CHAPTER 1

MULTIDISCIPLINARY NATURE OF ENVIRONMENTAL SCIENCE

1.1 ENVIRONMENT

Man has always inhabited two worlds. One is the 'natural-world' of plants, animals, air, water, and soil of which man himself is a part ; while the other is the 'built-world' of social institutions and artifacts which he created for himself by using science and technology, and political organisation. Since man inhabits both the worlds so they constitute an important part of the environment. Therefore, environment can simply be defined as one's surroundings ; which includes everything around the organism, *i.e.,* abiotic (non-living) and biotic (living) environment. Abiotic environment consists of soil, water and air ; while the biotic environment includes all other organisms, with which the organism comes into regular contact. But, to an environmental engineer, a more specific definition is required. Because for him the word 'environment', on one hand, may refer to a small localized area in which a specific problem is to be addressed, or it may take on global dimensions on the other hand.

The global environment consists of three segments, viz., atmosphere, hydrosphere and lithosphere.

1.2 ATMOSPHERE

The atmosphere is a blanket of gases and suspended liquids and solids that entirely envelops the earth, extending outward several thousand kilometers to a zone characterized more by magnetic field and ionized particles than by the familiar air near the surface. 'Pure air' is colourless, odourless, tasteless and cannot be felt except in motion. It is mobile, compressible and expansible ; and transmits compression waves and experiences tides. It is transparent to many forms of radiation and can absorb others. It absorbs most of the cosmic rays from outer space and a major portion of the electromagnetic radiation (EMR) from the sun; and transmits only near ultraviolet, visible and near infrared radiation (300 to 2,500 nm) and radiowaves while filtering out harmful ultraviolet radiation below about 300 nm.

Atmosphere has weight and exerts pressure. A litre of air weighs around 1.3 gm. At sea level, the air pressure is 1033.6 g/sq. cm (*i.e.*, one atmospheric pressure). Air is not nearly as dense as either land or water, but because it is compressible its density decreases with altitude. The total mass of the atmosphere is approximately 5×10^5 tonnes, which is roughly one millionth of earth's total mass. About half of the total mass of the atmosphere lies below 5.5 km, and about 99% lies within 30 km of the earth's surface. The atmosphere is bound to the earth by gravity. Satellites like moon, which have very low gravitational power, cannot and do not hold an atmosphere.

Without the atmosphere, life would be impossible. It is the atmosphere which is the source of oxygen (essential for life) and carbon dioxide (essential for photosynthesis). Further, without the atmosphere, there would be no clouds, winds or storms—and hence no weather. Among its other functions, the atmosphere acts as a great canopy to protect the earth's surface from the full range of solar effects by day and prevents excessive loss of heat by night. That is, it helps in maintaining habitable temperature on this marvelous planet by maintaining the heat balance of the earth.

1.2.1 Composition of Atmosphere

The atmosphere is composed of various gases and water vapour, and in its uppermost reaches it is charged with subatomic particles. The major gases of pollution-free dry air in the lower atmosphere are nitrogen, oxygen, argon and carbon dioxide; while there are number of other minor (or trace) gases like neon, helium, methane, hydrogen, carbon monoxide, ozone, etc., as shown in Table 1.1. The four major gases (*i.e.*, nitrogen, oxygen, argon and carbon dioxide) account for more than 99% of the dry air. Nitrogen alone constitutes nearly four-fifth by volume, and oxygen one-fifth. On the other hand, the total of all the trace (minor) gases does not exceed 0.02%. Varying amounts of these gases (major and minor gases) may be found in the atmosphere at different elevations. Water vapour is also present in the lower atmosphere (upto about 12 km) in concentrations ranging from 0.01 to 5.0%. Although the amount of water vapour present in the atmosphere is very small, its importance is very great. For without water in the atmosphere, there would be no water on the earth. Water enters the atmosphere by evaporation from the hydrosphere (and by transpiration), and leaves the atmosphere by precipitation. It is a never ending two-way traffic.

Table 1.1. Principal Gases of Dry-Air in the Lower Atmosphere (near ground level)

S. No.	*Gas*	*Symbol*	*Concentration % by volume*	*Concentration* ppm by volume*
1.	Nitrogen	N_2	78.084	780,000
2.	Oxygen	O_2	20.9476	209,500
3.	Argon	Ar	0.934	9,340
4.	Carbon dioxide	CO_2	0.0314	314
5.	Neon	Ne	0.0018	18
6.	Helium	He	0.00052	5.2
7.	Methane	CH_4	0.00015	1.5
8.	Krypton	Kr	0.00011	1.1
9.	Hydrogen	H_2	5.0×10^{-5}	0.5
10.	Nitrous oxide	N_2O	2.0×10^{-5}	0.2
11.	Carbon monoxide	CO	1.2×10^{-5}	0.12
12.	Xenon	Xe	8.0×10^{-6}	0.08
13.	Ozone	O_3	2.0×10^{-6}	0.02
14.	Ammonia	NH_3	6.0×10^{-7}	0.006
15.	Nitrogen dioxide	NO_2	1.0×10^{-7}	0.001
16.	Nitric oxide	NO	6.0×10^{-8}	0.0006
17.	Sulphur dioxide	SO_2	2.0×10^{-8}	0.0002
18.	Hydrogen sulphide	H_2S	2.0×10^{-8}	0.0002

*The concentration values in ppm (parts per million) can be obtained by multiplying the corresponding concentration value in % by volume by 10^4.

1.2.2 Structure of the Atmosphere

The vertical extent of the atmosphere is difficult to ascertain, as it has no sharp boundary with extraterrestrial space. Atmospheric phenomena associated with the earth's magnetic and gravitational fields extend outward for several thousand kilometres to a vague zone of nebulous gases and radiation particles that become rarer and rarer until at last terrestrial characteristics of the atmosphere ceases.

On the basis of temperature profile and other related phenomena, atmosphere is divided into four major layers (or shells), viz., *Troposphere, Stratosphere, Mesosphere* and *Thermosphere* (Fig. 1.1).

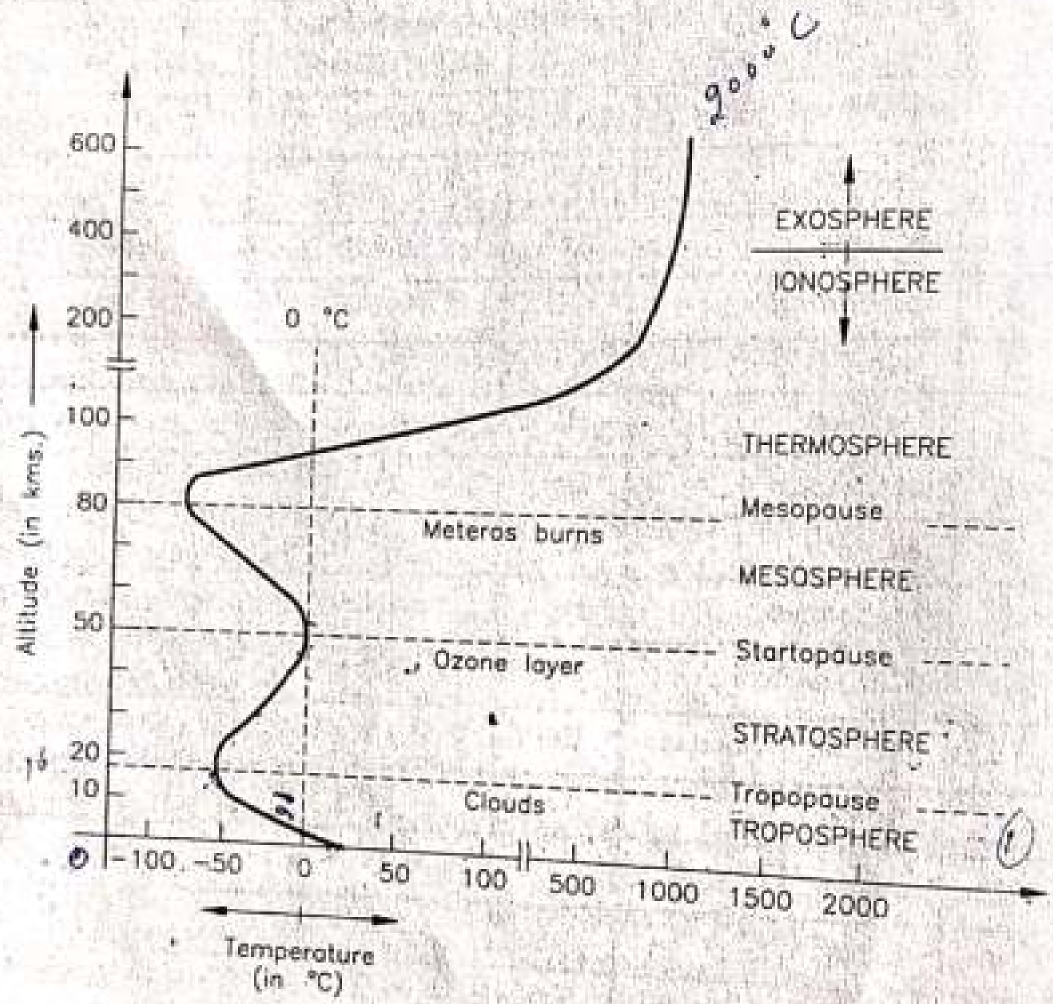

Fig. 1.1. Structure of Atmosphere along with Temp. Profile of Atmosphere and Related Phenomenon.

Troposphere is the lower portion of the atmosphere, extending upto about 8 km at the poles and 16 km at the equator. It contains about three-fourth of the atmospheric mass and is the abode of clouds, storms and convective motion. Thermal convection, being better developed in the low latitudes, is responsible for the greater vertical extent of the troposphere near the equator. Convective activity also explains the somewhat greater height of the troposphere in summer than in winter at a given latitude. This layer is of greatest interest in pollution control, since this is the layer in which most living things exist; and also the air which we breathe is the air in the troposphere. One of the more recent changes in troposphere involves the phenomenon of Acid Rains. The most outstanding characteristic of the troposphere is the fairly uniform decrease in temperature with increase in altitude (about 6°C/km) to a minimum of –50° or –60°C. The zone marking the end of this temperature decrease is the *tropopause*. The average global surface temperature is about 17°C, but local averages very widely.

