Indira Gandhi National
Open University
School of Sciences

BEVAE-181
ABILITY ENHANCEMENT COMPULSORY COURSE ON ENVIRONMENTAL STUDIES

Block

2

NATURAL RESOURCES

BLOCK 2 : NATURAL RESOURCES

This Block discusses about the natural resources, their distribution, significance, utilisation and problems arising out of their utilisation. Natural resources include land, water, mineral, plant and animal etc. Nature has given us these resources which are essential for survival and development of all the life forms. It is our prime responsibility to use our natural treasures wisely and judiciously. Our demand on natural resources is rapidly increasing and it is believed that the resources are being used indiscriminately. This is partly because of the tremendous increase in human population, rate of consumption and partly due to lack of realisation on our part that these resources are limited and will be exhausted one day. Therefore, there is a need for sustainable natural resource management

Unit 4 Land and Water Resource: In this unit we shall discuss the two vital natural resources namely land and water which are essential for survival and development of all the life forms. It is our prime responsibility to use our natural treasures wisely and judiciously despite of our increasing demand. Intensive and unregulated use of land surface for cultivation, grazing or exploitation of plant material has adversely affected the plant communities and their composition as well as regeneration capacity. Likewise, one of the most pronounced and long lasting effects of mining and pollution is both quantitative and qualitative deterioration of water resources. Industries add toxic wastes to the water bodies making them unusable. Demand for natural resources is increasing progressively, hence we need to use them more efficiently and also look for alternative sources or their substitutes.

Unit 5 Forest Resources: This unit will describe economic, ecological and socio-cultural significance of forest as a resource. It will also provide explanation for various causes and consequences of deforestation. The final section deals with methods of conservation and management of forest resources.

Unit 6 Biodiversity: Values and Services: This unit defines biodiversity and explains different levels of biodiversity namely genetic, species, and ecosystem diversity. It also enumerates and analyses the wild life species that occur in the different biogeographic zones of India. The unit also explains the value of diversity in terms of direct vs. indirect use, extractive vs. non-extractive use and resource vs. non-resource use.

Unit 7 Energy Resources: In this unit, we begin our discussion about energy as resource with an understanding of the multi-faceted role of energy in economic development. We will examine the energy resource base at our disposal and the various energy options available to us. Finally, we will analyse the carrying capacity of the Earth in relation to our energy demand with a view of switching over to renewable energy sources.

UNIT 4

LAND AND WATER RESOURCES

Structure

4.1 INTRODUCTION

In the previous units you have studied what constitutes your environment and how ecosystem supports myriad living forms including human beings. You have also understood the importance of environment and how energy moves from one form to another form, from sun to producers (trees, algae, etc.) and thereafter to herbivores and then to various life consumers like carnivores. In the present unit, we shall discuss the resources or the wealth, nature has given to us as these are essential for survival and development of all the life forms. It is our prime concern to use our natural treasures wisely and judiciously. Our demand on natural resources is rapidly increasing. However, it is believed that the resources are being used indiscriminately. This is partly because of the tremendous increase in human population and partly due to lack of realisation on our part that these resources are limited and will be exhausted one day.

Intensive and unregulated use of land surface for cultivation, grazing or exploitation of plant material has adversely affected the plant communities and their composition as well as regeneration capacity. Likewise, one of the most pronounced and long lasting effects of mining and pollution is both quantitative and qualitative deterioration of water resources. Industries add toxic wastes to the water bodies making them unusable.

There is another reason to conserve and safeguard our land and water resources as their supply is not unlimited. Demand for natural resources is increasing progressively, hence we need to use them more efficiently and also look for alternative sources or their substitutes. It will be only possible when we understand about their availability and limitations.

Expected Learning Outcomes

After completing the study of this unit, you should be able to:

- ❖ define renewable and non-renewable resources;
- ❖ explain how various human activities in agriculture and industry have led to degradation of land and water resources;
- ❖ describe how environmental degradation has led to conditions of floods and droughts; and
- ❖ explain the phenomena of soil erosion and desertification and how with wise and careful planning, various natural resources like land and water can be utilized in a sustainable manner.

