalbari, Kamrup and Darrang Districts	Assam	East Himalayas	Golden Langur, Red Panda
1989	**2013**	**Great Nicobar Biosphere Reserve**	**Southern most islands of Andaman and Nicobar Islands**	**Andaman and Nicobar Islands**	**Islands**	**Saltwater Crocodile**
1994	**2008**	**Simlipal**	**Part of Mayurbhanj district**	**Odisha**	**Deccan Peninsula**	**Gaur, Royal Bengal Tiger, Wild elephant**
1997		Dibru-Saikhowa	Part of Dibrugarh and Tinsukia districts	Assam	East Himalayas	Golden Langur
1998		Dihang-Dibang	Part of Siang and Dibang Valley	Arunachal Pradesh	Eastern Himalaya	
1999	**2009**	**Pachmarhi Biosphere Reserve**	**Parts of Betul District, Hoshangabad District and Chhindwara District**	**Madhya Pradesh**	**Semi-Arid**	**Giant Squirrel, Flying Squirrel**
2000		Khangchendzonga	Parts of Kanchanjunga Hills	Sikkim	East Himalayas	Snow Leopard, Red Panda

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2001		Agasthyamalai Biosphere Reserve	Neyyar, Peppara and Shenduruny Wildlife Sanctuary and their adjoining areas	Kerala, Tamil Nadu	Western ghats	Nilgiri Tahr, Elephants
2005	**2012**	**Achanakamar - Amarkantak**	**Part of Annupur, Dindori and Bilaspur districts**	**Madhya Pradesh, Chhattisgarh**	**Maikala Hills**	
2008		Great Rann of Kutch	Part of Kutch, Rajkot, Surendranagar and Patan Districts	Gujarat	Desert	Indian Wild Ass
2009		Cold Desert	Pin Valley National Park and surroundings; Chandratal and Sarchu & Kibber Wildlife Sancturary	Himachal Pradesh	Western Himalayas	Snow Leopard
2010		Seshachalam Hills	Seshachalam Hill Ranges covering parts of Chittoor and Kadapa districts	Andhra Pradesh	Eastern Ghats	
2011		Panna	Part of Panna and Chattarpur Districts	Madhya Pradesh	catchment area of the Ken River	Tiger, Chital, Chinkara, Sambhar and Sloth bear

11] UPSC Questions Covered

1. Discuss the wetlands and their role in ecological conservation in India. (UPSC 2009/15 Marks)
2. Mention the area of Shola forests in India. (UPSC 2003/2 Marks)
3. What are mangroves and in what way are they useful to us? (UPSC 2001/10 Marks)
4. What is waste land? Write a note on prospects of waste land development in India. (UPSC 2000/10 Marks)
5. Which parts of India have been identified as draught-prone? Mention the norms for such identification. (UPSC 1998/15 Marks)
6. Why has there been opposition from the North-Eastern States to the Supreme Court ban on all activities inside forests? (UPSC 1997/10 Marks)
7. Where do mangrove forests occur in India? Describe their main characteristics. (UPSC 1996/15 Marks)
8. Which parts of India are described as 'arid zones'? Comment on the characteristics and economic activities prevalent in these regions? (UPSC 1993/15 Marks)
9. Where do we find large desert areas in India? What steps have been taken by the Government for their development? (UPSC 1985/20 Marks)
10. Which is the largest expanse of tidal forests in India and in which State is it located? (UPSC 1981/3 Marks)