2. Above the tropopause lies the *Stratosphere* ; where temperature is nearly constant upward to about 20 km and then increases upto a maximum of 0°C near its outer limit, *Stratopause*, due to absorption of ultraviolet radiation by ozone. The outer limit of the stratosphere has a mean altitude of about 50 km.

3. Beyond the stratopause, is the *Mesosphere*. Here, the temperature decreases slowly with the altitude but then sharply to a minimum of about – 75°C near the *Mesopause*, at 80 km. Most meteorites burn and disintegrate, as they experience increasing friction, in this layer.

4. In the *Thermosphere*, the temperature again rises to very high values and at times approaches 2,000°C and even more at about 500 km depending upon solar activity. However, such temperatures are not strictly comparable with those registered by thermometers at the earth's surface. Although the gas molecules exhibit high kinetic energy, and therefore have high temperatures ; but they are too sparse to transfer significant quantities of energy to an ordinary thermometer. The exposed hand of an astronaut, thus, would not feel hot in the thermosphere. The temperature in thermosphere is measured by using the relation $\frac{1}{2}mv^2 = \frac{2}{3}RT$.

It must be strongly emphasized that these layers are not clearly defined and that there is considerable overlap.

Additional vertical subdivisions of the atmosphere can be identified on the basis of chemical composition (*e.g.*, ozonosphere) or physical properties other than temperature. Coinciding with the lower portion of the thermosphere is the 'Ionosphere'. It is an atmospheric layer at 100 to 400 km delimited on the basis of ionized particles and their effects on the propagation of radiowaves. It is due to this layer that radiowaves are reflected by ionized layers at great heights. Above the ionosphere, the portion is called 'Exosphere' till the edge of space.

Sometimes, the atmospheric layer closest to the earth's surface is called '*Boundary layer*'. It has a nominal thickness of about 1.0 km, and defines the normal limit of breathing air in which life in general can survive. There are wide variations in the thickness of this layer depending on topography and weather conditions. Though, there are some exceptional forms of life which can survive above the boundary layer.

CHAPTER 2

NATURAL RESOURCES

2.1 DEFINING RESOURCES

Simply stated, a resource is any useful information, material or service. Within this broad generalization, we can differentiate between 'natural resources' and 'human resources'.

Natural resources are the components of the environment (*i.e.* atmosphere, hydrosphere and lithosphere), which can be drawn upon for supporting life. In other words, natural resources are goods and services supplied by our environment (including sinks for wastes). These include energy, mineral, land (soil), food, forest, water, atmosphere (air), plants and animals.

Human resources refers to human wisdom, experience, skill, labour and enterprise.

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These are the components of our environment. These resources can be renewable or non-renewable :

(1) Renewable Resources (Inexhaustible Resources) : Inexhaustible resources have the inherent ability to reappear or replenish themselves by recycling, reproduction or replacement. These renewable sources include sunlight, plants, animals, soil, water and living organisms. Biological organisms are self-renewing. The rate at which their renewal occurs varies.

(2) Non-renewable Resources (Exhaustible Resources) : The non-renewable resources are the earth's geologic endowments, *i.e.*, minerals, fossil fuels, non-mineral resources and other materials which are present in fixed amounts in the environment. Unlike renewable resources, non-renewable resources are finite in quantity and quality.

There is also one more category *i.e.* "Intangible resources" (or abstract resources), such as, open space, information, diversity, satisfaction, serenity and beauty, which can be both exhaustible and inexhaustible. There is no upper limit to the amount of knowledge, leaves ~~from~~ seeing from the top.

information, or, beauty. But at the same time these can be destroyed easily. For example, a single and small piece of trash can destroy the beauty of any place. It is important to note here that the two most powerful and largest industries of the world—tourism and information management are based on the intangible resources.

2.3 FOREST RESOURCES

Forests are important renewable resources. A forest is a biotic community, predominantly of trees, shrubs or any other woody vegetation usually with a closed canopy. Forests vary a great deal in composition and density and are distinct from meadows and pastures. Forests contribute substantially to the economic development of a country. They are the vast natural resources for man that have been providing a broad array of commodities, amenities and environmental services. Fuelwood, timber, wildlife habitat, pasture for livestock, industrial forest products, animal products, recreation, soil moisture retention, climate regulation, production of atmospheric oxygen, a source of new agricultural or grazing land and spiritual renewal are a few examples.

2.3.1 Historical Perspective

Wood was the principal building material and fuel of past societies. A large accessible supply of wood was, thus, a prerequisite to the flowering of civilizations. History abounds with examples of societies that have flourished because of an abundance of wood and societies that have collapsed after exhausting their forests.

Around 2,700 B.C. the Sumerian civilization in Mesopotamia thrived in the lower reaches of the Tigris and Euphrates rivers of the present-day Iraq. But by 2,000 B.C. the civilization had collapsed largely due to the progressive decline of barley yields caused by salinization of soils, triggered by the clearing of the forests in the watersheds of the two rivers, exposing the salt-rich sedimentary rock on the denuded slopes.

The Romans financed the growth of their empire largely from silver mined and smelted in Spain, using local wood for fuel. During the 400 years they operated, the furnaces consumed an estimated 500 million trees, deforesting about 1.8 million hectares of Spanish landscape. When silver production declined, not because the silver ore supply was exhausted but because fuel was inaccessible, the emperors were forced to debase the coinage progressively, until by the end of the 3rd century AD when the public had little confidence in the almost-silverless currency resulting in the collapse of the Roman Empire.

Scarcity of wood was created in England from centuries of iron and glass making, ship building, and domestic heating and cooking. The English responded to their wood scarcity by seizing new forests in North America, especially the tall white pine forests of New England prized for masts on Royal Navy ships.

As in past centuries, the distribution and condition of the world's forests continue to be altered by human activities, generated by ever increasing demands for food, timber, shelter and energy of the growing population.

2.3.2 Forest Distribution

The United Nations Food and Agriculture Organization (FAO) estimates the world's land area as of 1994 to be 144.8 million sq km (or about 29% of the surface of the globe), of which forest and woodland account for 30% (Fig. 2.1). The FAO defines forest and woodland as land under natural or planted strands of trees, whether productive or not, including land from which forests have been cleared but which will be reforested in the near future.

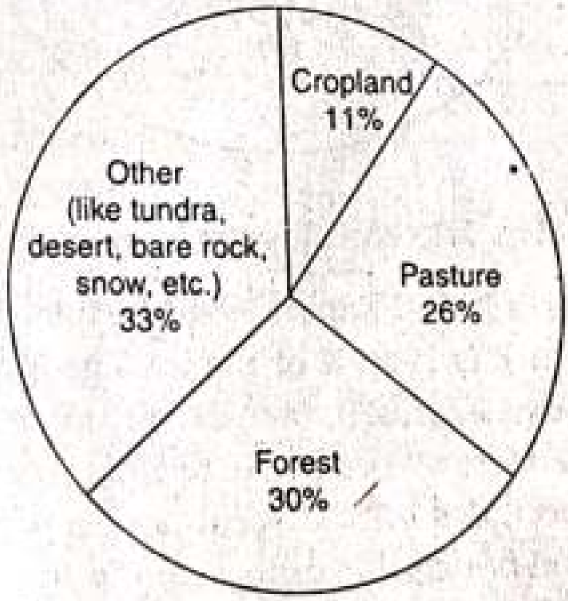

Fig. 2.1. World land use distribution.

Thousands of years ago, before large-scale human disturbances of the world began, forests and woodlands probably covered nearly 6.0 billion hectares. Since then, about 16% of that area has been converted to cropland, pasture, settlements or unproductive wastelands. The FAO estimates the world's area of forest and woodland as of 1994 to be about 4.7 billion hectares. About four-fifths of the forest is classified as 'closed canopy' in which tree crowns spread over 20% or more of the ground and has potential for commercial timber harvesting; and the rest is 'open

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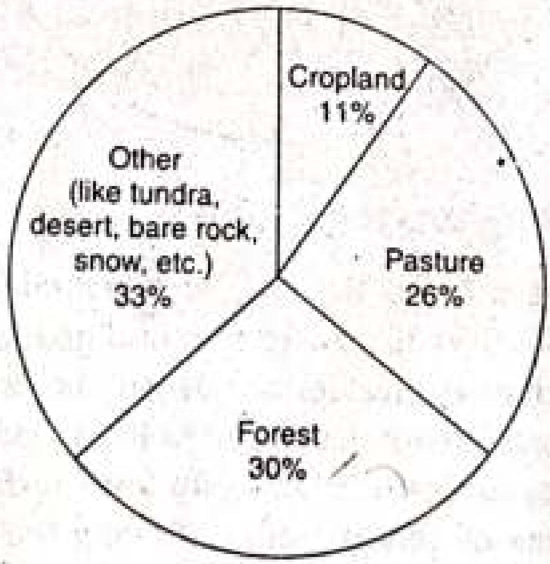

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Box 2.1. Types of Forests in India

I Moist Tropical Forests	III Montane Sub-Tropical Forests
1. Tropical Wet Evergreen—Western Ghats (Maharashtra, Karnataka, Kerala). 2. Tropical Semi-evergreen—Lower hills of Western Ghats (Karnataka, Kerala). 3. Tropical Moist Deciduous—Dehradun, Mahabaleshwar and Eastern Ghats (Andhra Pradesh, Tamil Nadu). 4. Littoral and Swamp Forests—Sundarbans, Bengal Delta, Andamans.	8. Sub-tropical broad—Shillong (Meghalaya), Nilgiris (Tamil Nadu). 9. Sub-tropical Pine Forest—Arunachal Pradesh, Kashmir. 10. Sub-tropical Dry Evergreen—Foothills of Himalayas. **IV Montane Temperate Forests** 11. Montane Wet Temperate—Nilgiri, Palni Hills (Tamil Nadu). 12. Himalayan Wet Temperate—Assam, Himachal Pradesh. 13. Himalayan Dry Temperate—NW Kashmir.
II Dry Tropical Forests 5. Tropical Dry Deciduous—MP, UP. 6. Tropical Thorn Forest—Delhi, Punjab, Gujrat. 7. Tropical Dry Evergreen—Eastern Ghats (AP, Tamil Nadu).	**V Sub-Alpine Forests** 14. Sub-Alpine—Ladakh, Sikkim. **VI Alpine Scrubs** 15. Moist Alpine Scrub—High Himalayan. 16. Dry Alpine Scrub—Sikkim.