4.2 RENEWABLE AND NON-RENEWABLE RESOURCES

Our resources are basically of two kinds viz., renewable and non-renewable. Let us see what this means. A resource may be defined as any useful information, material or service. Broadly we can differentiate between natural resources i.e., goods and services supplied by the environment and human-made resources i.e., cities, buildings, institutions and other artefacts and human resources which include wisdom, experience, skill and enterprise.

Natural resources are of two kinds. Some of the resources of the earth are replaced from time to time by natural multiplication such as vegetation. In other words these resources are regenerated and are, therefore, called **renewable resources**. Forests, pastures, wild life and aquatic life are examples of renewable resources. Water is also a renewable resource because it gets recycled. There are some other resources such as minerals and fossil fuels which once used are lost for ever. They cannot be regenerated. Mineral deposits were formed slowly in millions of years. Once a deposit is used it cannot be regenerated. For example, fossil fuels (petrol, coal) get burnt up and cannot be recovered. These are known as **non-renewable resources**. Similarly, the formation of soil is a very slow process and formation of a layer of top soil can take thousands of years. Hence, it is also a non-renewable resource. Let us examine water and land as the renewable and non-renewable resources individually.

4.3 RENEWABLE WATER RESOURCE

Water is one of the most essential components of life. Our water resources are limited though apparently water is available in an abundant quantity. There is scarcity of usable quantity of water in large parts of the world.

Human survival since ages has depended on the relationship societies had with land and water resources. This relationship has been evolving ever since riverbanks and river valleys influenced the early human settlements. Many early civilizations have flourished on the riverbanks, and perished in the river floods – some probably due to the faulty watershed/river basin management. However, eventually human beings had come to understand the cyclical relationship of water with land. This understanding led to the creation of tanks using highly developed engineering techniques.

Freshwater is one of the most important substances for sustaining human life. Considered as one the important one in the five elements – earth, fire, air, space and water – it was revered and worshiped and treated by all with respect.

This is because a mere one percent of all water on the planet is readily accessible to us for use. Of this amount, about 73 per cent goes to agriculture, 20 per cent to industry and the rest is used for domestic and recreational needs such as drinking and other non-potable uses.

The global distribution of water resources reveals that less than 3% of the total quantity is fresh water. A break up of the total fresh water among various resources and its availability is shown in Table 4.1

Table 4.1: Global distribution of fresh water

Types of Fresh Water	% of Fresh Water	% Available
1) Frozen	80.00	
2) Liquid	20.00	
Lakes	0.2	1.0
Soil	0.04	0.2
Rivers	0.02	0.1
Atmosphere	0.02	0.1
Biological (Metabolic)	0.001	0.005
Ground water	19.7	98.4

It is evident from the Table 4.1 that only one fifth of the fresh water is available in the liquid form. This limited amount is replenishable and therefore, has been relied upon for recurrent use by human being. More than 90% of this scarce commodity is in the form of ground water, while only 1% is in the lakes and ponds. The soil profile carries only 0.2%, but double the amount is held either by rivers or atmosphere. India, in terms of total annual rainfall is very fortunate. It receives an average rainfall of 400 m ham (million hectare metres) out of which 185 m ham is available as surface water, 50 m ham is stored as underground water and 165 m ham is stored in soil.

The total amount of fresh water is more than enough to meet the present and future needs of human kind. But due to its uneven distribution, wide seasonal as well as yearly fluctuations, water shortage is a chronic problem in many parts of the world.

Thus we can see that the water which is required for various purposes like irrigation, navigation, generation of hydroelectricity and domestic and industrial needs is rather scarce. It is, therefore, necessary that water resources should be utilized judiciously.