2.3.3 Importance of Forests

Forests are of immense value to the life and prosperity of human beings and of nations. They provide a rich variety of goods useful both to the affluent industrial societies and the rural poor. The importance/ uses of forests include :

(i) **Wood :** Wood is the major forest produce. In developing countries, the heaviest demand on forest is for fuel wood for cooking and heating. Fuelwood, in fact, accounts for almost half of all wood harvested worldwide. About 1.5 billion people depend on fuelwood as their primary energy source. About 58% of the total energy used in Africa and 42% in South-East Asia comes from fuelwood. The world consumption of fuelwood is estimated to be more than 1,000 million cubic meters and is expected to increase to 2,600 million cubic meters in 2025.

(ii) **Timber :** Industrial timber and roundwood (unprocessed logs) obtained from forests are used to make lumber, plywood, veneer, boards, doors, windows, furniture, carts, ploughs, tool handles, sports goods, etc. It is also a raw material for the manufacture of paper, rayon and film. Together, they account (*iii*) **Minor forest products :** Besides timber, the contribution of minor forest produce to economy is not negligible. Forests provide resins, thatch, rattan, fruits, nuts, herbs, medicinal plants, pharmaceuticals, oil, forage, commercial flowers, spices and syrups. Bamboos (also called the poor man's timber) are used in rafters, roofing, walling, flooring, scaffolding, matting, basketry and cartwood ; and also used as a raw material in paper and rayon industry. Canes are used for making furniture, ropes, walking sticks, umbrella handles and sports goods. Oils obtained from a variety of forest plants such as sandalwood, rosha grass and khas are used in the manufacture of cosmetics, soaps, pharmaceuticals, tobacco, confectionery and incense. Several types of tanning materials, dyes, gums and resins obtained from forest plants are utilized in many industries. Lac, honey, wax and silk are items of economic value obtained from forest insects. Forest plants also provide hundreds of drugs, spices, insecticides and poisons. Other forest products of economic value include—Tendu leaves for wrapping *bidis* (Indian cigar), *Ritha* and *Shikakai* as soap substitutes, *Sola pith* and *Rudraksha* are important commercial forest products.

(*iv*) **Vital role in the life and economy of Tribals :** Forests play a vital role in the life and economy of forest dwellers and tribes living in forests. Forests provide food (fruits, roots, tubers and leaves of plants and meat from animals), medicines and many other commercial products that are necessary for forest-based subsistence pattern.

(*v*) **Ecological significance of forests :** Forest ecosystems provide a host of environmental services including maintaing biological diversity, providing wildlife habitat, cycling nutrients, producing oxygen, reducing atmospheric pollution by collecting the suspended particulate matter and by absorbing carbon dioxide and affecting regional rainfall patterns. They also regulate streamflow, reduce flooding, store water, moderate wind erosion and reclaim degraded land. Forests prevent erosion of soil by wind and water and provide shade which prevents the soil from becoming too dry and friable (easily crumbled) during the summer. Further, they improve the quality of soil by increasing its porosity and fertility by contributing humus to it.

(*vi*) **Aesthetic and other values :** Forests have a great aesthetic value. There is hardly any part of the earth where people do not appreciate the beauty and tranquillity of forests. Additionally, forests provide areas for ecosystem research ; provide opportunities for recreation and spiritual renewal ; and inspire literature, music, religion and art.

2.3.4 Deforestation

Deforestation is defined as the reckless felling of trees by human beings for their ulterior ends. Forests are burned or cut down for various reasons, like clearing of land for agriculture, harvesting of timber, expansion of cities, and many more ; but the aim behind all these reasons is 'economic gains'. But we forget that these economic gains are short-lived, while the long-term damaging effects of deforestation are disastrous and irreversible. At present we are losing forests at the rate of 1.7 crores hectares annually worldwide.

Causes of Deforestation : Although the forest area in some developed regions has expanded (For example, former USSR, North and Central America and Europe) as economic development has encouraged the reversion of agricultural lands to forest. However, in developing countries, the trend is toward deforestation, particularly in tropical forests. Although broad issues of poverty, rapidly increasing population pressures, unequal political power, lack of opportunities to make a living, landlessness and inadequate knowledge and means to exploit the tropical forest without destroying it are at the root of deforestation, but there are more specific causes too. Such as :

(i) Shifting cultivation (also called 'Jhum Cultivation'), that is slash and burn agriculture, practices by landless indigenous people or tribals who clear trees to grow subsistence crops is the principal cause of deforestation in the tropics, accounting for 70, 50 and 35 percent respectively in Africa, Asia and tropical America. Because of low productivity of most tropical forest soils, the farmers move to new sites after few years leaving behind abandoned patches (called 'forest fallows'). These forest fallows may revert back to forest if left undisturbed ; however, because rising populations and the ensuing competition for land are forcing farmers to return to these fallows at increasingly shorter intervals. As a result, little of this is allowed to revert to forest. According to an estimate, about 500 million people (nearly 10% of the world population) and 240 million hectares of closed forest are involved in shifting cultivation, which is increasing at an annual average rate of 1.25%.

(ii) Deforestation also occurs due to overgrazing and conversion of forest to pasture for domestic animals.

(iii) Fuelwood gathering is also an important deforestation agent in dry forests.

(iv) Commercial logging is another deforestation agent. It may not be a primary cause of deforestation in the tropics (except in parts of West Africa) because the number of trees left after logging may be sufficient to classify the site as forested. However, it is often a secondary cause because new logging roads permit shifting cultivators and fuelwood gathers to gain access to logged areas and fell the remaining trees. Further, if logging is performed poorly, it results in a degraded forest.

(v) Deforestation also occurs due to mining, quarrying, and irrigation and industrial projects.

(vi) Expansion of agribusiness that grows oil palm, rubber, fruit trees and ornamental plants has also resulted in deforestation.

(vii) Finally, government-sponsored programmes that resettle landless farmers on forested sites have contributed to deforestation all around the world.

The forest resources are thus threatened due to overagrazing and other forms of over-exploitation, both for commercial and household needs, encroachments, unsustainable practices like unscientific cultivation and development activities.

2.3.5 Effects of Deforestation

Deforestation adversely and directly affecfs and damages the environment and humans both. Some of the ill-effects of deforestation (due to timber extraction, mining, construction of dams, etc.) on forests and tribal people are as under :

(i) **Soil erosion.** In the absence of forests/trees, especially on slopes, the soil gets washed away with rain water.

(ii) **Expansions of deserts.** Denuded land mass gradually gets converted into sand deserts due to the action of strong winds laden by fragmented rock dust. This effect is more pronounced in rain scarced areas.

(iii) Migration of local and tribal population from deserts to other fertile land in search of food, leaving behind vast tracks of sands only.

(iv) **Decrease in rainfall.** Forests bring rains due to high rate of transpiration and precipitation. In the absence of forests, rainfall declines considerably.

(v) **Loss of fertile land.** Less rainfall results into the loss of fertile land owing to less natural vegetational growth.

(*vi*) **Effect on climate.** The climate of a region is mainly controlled by the rainfall, snowfall, etc. Deforestation causes decrease in rainfall, which in turn increases the climatic temperature.

(*vii*) **Lowering of water table.** Decrease in rainfall results into a lowered water table due to lack of recharging of underground reservoirs.

(*viii*) **Economic losses.** Deforestation will cause loss of industrial timber and non-timber products and loss of long-term productivity on the site.

(*ix*) **Loss of flora and fauna.** Certain species of flora and fauna are getting extinct from the face of planet, mainly due to deforestation.

(*x*) **Loss of biodiversity.** Loss of flora and fauna has resulted into loss of biodiversity, leading to disturbances in ecological balance worldwide.

(*xi*) **Loss of medicinal plants.** There are many species of plants which have medicinal and other advantages, like Neem (*Indian Margosa*) which has been used in India for centuries as insecticide, fungicide, in medicine and in biofertilizers. Deforestation may lead to the extinction of these types of valuable plants.

(*xiii*) **Environmental changes.** The air we breathe, is purified by forests. So, deforestation will lead to increase in carbondioxide and other air pollutants concentration. This will lead to global warming, which is a serious effect as well as threat.

(*xiv*) In many places the lack of fuelwood due to deforestation challenges local/tribal people, especially where fuelwood had already been scarce.

(*xv*) Agriculture may be negatively impacted if deforestation causes soil loss or compaction, or sedimentation of irrigation systems.

(*xvi*) Indigenous people may be forced into a new way of life for which they are unprepared.

(*xvii*) Human life and downstream structures may be endangered by floods that may be intensified by clearing forests on upstream watersheds.

(*xviii*) Disturbance of forest ecosystems in a particular location may result in important changes in other ecosystems that may be separated by great distances.

(xix) Shortage of firewood may cause serious misery among the tribal womenfolk. For example, shrinkage of forests has resulted in such an acute scarcity of fuelwood that gathering alone takes 360 women days a year per family in Gambia.

(xx) In rural and tribal societies, fuel budged constitutes the major portion of the household budget. There is a serious apprehension that time is not far.when the cost of food would be far less than the fuel needed to cook it for the rural and tribal people.

2.3.6 Effects of Timber Extraction

There has been unlimited exploitation of timber for commercial use. Commercial/industrial demand could out-strip supply leading to decimation of forests, particularly the wood.

The major effects of timber extraction on forests and tribal people include :

- poor logging results in a degraded forest.
- soil erosion, especially on slopes.
- sedimentation of irrigation systems.
- floods may be intensified by cutting of trees on upstream watersheds.
- loss of biodiversity.
- climatic changes, such as lower precipitation.
- new logging roads permit shifting cultivators and fuelwood gatherers to gain access to logged areas and fell the remaining trees.
- loss of non-timber products and loss of long-term forest productivity on the site affect the subsistence economy of the forest dwellers.
- forest fragmentation, the reduction of a large block of forest to many smaller tracts, promotes loss of biodiversity because some species of plants and animals require large continuous areas of similar habitat to survive.
- species of plants and animals, which may occupy narrow ecological niches and whose potential value to humans is unknown, may be eliminated.
- indigenous people may be forced into a new way of life for which they are unprepared.
- exploitation of tribal people by the contractors.
- cutting of more trees than permitted in a particular area by the greedy contractors.

2.3.7 Effects of Mining

The major effects of mining operations on forests and tribal people include :

- degradation of lands.
- loss of top soil due to deforestation.
- pollution of surface and ground water resources due to the discharge of highly mineralized mine waters.
- lowering of ground water table.
- air pollution due to release of greenhouse gases and other toxic gases during mining, *e.g.* release of CH_4 during coal mining.
- deforestation including loss of flora and fauna.
- sediment production and discharge.
- ore transport hazards.
- fire hazards.
- subsidence above and near mine areas can change local hydraulic gradients and drainage basin limits, and create numerous ponds.
- drying up of the perennial sources of water like springs and streams in hilly areas.
- tribal people may be forced into a new way of life for which they are unprepared.
- migration of tribal people from mining areas to other areas in search of land and food.

2.3.8 Effects of Dams/River Valley Projects

The major impacts of dams/river valley projects on forests and tribal people which need consideration are :

- degradation of catchment areas.
- command area development.
- reservoir induced seismicity.
- deforestation and loss of fauna and flora including gene pool reserves due to submergence.
- increased incidence of water-borne diseases like malaria, filaria, schistosomiasis, etc.
- disturbance of the dam (or reservoir) site forest ecosystem may result in important changes in the neighbouring and other ecosystems that may be separated by great distances.
- acute scarcity of fuelwood and other forest products for tribal people.
- rehabilitation and resettlement of those affected.

and domestic use in many areas of the world, particularly areas having insufficient surface water sources. Overuse of groundwater sources can cause several kinds of problems if groundwater is being withdrawn from aquifers faster than natural recharge can replace it, such as :

- a heavily pumped well can lower the local water table as a result of which shallower wells go dry.
- heavy pumping, on a broader scale, can deplete a whole aquifer.
- excessive pumping of groundwater causes porous formations to collapse, resulting in subsidence or settling of the above-surface.
- overuse of freshwater reservoirs along coastlines often allows saltwater to intrude into aquifers used for domestic and agricultural purposes.

Then, there are many aquifers that have slow recharge rates which will take thousands of years to refill them once they are emptied. In a sense, it is a 'fossil water'. When water is pumped out from such a reservoir that cannot be refilled in our lifetime, we essentially are mining a non-renewable resource.

2.4.4 Dams—Benefits and Problems

Water is a precious resource that is becoming an increasingly scarce commodity worldwide. To assuage scarcity, there is a growing pressure to harness and utilize surface water sources, like rivers. The potential use could be for irrigation, hydroelectricity, water transport to deficit areas, etc. This is not a new trend, people have been moving water around for thousands of years. Some of the great ancient civilizations (including the Sumerian, Indus, Babylonian and Inca Culture of S. America) were based on large-scale irrigation systems that brought river water to farm fields. Some historians, in fact, are of the view that organizing people to carry out large-scale water projects was the catalyst for the emergence of civilization. Romans and Native Americans constructed canals and aqueducts two thousand years ago to transport water from distant rivers to where it was needed. However, those early water engineers probably never even dreamed of moving water on a scale that is being proposed and, in some cases, being accomplished now.

As per the World Commission on Dam Report-2000, there are 45,000 large dams (in 140 countries) in the world. The first ever dam was built in 1890, but by 1950 the world had 5,000 large dams. Of these, 22000 are in China, USA–6390, India–4291 (9% of the world's total), Japan–1200, Spain–1000. According to an estimate, 160–320 new large dams are built every year worldwide to trap runoff with dams and storage reservoirs so as to impound huge amount of rain water. The various benefits of dams are :

- hydroelectricity generation.
- ensuring a year-round water supply.
- transfer of water from areas of excess to areas of deficit using canals.
- flood control and soil protection.
- irrigation during dry periods.
- multi-purpose river valley projects also provide for inland water navigation, and can be used to develop fish hatcheries and nurseries.

Though dams have been useful over the centuries ; but in recent years tapping of rivers through big dams has created lot of human as well as environmental issues. In many cases, they reduce water availability and destroy both natural and human values. Some of the disadvantages/problems of dams are as under :

- some dams lose so much water through evaporation and seepage into porous rock beds that they waste more water than they make available.
- salts left behind by evaporation increase the salinity of the river and make its water unusable when it reaches the downstream cities.
- accumulating sediments in the storage reservoir not only makes dams useless but also represents a loss of valuable nutrients to the downstream agricultural lands.
- growth of snail populations in the shallow permanent canals that distribute water to fields may lead to an epidemic of *schistosomiasis*.
- the enormous weight of water behind the dam could trigger seismic activity that might crack the dam and unleash a flood of biblical proportions.
- submergence of large areas of land that might include fertile fields and human settlements.
- resettlement and rehabilitation of displaced people.
- loss of free-flowing rivers that are either drowned by reservoir impoundments or turned into linear, sterile irrigation canals.
- A number of water-related diseases have heen casually linked with the creation of reservoirs and the resettlement of populations when dams are built. The greatest concern has been significant increase in the transmission of *schistosomiasis* and *malaria*, particularly where water impoundments provide breeding -sites for the vectors. The spread of *onchocerciasis* in populations living near dam spillways and downstream has also been reported.

- Dam projects can also lead to lowered nutritional status when highly productive fields are flooded.

Do the benefits outweigh the risks of big dams ?—this is the most obvious question that arises in our mind. Some people are of view that a series of small dams on tributary streams, instead of a large dam, is a better approach.

2.4.5 Water Resource Potential of India

Average run-off in the river system of the country has been assessed as 1869 km^3. Of this, the utilisable portion is estimated to be about 690 km^3. In addition, there is substantial replenishable groundwater potential in the country estimated at 432 km^3. The per capita availability of water has reduced from about 5277 m^3 in 1955 to 1970 m^3 in 2000. The situation may aggravate in future due to the growing water scarcity in the river basins.

Water is vital for realising the full potential of the agriculture sector and the country's development. Optimum development and efficient utilization of our water resources, therefore, assumes great significance.

2.5 MINERAL RESOURCES

Some mineral elements are essential for the formation and functioning of the body of all organisms, plants as well as animals, including human beings. But the humans today use a wide variety of minerals, many in large quantities to sustain his industry based civilization. Modern society depends on the availability of mineral resources, which can be considered a non-renewable heritage from the geologic past. Although new deposits are still forming from earth processes, but these processes are producing new mineral deposits too slowly to be of use to us today. Unlike forestry or agriculture (biological resources), where crops can be grown over and over again, mining is a robber industry. However large the deposit of a given mineral is, continuous mining will exhaust the ores. Hence minerals are thus a finite and declining resource.

Mineral resources are broadly defined as elements, chemical compounds, minerals or rock concentrated in a form that can be extracted to obtain a sustainable commodity.

The origin and distribution of minerals is intimately related to the history of the biosphere and to the entire geologic cycle. Almost every aspect and process of the geologic cycle is involved to some extent in producing local concentrations of minerals.

2.5.1 Distribution of Mineral Resources

The finite stock of minerals on earth is non-renewable ; and, ~~not~~ only that, the geographical distribution of essential minerals is unequal.

peninsular rocks east of a line from Mangalore to Kanpur have the major reserves of metallic minerals, coal, mica and many other non-metallic minerals. The sedimentary rocks on the eastern and western flanks of the peninsular formations in Assam and Gujarat respectively have most of the reserves of petroleum ; while Rajasthan, with the rock system of the peninsula, has reserves of many non-ferrous minerals. Outside this area, most of the states including Jammu & Kashmir, Punjab, Himachal Pradesh, Haryana, Uttaranchal, Tripura, Nagaland and Gangetic West Bengal are very poor in mineral resources.

According to Geological Survey of India (GSI), there are fifty important mineral occurrences and four hundred major sites where these minerals occur.

2.5.2 Uses and Exploitation of Minerals

The mineral resources can be divided into several broad categories, depending on their use, such as elements for metal production and technology, building materials, minerals for the chemical industry, and minerals for agriculture. When we think about mineral resources we oftenly think of metals, but, with the exception of iron, the predominant mineral resources are not metallic. When we consider the annual world consumption of a few selected elements, the following picture emerges :

- sodium and iron are used at a rate of about 0.1 to 1.0 billion metric tons per year ;
- nitrogen, sulphur, potassium and calcium are used at a rate of about 10 to 100 million metric tons per year, primarily as fertilizers ;
- zinc, copper, aluminium and lead are used at a rate of about 3 to 10 million metric tons per year ;
- gold and silver are used at a rate of about 10 thousand metric tons per year or even less ; and
- of all the metallic minerals, iron makes up 95% of all the metals consumed.

Thus, with the exception of iron, the non-metallic minerals are consumed at much greater rates than are the elements used for their metallic properties. Some of the important minerals, along with their uses, are listed in Table 2.3.

The ever-increasing demands from the industry, transport, agriculture and defence preparation are a cause of concern. Depletion of almost all known and easily accessible deposits are anticipated in the very near future. Moreover, there may be shortage of some crucial elements such as mercury, tin, copper, gold, silver and platinum. The limited resources of phosphorus, which is an essential component of chemical fertilizers, is another cause of concern.