4.3.1 Water Cycle (Hydrological Cycle)

The movement of water on the earth is continuous and forms many complex inter-related loops (Fig. 4.1). Cycling of water involves atmosphere, sea, earth and the entire living biota. The circulation of water is highly dynamic and global in extent. However, for the sake of convenience it is divided into different categories:

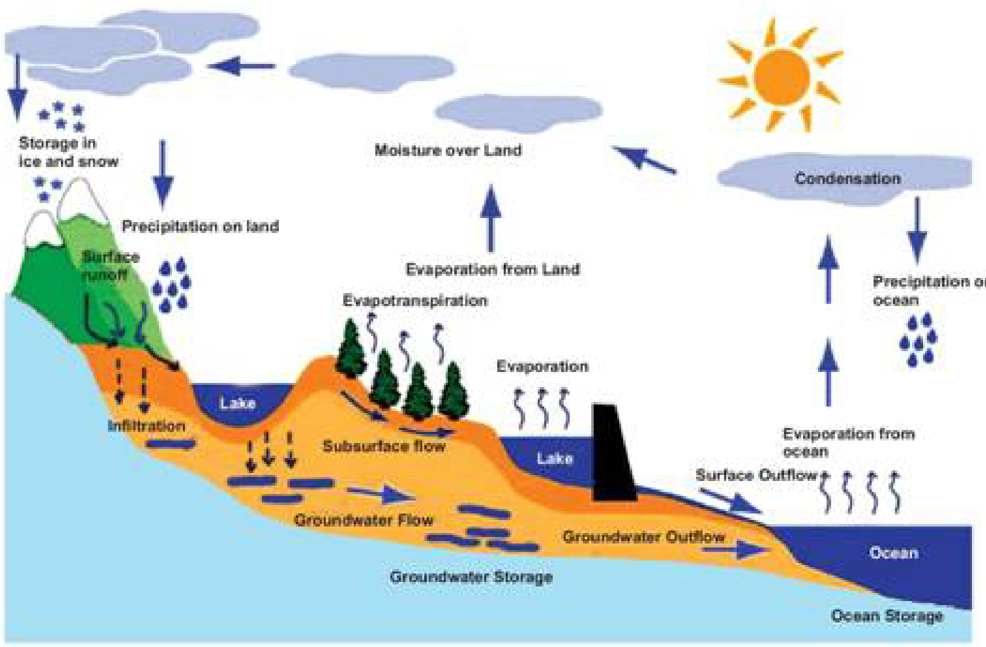

Fig. 4.1: Hydrological cycle.

i) **Precipitation:** Precipitation includes all forms in which atmospheric moisture descends to earth: rain, snow, hail, sleet and dew. The moisture that enters the atmosphere by the vaporisation of water condenses either into liquid (rain) or solid (snow, hail and sleet) before it can fall (Fig. 4.2). Water returns to the land and the sea from the atmosphere by means of condensation, deposition and precipitation. **Condensation** is defined as the process by which water changes from vapour phase to a liquid state (in the form of dew droplets). **Deposition** is the process by which water changes directly from a vapour into a solid (ice crystals) phase. In the atmosphere tiny droplets of water and ice crystals produced through condensation and deposition form clouds. The major amount of water on earth, is received as rainfall.

The water cycle in nature is sustained by energy from the sun. Solar energy evaporates water from the sea and the land. Water vapours condense in the atmosphere to form clouds which are transported to long distance by wind currents. Rainfall and melted snow replenish water in rivers, which carry it back to the sea.