Table 2.3. Important Minerals and their Uses

S. No.	Mineral	Uses
	METALLIC	
(i)	Aluminium	Building materials, electrical wiring, utensils, aircraft, rockets
(ii)	Beryllium	Refractories, copper alloys
(iii)	Chromium	Refractory, metallurgy, chemicals
(iv)	Cobalt	Alloys, radiography, catalysts, therapeutics
(v)	Columbium	Stainless steel, nuclear reactors
(vi)	Copper	Alloys, electrical products
(vii)	Gold	Monetary purposes, jewellery, dentistry
(viii)	Iron	Steel, building materials, numerous industrial uses
(ix)	Lead	Batteries, paints, alloys, public health fittings, gasoline
(x)	Magnesium	Structural refractories
(xi)	Manganese	Alloy steels, disinfectants
(xii)	Molybdenum	Alloy steels
(xiii)	Nickel	Used in over 3,000 alloys
(xiv)	Thorium	Nuclear bombs, electricity generation
(xv)	Tin	Soldering, chemicals, tin plates
(xvi)	Tungsten	Alloys, chemicals
(xvii)	Titanium	Alloys, pigments, aircraft
(xviii)	Uranium	Nuclear bombs, electricity generation, tinting glass
(xix)	Vanadium	Alloys
(xx)	Zinc	Galvanising, chemicals, soldering, die-casting
	NON-METALLIC	
(xxi)	Asbestos	Roofing, insulation, ceramics, textiles, gasoline, solid propellants
(xxii)	Corundum	Abrasives
(xxiii)	Felspar	Ceramic flux, artificial teeth
(xxiv)	Fluorspar	Flux, refrigerants, propellants, acid
(xxv)	Nitrates	Fertilizers, chemicals
(xxvi)	Phosphates	Fertilizers, chemicals
(xxvii)	Potassium	Fertilizers, chemicals
(xxviii)	Salt	Chemicals, glass, metallurgy
(xxix)	Sulphur	Fertilizers, acid, iron and steel industry

2.6.s1 Sources of Food

Primitive societies obtained food through hunting and gathering. Even today some societies exist that depend solely on these sources of food ; but the great majority of people obtain food from cultivated plants and domesticated animals. Although some food is obtained from oceans and fresh waters, but the great majority of food for human populations is obtained from traditional land-based agriculture of crops and livestock. A brief description of the sources of food is as under :

1. **Crops :** Out of about 2,50,000 species of plants, only about 3,000 have been tried as agricultural crops, only 300 are grown for food, and only 100 are used on a large scale. Some crops provide food, whereas others provide commercial products (*e.g.* oils, fibres, etc.). Amazingly, but true, most of the world's food is provided by only twenty crop species. These are, in approximate order of importance, wheat, rice, corn, potatoes, barley, sweet potatoes, cassavas, soyabeans, oats, sorghum, millet, sugarcane, sugar beets, rye, peanuts, field beans, chick-peas, pigeon-peas, bananas and coconuts. Out of these, wheat, rice and corn are the three crops on which humanity depends for the majority of its nutrients and calories. Together, about 1.6 million metric tons of these three grains are grown each year, roughly half of all agricultural crops. Further, wheat and rice are especially important as they are the staple foods for most of the people in developing countries of the world. These two crops supply around 60% of the calories consumed directly by humans. Both contain 8 – 15% protein and are good sources of vitamins and fibre, if whole grains are consumed.

In mountainous regions and high latitudes, potatoes, barley, oats and rye are staples as they grow well in cool, moist climate. Cassava, sweet potatoes, and other roots and tubers are staples in Amazonia, Africa and South Pacific as they grow well in warm, wet areas. Drought-resistant sorghum and millet are staples in the dry regions of Africa.

Fruits and vegetables (including vegetable oils) also make a large contribution to human diets. Altogether, they amount to nearly as large a quantity as corn. They are especially important because they are rich in vitamins, minerals, dietary fibre and complex carbohydrates.

2. **Livestock :** Domesticated animals are an important food source. The major domesticated animals used as food by human beings are 'ruminants' (*e.g.* cattle, sheep, goats, camel, reindeer, llama, etc.). Ruminants convert woody tissue of plants (cellulose), indigestible to people but earth's most abundant organic compound, to human food. Milk, prized by people everywhere, is provided by milching animals.

3. **Aquaculture :** It is the production of food from aquatic habitats—marine and freshwater. Fish and seafood contribute about 70 million metric tons of high-quality protein to the world's diet, which is about one-half as much as that from land animals. Although aquaculture provides only a small amount of the world's food at present, but it is an important source of protein for many countries, especially in Asia and Europe. For instance, fish and sea food contribute up to one-half of the animal protein and one-fourth of the total dietry protein in Japan.

2.6.2 World Food Problems

The Food and Agriculture Organization (FAO) estimates that about 840 million people remain chronically hungry, nearly 800 million of them in the developing world. Though the number has been decreasing 2.5 million per year over the last eight years, but the world's target of cutting half the number of world's chronically hungry and undernourished people by 2015 will be met 100 years late if the present trend continues. In India alone, more than 300 million people are food insecure and poverty stricken. This means that they do not possess adequate purchasing power to buy food which could fulfill the minimum calorie requirement of a human body per day. The main reason for such kind of insecurity can be attributed to inequitable distribution of income with a minority of population possessing majority of wealth of that nation.

There are two kinds of food insufficiency—undernourishment and malnourishment. Both of these food insufficiencies are global problems :

1. **Undernourishment :** Undernourishment is the lack of sufficient calories in available food so that one has little or no ability to move or work. The FAO estimates that the average minimum daily caloric intake over the whole world is about 2,500 calories per day. People who receive less than 90% of their minimum dietary intake on a long-term basis are considered undernourished. While not starving to death, they tend not to have enough energy for an active, productive life. Lack of energy and nutrients makes them more susceptible to infectious diseases. Poor diet and poverty create a vicious cycle. Because of poor diet people are weak or sick and can't work ; without an adequate income, they can't afford good food. This cycle doesn't stop here, it extends from one generation to the next. Parents who can't work can't buy food for their children, fail to grow their children properly as a result the children are likely to be impoverished when they become adults.

Those who recieve less than 80% of their minimum daily caloric intake requirements are considered 'seriously' undernourished. Children in this category are likely to suffer from permanently stunted growth, mental retardation, and other social and developmental disorders.

Further, infectious diseases that are only an inconvenience for well-fed individuals become lethal to those who are poorly nourished. In the developing countries, one child in four—around 13 million children per year—dies of diseases that could be prevented with a better diet, clean water and simple medicines.

Undernourishment also leads to famines that are obvious, dramatic, and fast acting when they happen.

2. Malnourishment : Malnourishment is the lack of specific components of food, such as proteins, vitamins or essential chemical elements. It is possible to have excess food and still suffer from malnourishment due to nutritional imbalance caused by a lack of specific dietary components or an inability to absorb or utilize essential nutrients. People in richer countries often eat too much meat and fat and too little fiber, vitamins, trace minerals and other components lost from highly processed foods. In poorer countries, on the other hand, people often lack specific nutrients because they cannot afford more expensive food such as meat, fruits and vegetables that would provide a balanced diet. Malnourishment is long-term and insidious. Although people may not die outright, they are less productive than normal and can suffer permanent brain damage. Some of the major problems of malnourishment are :

- *marasmus*, a progressive emaciation caused by lack of protein and calories ;
- *kwashiarkor*, a lack of sufficient protein in the diet which leads infants to a failure of neural development and therefore learning disabilities ;
- *anemia*, which more often is caused by an inability to absorb iron from food than a lack of iron in the diet ;
- *goiter and hypothyroidism*, an iodine deficiency in the diet in early childhood can cause developmental abnormalities, such as mental retardation and deaf-mutism ;
- *pellagra*, which occurs due to the deficiency of tryptophan and lysine vitamins ; and
- *chronic hunger*, which occurs when people have enough food to stay alive but not enough to lead satisfactory and productive lives.

Overnutrition : In the richer countries, the most common dietary problem is too many calories. For instance, the average daily caloric intake in North America and Europe is above 3,500 calories, nearly one-third more than is needed for adequate nutrition. Overnutrition contributes to overweight, high blood pressure, heart attack, and other

2.6.4 Changes Caused by Agriculture

Undoubtedly, agriculture is the world's oldest and largest industry ; more than half of all the people in the world still live on farms. Because the production, processing and distribution of food all changes the environment, and because of the size of the industry, larger effects on the environment are unavoidable. Agriculture has both primary and secondary environmental effects. A primary effect is an effect on the area where the agriculture takes place, *i.e.* on-site effect. A secondary effect, also called an off-site effect, is an effect on an environment away from the agricultural site, typically downstream and downwind.

The effects of agriculture on the environment can be broadly classified into three groups, viz. local, regional and global :

1. **Local changes :** These occur at or near the site of farming. These changes/effects include soil erosion and increase in sedimentation downstream in local rivers. Fertilizers carried by sediments can cause eutrophication of local water bodies. Polluted sediments can also transport toxins and destroy local fisheries.

2. **Regional changes :** They generally result from the combined effects of farming practices in the same large region. Regional effects include deforestation, desertification, large scale pollution, increases in sedimentation in major rivers and in the estuaries at the mouths of the rivers and changes in the chemical fertility of soils over large areas. In tropical waters, sediments entering the ocean can destroy coral reefs that are near the shore.

3. **Global changes :** These include climatic changes as well as potentially extensive changes in chemical cycles.

2.6.5 Changes Caused by Overgrazing

The carrying capacity of land for cattle depends on the fertility of the soil and the rainfall. When the carrying capacity is exceeded, the land is overgrazed. The changes that result from overgrazing include :

- reduction in the diversity of plant species ;
- reduction in the growth of vegetation ;
- dominance of plant species that are relatively undesirable to the cattle ;
- increased soil erosion as the plant cover is reduced ; and
- damage from the cattle trampling on the land. For example, paths made by cattle develop into gullies, which erode rapidly in the rain.

2.6.6 Effect of Modern Agriculture

Modern agricultural practices have both positive and negative effects on environment. For example, modern pesticides have created a revolution in agriculture in the short-term, but the long-term effects of these chemicals have proved extremely undesirable. The major problems that have arised due to the modern agricultural practices are related to fertilizers, pesticides, waterlogging and salination, and are briefly discussed as under :

1. Fertilizers : Besides water, sunshine and carbon dioxide, plants need small amounts of inorganic nutrients for their growth. The most important elements required by plants are nitrogen, potassium and phosphorus along with calcium, magnesium and sulphur. Adding these elements in fertilizer stimulates growth and greatly increases crop yields.

Once agriculture relied on livestock and human manure, compost, bonemeal, green manures, agricultural lime and crop rotation. Work in UK and Germany, in the 1840s, led to the development of superphosphate artificial fertilizers. After 1945, combined nitrogen-phosphate-potassium (NPK) fertilizers use in developed countries increased considerably. The same period also saw changing agricultural practices, leading to reduced use of animal manure and agricultural lime, more mechanization and less input of manual labour. In the 1930s UK agriculture could not feed the population ; between 1952 and 1972 UK agriculture output rose by about 60% and now feeds a much larger population, largely thanks to artificial chemical fertilizers, although changes in the crops grown make it difficult to assess how much.

On a world scale, chemical fertilizers (particularly N-fertilizers) have played a key role in increasing crop production. Because of the diversity of factors involved, it is difficult to be sure how much is attributable to improved crops. In 1950 the world used about 14 million tonnes of N-fertilizer ; by 1985 this had risen to about 125 million tonnes. In the late 1970s, on an average the developing countries used 28 kg/ha and the developed countries 107 kg/ha of fertilizer. Most of the chemical fertilizer used in developing countries is for large-scale grain and export crop production. In 1990, the world total fertilizer use was 134 million metric tons. Japan's success in modernizing its agriculture and the roughly one-third increase in food production in China between 1970 and 1985 are attributed largely to fertilizer use.

There is considerable potential for increasing world food supply by increasing fertilizer use, particularly in low-production countries. India, for instance, has a relatively low average fertilizer level of only 30 kg/ha. It has been estimated that the developing countries could at least triple their production by raising fertilizer use to the world average.

There are ways of controlling fertilizer use :

- removal of subsidy on chemical fertilizers.
- reduction of price supports for crops.
- regulation of crops grown.
- set-aside—the withdrawal of land from production.
- costly slow-release liming treatment can be done.
- in temperate climates, planting winter wheat with white clover might help to reduce nitrate leaching, and would cut costs of fertilizer inputs and discourage pests.
- interplanting or rotating some leguminous crop (plants in whose root nodules live nitrogen-fixing bacteria) with such crops as wheat and corn.

2. **Pesticides :** All agriculture suffers from pests. Pests are undesirable competitors, parasites or predators. The major agricultural pests are insects (feed mainly on leaves and stems of live plants) ; nematodes (small worms that feed on roots and other plant tissues) ; bacterial and viral diseases ; weeds (flowering plants that compete with the crops) ; and vertebrates (mainly birds and rodents that feed on fruit or grain).

Pesticides are compounds used to kill, deter or disable pests, for one or more of the following purposes :

- to maximize crop or livestock yields ;
- to reduce post-harvest losses to rodents, fungus, etc.
- to improve appearance of crops or livestock ;
- for disease control (human health and veterinary use) ;
- for preservation and maintenance of buildings, clothing, furniture, etc. ;
- to control weeds ;
- for aesthetic reasons, lawn-care, garden flower and golf-courses.

The early pest control methods used by preindustrial farmers were :

- use of salt, smoke and insect-repelling plants.
- use of oil sprays, ash and sulphur ointments.
- use of spices to deter spoilage and pest infestations.
- use of predatory ants in orchards to control caterpillars.
- use of ducks and geese to catch insects and control weeds.
- practicing *'swidden agriculture'* to reduce the density of pests by allowing non-crop plants to grow and by maintaining a diversity of crops in a single field.
- burning fields and rotation of crops to reduce crop diseases.

Nevertheless, pesticides probably affect far more people than tragic but local accidents such as the deaths of thousands of people in the explosion of a Union Carbide pesticide manufacturing plant in Bhopal in 1984.

Pesticides problems can be reduced by :

- banning dangerous compounds ;
- developing alternatives like biological control or integrated pest management ;
- restricting trade of pesticide-contaminated produce ;
- controlling pesticide usage by monitoring, inspection and licensing to ensure sensible procedures ;
- developing less dangerous pesticides ;
- controlling prices of pesticides to discourage excessive use ;
- education to discourage unsound strategies ;
- rotation of crops to upset pest breeding and access to food ;
- hand weeding or non-chemical weeding ;
- encouraging agencies to cut funds for pesticides ; and
- treating drinking water to remove pesticides.

3. Water logging : The problem of water logging arises either due to surface flooding or due to high water table. The productivity of water-logged soils is very poor due to less oxygen availability for respiration of plants sown over such soils/areas. Though construction of canals has improved irrigation and increased the crop yield in many areas, but excessive use of canal irrigation in some areas has disturbed the water balance. This has created water logging problem as a result of seepage or rise in the water table.

In India, the areas which are frequently waterlogged include estuarine deltas of Ganges, areas of Kerala and Andaman & Nicobar Islands.

4. Salinity : Salinity refers to increased concentration of soluble salts in the soil. It results due to intensive agricultural practices. Due to poor drainage of irrigation and flood waters, the dissolved salts in these waters accumulate on the soil surface. In arid areas with low rainfall, poor drainage and high temperatures, water evaporates quickly from the soil leaving behind the salts in high concentrations. Excess of these salts (mainly carbonates, chlorides and sulphates of sodium and traces of calcium and magnesium) form a crust on the soil surface and are injurious to the survival of plants. The water absorption process of the plant is severely affected. Even if sufficient water is available in the soil, it is not available to the plants due to higher concentrations of the soil solution.

(iii) management of demand of oil and other forms of energy ;
(iv) energy conservation and management ;
(v) optimisation of utilisation of existing capacity in the country
(vi) development and exploitation of renewable sources of energy to meet energy requirements of rural communities ;
(vii) intensification of resources and developmental activities in new and renewable energy resources ; and
(viii) organisation of training for personnel engaged at various levels in the energy sector.

In the short term, the energy policy concentrates on development of domestic conventional energy resources along with demand management without adversly affecting economic growth. In the medium term, energy conservation and improved energy efficiency will improve the position. And in the long term, development of technologies to exploit resources of thorium as well as new and renewable ones on a large scale will be undertaken.

In India, the development of conventional forms of energy for meeting the growing energy needs of the society at a reasonable cost is the responsibility of Deptt. of Power, Deptt. of Coal, and Ministry of Petroleum and Natural gas. The development and promotion of non-conventional/alternate/new and renewable sources of energy is the responsibility of Deptt. of Non-conventional Energy Sources set up in 1982. The development of nuclear energy so as to contribute significantly to the overall energy availability in the country is the responsibility of the Deptt. of Atomic Energy.

2.7.3 Energy Resources

The energy resources can be classified in many ways :

(A) **Commercial fuels.** These include coal, lignite, petroleum products, natural gas and electricity.

Non-commercial fuels. These include fuelwood, cow-dung, agricultural wastes, etc.

(B) **Primary energy resources.** Primary energy resources are those which are mined or otherwise obtained from the environment. These include fossil fuels (coal, lignite, crude oil and natural gas), nuclear fuels, water (hydro energy), solar, wind, ocean and geothermal energy.

Secondary energy resources. Secondary energy resources are those which do not occur in nature ; instead, they are derived from primary energy resources. These include petrol, diesel, electrical energy (from coal, diesel and gas), etc.

(C) **Conventional energy resources.** These include fossil fuels (coal, petroleum and natural gas), water (hydel power) and nuclear energy.

Non-conventional energy resources. These include solar, wind, geothermal, ocean (thermal, tidal and wave), biomass and hydrogen energy.

(D) **Non-renewable energy resources.** Non-renewable energy sources are those natural resources which are exhaustible and cannot be replaced once they are used. These are available in limited amount and develop over a long period. These include fossil fuels (such as coal, oil and natural gas), and nuclear power.

Renewable energy resources. Renewable energy resources are those natural resources which are inexhaustible (*i.e.*, which can be replaced as we use them) and can be used to produce energy again and again. These are available in unlimited amount in nature and develop in a relatively short period of time. These include solar, wind, water, geothermal, ocean, and biomass energy. Nuclear energy, however, can also be considered as inexhaustible source of energy if atomic minerals are used in fast breeder reactor technology.

2.7.4 The Role of Unconventional (Renewable) Sources of Energy

The unconventional (renewable) sources of energy are capable of solving the twin problems of energy supply in a decentralized manner and helping in sustaining cleaner environment. But it is difficult to predict the role of unconventional sources of energy. Where substantial technological development is required (such as fusion power or solar photo-voltaic electricity), little confidence can be placed in cost estimates. Some other sources (such as tidal power and solar low grade heat), require atleast modest extensions of existing technologies, and their role will be determined mainly by fossil fuel prices and the development in competing technologies.

Tables 2.5 and 2.6 summarise the characteristics of the unconventional (renewable) energy sources discussed later in this chapter. Tentative estimates of the long-term contribution of various unconventional sources of energy are given in Table 2.7. For comparison, current world annual energy consumption is around 300×10^{18} J (300 EJ), and may be 800 to 1000 EJ by 2020. The estimates can only be regarded as a general indication of the scale of the contribution of unconventional sources ; although, this contribution sources of coal, lignite and oil, growing reliance would have to be placed on hydel power. Except for the heavy initial investment, hydel projects have a definite edge over other power plants. Hydro or hydel power is one of the most important sources of energy, next only to thermal power. This can be assessed by the fact that nearly 30% of the total power of the world is met by hydro-electric power. The total hydro potential of the world is about 5,000 GW. There are countries in the world where almost entire power generation is hydro based. In Norway, the hydro power forms 99% of its total installed capacity. In South America, about 75% of the total electricity consumption comes from hydel-plants. Some of the leading countries in the production of hydro-power are USA, former USSR, Japan, Brazil, etc.

The Indian Scenario

24.8%

At present about 24% of the country's electricity is being generated through the hydro power plants. Out of the total installed power generating capacity of 92,864 MW (at the end of 1998–99) in the country, 22,438.48 MW is from hydel plants. As per the estimates of central electricity authority, the annual hydro electricity potential of our country at 60% load factor is 89,830 MW; yet hardly 25% of it has been harnessed so far. About 80 per cent of the developed hydel resources of India lie in the states of Maharashtra, Tamil Nadu, Karnataka, Kerala, Punjab, Himachal Pradesh, Jammu and Kashmir and Western Uttar Pradesh (now Uttaranchal).

Utility

94.8%

Hydro power, which provides about 30% of the world's electricity, plays a significant role in the world's supply of energy. 'Sustainability', a frequent discussion topic, is a key feature of hydro power. Once a hydro power plant has been built, it produces electricity with only minimal investments in upkeep for many years to come. The idea of one generation leaving a legacy to subsequent generations, certainly lives in hydro power facilities. Some of the inherent advantages of hydel power over thermal power plants and other plants are as under:

(i) Hydro-electric power is the cheapest and most versatile source of energy out of all the known sources of energy.
(ii) Hydel projects, not only provide cheap generation of electricity, but are renewable in nature.
(iii) Hydel projects have a very low generation and maintenance cost.
(iv) The reliability of hydro power plant is greater than that of other power plants.
(v) Hydro power plants have a relatively long life. The life expectancy of hydro power plant equipment is about 50 years or even more.
(vi) They have a very high efficiency over a considerable range of load.

(vii) The hydro power plants are flexible and have quick start up and stopping time, and rapid response to change in demand ; whereas, nuclear and thermal power plants lack this facility.

(viii) The generation of hydel power does not create problems of pollution, unlike that from nuclear or thermal power plants.

(ix) The use of hydel power also enables a nation to economise on its coal resources. Because every horse power of hydel power generated replaces thermal power generated by about 4 metric tons of coal.

(x) Hydel projects are labour-intensive in nature. They can be used for tackling problem of unemployment. Provision of cheap electric power creates further employment opportunities through establishment of industries and development of agriculture.

(xi) Most of the hydro projects are organized as multi-purpose projects. In addition to the generation of electricity, hydel projects can also be used for irrigation, source of water supply for industrial and domestic uses, flood control navigation and recreational sites.

The major hurdle in harnessing hydro power, probably, is the initial investment and comparatively much more gestation period of hydel projects. Another major drawback of hydel projects is displacement of population and damage to environment and fertile lands.

There seems to be no escape from long gestation periods. But for the displacement of population and damage to environment and fertile lands, the focus is now shifting from constructing a few big dams to the construction of many small-scale hydroelectric facilities. To be fair, a blend of both types of hydel projects is recommended.

2.7.7 Solar Energy

The sun is a source of enormous energy. It is a fusion reactor at a distance of about 150×10^6 km from the earth. Its probable age is 4×10^9 years and it is expected to radiate energy for another 4×10^9 years. The energy from the sun in the form of radiations is called solar energy. It is believed that with just 0.1% of the 75,000 trillion kWH of solar energy that reaches the earth, the planet's requirements can be easily fulfilled.

Solar energy technology comprises of two distinct categories, viz., thermal conversion and photoconversion. Thermal conversion takes place through direct heating, ocean waves and currents, and wind. Photoconversion includes photosynthesis, photochemistry, photoelectrochemistry, photogalvanism and photovoltaics. Solar radiation is collected and converted by natural collectors such as the atmosphere, the ocean and plant life, as well as by man-made collectors of many kinds (Fig. 2.4). There are a number of solar technologies by which it can be harnessed (Fig. 2.5).

(ii) Solar space heating of buildings.
(iii) Solar air-conditioning.
(iv) Solar refrigeration.
(v) Solar drying.
(vi) Solar cooking.
(vii) Solar green-houses.
(viii) Solar furnaces.
(ix) Solar desalination.
(x) Salt production.
(xi) Solar electricity—thermal.
(xii) Solar electricity—photovoltaic.

1. Solar Water Heating

A solar water heater unit comprises a flat plate collector and an insulated storage tank. A typical collector consists of a blackened metal plate absorber containing metal tubes/pipes for water to remove the heat and is usually provided with a glass cover (one or more layers of glass) and a layer of insulation beneath the plate. The collector tubing/piping is connected to a hot water storage tank. The collector absorbs solar radiations and transfer the heat to the circulating water (either by gravity or by a pump). Usually, the storage tank is located above the top of the collector. The elevated position of the tank results in natural convection, *i.e.*, the water circulates from the collector to the storage tank and no pump is required.

This system of water heating is commonly used in hostels, hospitals, hotels, guesthouses, etc. as well as domestic and industrial units. A solar collector area of 3–4 m^2 in combination with an insulated tank of 200–400 litre capacity can provide 200–300 litres of hot water at about 60°C per average sunny day in a favourable climate.

2. Solar Space Heating of Buildings

Solar space heating can be provided passively through the architectural design of the premises. At its simplest, this involves only the orientation of the building and providing large south-facing windows. More radical possibilities include the provision of an entire wall of double-glazed windows or a heavy dark-coloured south-facing wall behind a layer of glass, with room air circulating by convection between the wall and the glass, or a flat roof covered by a pond of water over which insulating screen can be drawn at night (this also provides summer cooling).

Alternatively, an active technology of solar space heating where water is the medium, is essentially an extension of the technology employed in solar water heating except that energy has to be recovered from the tank through a heat exchange surface. In systems employing air as the heat-transfer constructed over large areas enabling the diffused solar radiation to be concentrated on a large scale.

(*iii*) They can supply energy even during the monsoon season.

(*iv*) Solar energy from solar ponds can be utilized for various purposes.

Limitations :

A solar pond multipurpose facility involves high capital cost and, thus, the development of the process and its potential applications are probably less attractive in the developing countries than in industrialized nations.

The Indian Scenario

India is the first Asian country to have a solar pond project in Bhuj, Kutch district of Gujarat. The Bhuj solar pond has been designed to supply about 220 lakh kWh of thermal energy per annum, about 1,25,000 kWh of electricity per annum and about 80,000 litre of potable water per day.

2.7.9 Wind Energy ✓

technology

Wind power is as old as the first sailing ship, and windmills for pumping water from wells or for grinding agricultural produce dates back to the earliest times of recorded history. Evidence shows that the ancient (Egyptians used windmills as early as 3600 B.C. to pump water for irrigating their arid fields and to grind grain.)

Wind energy is a renewable source of non-polluting energy and is emerging as one of the most potential sources of alternate energy which will be helpful to a great extent in bridging the gap between the energy demand and supply. Compared to solar energy, the wind is a very complex resource, possessing a three-dimensional value as compared to solar's two-dimensional qualities. The wind resource is more intermittent and is strongly influenced by terrain or geography factors. Also, due to fluid mechanics considerations, there is a non-linear (cubic) relationship between wind speed and the power production from a wind turbine (a wind energy conversion device).

Wind, which is essentially air in motion, has kinetic energy by virtue of the movement of large masses of air caused by differential heating of the atmosphere by the sun. At any given time, the amount of energy contained in the wind is proportional to the wind speed at that instant in the context of wind-based energy production systems. This energy can be utilized for performing mechanical and electrical works. Wind turbines can be used to generate electricity, for lifting water from wells, for direct water pumping and many more.

Wind turbine, basically, consists of a few vanes or blades radiating from a central axis. As the wind blows against the vanes/blades, they rotate about the axis. This rotational motion is then utilized to perform some useful work—mechanical and/or electrical.

The Indian Scenario

T.N, Guj, Karnataka, Maharashtra, Rajasthan 8.4% 36.625GW

India is rated high in the world for wind resource availability. The total wind energy potential in India is estimated at 25,000 MW. Of this about 6,000 MW is located in Tamil Nadu and 5,000 MW in Gujarat. Coastal areas of Tamil Nadu, Gujarat, Andhra Pradesh and Maharashtra ; plains of Rajasthan, Uttar Pradesh and Madhya Pradesh ; and hill tops are favourable to wind power generation. A total capacity of 732 MW has already been installed by 1995–96.

Wind power in India has been developed both :

(*i*) in the stand-alone mode, with diesel back-up and pumped storage to ensure supply during little wind, and

(*ii*) in wind farms, which have arrays of turbines for supplying bulk power needs for grids.

Asia's first wind farm project is at Mandvi in Kutch district of Gujarat; while a wind farm cluster of 150 MW at Muppandal in Tamil Nadu is Asia's largest wind farm cluster. Kayathar, Muppandal, Ayukudi and Tuticorin in Tamil Nadu ; and Mandvi, Okha, Tuna, Lamba and Veraval in Gujarat are the famous wind farms in India.

Wind energy generation has been given a strong thrust by Ministry of Non-Conventional Energy Sources, Govt. of India. The government has allowed a number of incentives for setting up wind power plants, such as, hundred percent depreciation, exemption from paying of excise duty and sales tax, tax holidays, concessional finance, and buy back of power. Research in the exploitation of wind energy is being carried out at the following institutes :

(i) National Aeronautical Laboratory (NAL), Bangalore.
(ii) Marine Chemicals Research Institute (MCRI), Bhavnagar.
(iii) Central Arid Zone Research Institute (CAZRI), Jodhpur.
(iv) Madurai Wind Mill, Madurai.

Merits of Wind Energy

(1) It is a non-polluting and environment friendly source of energy.
(2) It is an important renewable and sustainable source of energy, available free of cost.
(3) The scope of wind resource, globally, is enoromous and is less dependent on latitude than other solar based renewable energy technologies.
(4) The generation period is low and power generation starts from commissioning.
(5) Power generation is cheaper as there is no shortage of input cost and recurring expenses are almost nil.
(6) It can be made available easily in many off-shore, on-shore and remote areas ; thus, helpful in supplying electric power to remote and rural areas.
(7) In addition to the large-scale (MW sized) production of electrical energy, wind power systems can be applied to smaller sized applications in developing countries as well as for energy supply in remote or specialized applications such as water pumping, battery charging, operating simple machinery, and heating end uses as well as hybrid energy (wind/diesel, wind/PV) systems.
(8) Wind power is particularly relevant to developing countries where electricity supply may be absent or of limited capacity.
(9) Development of wind energy is recommended to broaden the nation's energy options for new energy sources.

Limitations of Wind Energy

(1) It has low energy density.
(2) It is generally favourable in geographic locations which are away from cities.

(3) It is variable, unsteady, irregular, intermittent, erratic and sometimes dangerous.

(4) Wind turbine design, manufacture and installation have proved to be complex due to widely varying atmospheric conditions in which they have to operate.

(5) Wind farms can be located only in vast open areas in locations of favourable wind. Generally, such locations are away from load centres.

(6) The location of wind farms should not be on migratory routes. Otherwise, it could play havoc with the birds and might lead to a disaster for some avian populations.

(7) The appearance of windmills on the landscape and their continual whirling and whistling can be irritating.

(8) The use of wind power for electricity generation on a small scale is already economical in remote locations. But, at present, it does not appear to be economic for large scale generation.

(9) Being fluctuating in nature, it requires energy storage batteries (which indirectly and substantially contribute to environmental pollution) or alternate source of energy to fall back on, in case of non-availability of winds.

2.7.10 Bio-energy

Biomass, defined as living matter or its residues, is a renewable source of energy. The biomass includes all the new plant growth, residues and wastes, herbage, algae, agricultural and forest residues (like bagasse, corn cobs, bark, saw dust, wood shavings, roots, animal droppings, etc.), wastes (like sewage, garbage, night soil, etc.), biodegradable organic effluents from industries like sugar, slaughter house, meat packing plants, breweries, distilleries, etc. The main sources of biomass can be classified broadly in two groups:

(i) waste material including those derived from agriculture, forestry, municipal and industrial wastes ; and

(ii) growing energy crops involving short rotation forestry plantations.

Land plants considered for energy production include sugarcane, sugarbeet, sorghum, corn, wheat, grass, eucalyptus, sun flowers, kneaf, Biogas production is carried out in an enclosed water-tight biogas plant (or digester) made of bricks or steel. A slurry of waste organic matter is fed into the digester from an inlet, and gas formed is trapped by an inverted drum which covers the surface of the liquid. As gas is produced, the drum rises—acting as a gas-storage chamber. From this chamber, the gas may be drawn-off as per requirement. The optimum digestion takes place between a pH of 7.0 to 7.4 and at a temperature of 20–40°C.

Biogas is a clean, cheap and convenient cooking fuel. It is a storage energy source that can also be used for lighting purposes and running small motors for lifting and providing power for cottage industries. There

2.8 LAND RESOURCES

Land is a major constituent of the lithosphere and is one of the main components of natural environment besides air, water and plants. It forms about one-fifth of the earth's surface, covering about 13,393 million hectares, and is the source of many materials essential to man and other organisms. Most human or natural activities need space for their location and development, which is provided by land. The various purposes for which land can be used, include agriculture and horticulture for food production, energy production, human dwellings and industrial/commercial purposes, waste disposal, forests, etc.

Though the pattern of land use varies from country to country ; broadly, the pattern of land use on earth is :

- Agricultural (arable) land 11%
- Pastures and meadows 22%
- Forest land 30%
- Urban and non-agricultural land 37%
  (*i.e.* land area occupied by human dwellings and factories, roads and railways, deserts, glaciers, polar ice, marshes, rocks and mountains).

In India, more than two-fifth land is agricultural land. The pattern of land distribution in India is as under :

- Agricultural land 43.6%
- Permanent pastures and meadows 14.6%
- Culturable wastelands 12.2%
- Forests 10.7%
- Barren and inculturable land 8.4%
- Urban land 5.3%
- No information available 5.2%

2.8.1 Soil as a Natural Resource

The surface layer of the land is called 'soil'. About four-fifth of the land area is covered by soil. The word 'soil' has been derived from the Latin word 'Solum'—meaning upper crust of the earth. Soil is generally defined as upper layer of the earth differentiated into various horizons and capable of supporting plant life. It is a collection of natural bodies on the earth's surface containing living as well as non-living matter, and supporting or capable of supporting plants. Its upper limit is air or water and its lateral margins grade to deep water or barren areas of rock or ice. Its lowest limit is most difficult to define but is normally thought of as the lower limit of the common rooting depth of the native perennial plants, a boundary that is shallow in deserts and tundra and deep in humid tropics.

Soil is a dynamic layer of earth's crust which is constantly changing and developing. Soil formation takes place with the decomposition of rocks and minerals. Soil properties like soil texture, structure, permeability, soil water porosity, soil pH, organic and inorganic (nutrients) content, cation exchange capacity, microbial properties, etc. play an important role to determine its productivity. The topography, climate and biotic factors control the conditions of the soil.

Soil is a renewable natural resource. It plays a very vital role in the determination of the quality and composition of the biosphere. In fact, the biosphere develops over the soil. It is not only a home for microbes, but also gives nutrition for plants. Some of the important functions of soil are as under :

(*i*) It provides mechanical support to the flora.

(*ii*) Due to its porosity and water-holding capacity, the soil serves as a reservoir of water and supplies water to the plants (even when the land surface is dry).

(*iii*) The ion-exchange capacity of soil ensures the availability and supply of micro- and macro-nutrients for the growth of plants, microbes and animals.

(*iv*) Soil also helps in preventing excessive leaching of nutrient ions, while maintaining proper pH.

(*v*) Soil contains a wide variety of bacteria (like nitrifying, nitrogen-fixing, organotrophic, etc.), fungi, protozoans, and many other microbes which help in the decomposition and mineralization of organic matter and regeneration of nutrients.

2.8.2 Land Degradation and its Causes

Land degradation refers to deterioration or loss of fertility or productive capacity of the soil. All modern and growth oriented activities are having their direct or indirect impact on land. Though land resources are very much related to natural disasters like volcanic eruptions, earthquakes, etc., but it is due to human activities that soil gets polluted. The factors which are mainly responsible for land degradation are

1. Soil Erosion : Soil erosion refers to the loss or removal of the superficial layer of the soil by the action of wind, water or human actions. The factors that influence the extent to which soil erosion will occur include :

(*a*) *Distribution, intensity and amount of Rainfall*. The soil fails to absorb heavy rainfall restricted to a few months of the year resulting in plenty of run-off water which removes soil layers as it moves along, thus causing soil erosion.

(b) *Slope of the ground.* If the ground/landscape has steep slopes, then infiltration of rain water decreases and the run-off is much faster, thus causing more soil erosion.

(c) *Soil type.* Light and open soils lose more silt than heavier loams (which merely swellup by wetting).

(d) *Vegetation cover.* Rain falling on bare land causes soil erosion because the top soil is loose and is easily carried away by the run-off. On the other hand, vegetation holds the soil in place by forming a network of roots of the plants. Further, rain falling on thick vegetation cover gets partly absorbed by the vegetation, partly evaporates and partly soaked into the ground (by the humus formed by the decay of fallen leaves and twigs), resulting in less surface run-off and hence less soil erosion.

(e) *Soil mismanagement.* Uncontrolled grazing by cattle, faulty methods of surface drainage, wrong cultivation practices (like cutting fields along the direction of hill slopes), removal of forest litter, etc. are common practices that aggravate soil erosion.
cause

2. Salination : Salination refers to increase in the concentration of soluble salts in the soil. Poor drainage of irrigation and flood waters results in accumulation of dissolved salts on the soil surface. In arid and semi-arid areas with poor drainage and high temperatures, water evaporates quickly leaving behind a white crust of salts on the soil surface. The high concentration of salts in soil severely affect the water absorption process of the plants, resulting into poor productivity.

Salinity, however, can be checked by improving the drainage, and the salinated lands can be reclaimed by 'leaching' with plenty of water (*i.e.* heavy irrigation).

3. Water-logging : Water-logging may be due to surface flooding or due to high water table. Excessive use of canal irrigation may disturb the water balance and create water-logging as a result of seepage or rise in the water table of the area. The productivity of water-logged soil is severely affected reduced due to lesser availability of oxygen for the respiration of plants. Water-logging reduces the productivity of soil

4. Desertification : Desertification is a slow process of land degradation that leads to desert formation. It is like a 'skin disease' over the planet wherein patches of degraded land, erupting separately, gradually join together. For example, the Thar desert (India) was formed by the degradation of thousands of hectares of productive land. It may result either due to a natural phenomenon linked to climatic change or due to abusive use of land. In fact even for climatic change, it is the abusive land use that is largely responsible. Increasing human population has put a great pressure on the land. Vast areas of land have been cleared for agricultural, industrial, and other purposes. Over-cultivation, overgrazing, deforestation, poor irrigation practices, all contribute towards desertification. These activities bring about changes in rainfall, temperature, wind velocity, etc. and lead to soil erosion. Such changes then lead to desertification of the productive lands. The topsoil, which takes centuries to build up, can be lost in just a few years through such practices. Land that recovered quickly in the past after long droughts and dry periods, now tends to lose its biological and economic productivity if not sustainably managed. Economic forces can encourage people to over-exploit their land for short-term gains. Ignorance, errors, natural disasters such as floods and droughts as well as man-made disasters, like war and national emergencies, can destory land productivity by placing undue pressure on it. The circle of desertification and poverty is a vicious one. One factor leads to the other. Degraded land means poverty for those living off it and poverty causes those dependent on the land to over-exploit it for food, energy, housing and income.

India figures prominently in the United Nations Environment Programme, UNEP's *World Atlas of Desertification*, which shows the largest degraded area of agricultural land in the world, 1475 million ha to be in Asia. The annual loss of productivity due to soil erosion in the South Asia region is estimated at about US $ 5.4 billion. The re-classification of some towns in India as being not drought-prone but *desert*-prone is also significant in this regard. The Centre and the States have launched a number of programmes to combat the menace of desertification such as the Drought Prone Area Programme, The Integrated Watershed Management Programme and others. The need is for concerted action for sustainable development with a "bottom-up" approach.

5. Shifting cultivation : Shifting (Jhum) cultivation, a very peculiar practice of slash and burn agriculture, prevalent among many tribal communities inhabiting the tropical and sub-tropical regions of Africa, Asia and Islands of Pacific ocean has also laid large forest tracts bare. This practice has led to complete destruction of forests in many hilly areas of India, especially the North-East and Orissa, and caused soil erosion and other associated problems of land degradation.

6. Urbanization : Human activities are responsible for the land-degradation of forests, croplands and grasslands. The productive areas are fast reducing because of urbanization *i.e.* the developmental activities such as human settlements and industries.

7. Landslides : Human activities such as construction of road and railway, canal, dams and reservoir and mining in hilly areas have affected the stability of hill slopes and damaged the protective vegetation cover both above and below roads and other such developmental works. This has upset the balance of nature, making such areas vulnerable to landslides.

that can causes landslide

8. Soil Pollution : Soil pollutants (such as pesticides, chemicals, radioactive and industrial wastes, plastics, bottles and tin-cans, clothes, carcasses, etc.) have an adverse effect on the physical, chemical and biological properties of soil and hence reduce its productivity. [For detail refer Chapter 5].