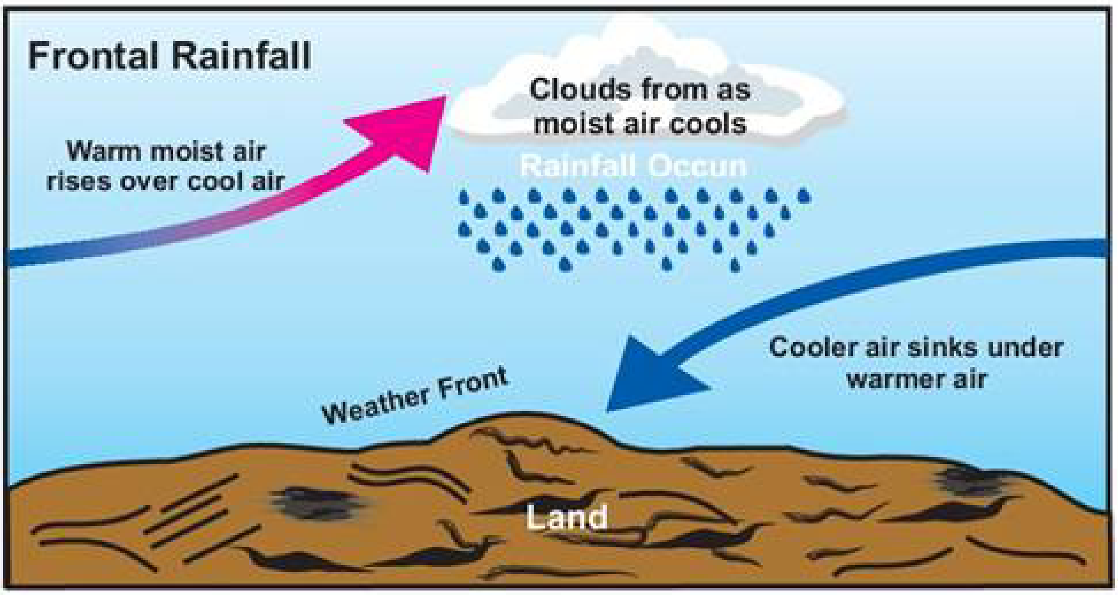

Fig. 4.2: Relative humidity for a given parcel of moisture laden air varies with temperature.

ii) **Run off:** Some of the rainfall is soaked into the soil and excess water flows over the land surface along the natural slope of the area. Run off is the main source of water for lakes and rivers which ultimately drain into the sea. The flowing water acts as an agent of soil erosion and weathering of the underlying rock. Excessive run off during the rainy season causes flood in many parts of our country.

iii) **Sublimation:** It is the process by which solid water changes directly to vapour phase without passing through the intervening liquid phase. The gradual disappearance of flakes of ice during the periods when the temperature remains well below freezing is an example of sublimation.

iv) **Evaporation:** It is the process by which liquid water changes into vapour at ambient temperature. Water evaporates from all aquatic bodies as well as from wet surfaces. Evaporation from the ocean surface is by far the largest source of atmospheric water vapour.

v) **Transpiration:** It refers to the loss of water in vapour form from plant leaves. On land, transpiration is considerable. For example, the loss of water through transpiration alone by one hectare (2.5 acres) of corn approximately amounts to 35,000 litres (8800 gallons) of water each day.

After learning the cycling of water in nature you would like to know about the different types of water found on the earth.

4.3.2 Forms of Water

Water exists on land in three forms viz: fresh water,brackish water and marine water.

Fresh Water

Water, a universal solvent, invariably contains many soluble salts. In fresh water the total salt content remains under 1.5 per cent. Different types of soluble salts released by weathering of rocks, soil erosion and decay of organic matter, readily dissolve in water. Dissolved salts have particular significance for floating aquatic vegetation and phytoplankton.

Brackish Water

The content of dissolved salts in brackish water is higher than the fresh water and ranges between 0.5 and 3.5%. These waters of intermediate salinity range are distinct from fresh or marine waters. In an estuary which represents the tail end of a river, mixing of fresh water with sea water results in brackish water.

Marine Water

The sea water is highly saline. The average salinity of sea water remains almost constant at 35 parts of salt per 1000 parts of water by weight and is written as 3.5%. Some salt lakes may also have salinity levels up to and above 35%. The biotic activity in such habitats is greatly restricted.

4.3.3 Over Exploitation of Surface and Groundwater

Water which falls in the form of precipitation moves down into soil and through rocks and gets accumulated as **ground water.** The layer of rock through which it percolates down is known as **aquifer** and water can be utilised by digging out wells. Ground water can be found in two layers of the soil. The **zone of aeration,** where gaps in the soil are filled both with air and water. Further down there is a **zone of saturation** where in the gaps are filled up completely with water. Water table is the boundary between the saturated zone and unsaturated zone in rock and it rises and drops drown with increase or decrease in the amount of ground water. Ground water provides a constant supply to us for different purposes and this is not likely to dry up under natural conditions.

Box 4.1 : Ground Water Depletion

Ground water is a major source of drinking water. Its usage has been estimated at around 50% but much of its availability is dependent on the rainfall and recharge conditions. While the demand is on the rise, it has also led to water scarcity, and where available it is affected by pollution, depriving millions of people an access to safe drinking water. This kind of crisis is more a human made crisis than a natural one. The extraction levels have gone up and even the farming and industrial sectors are increasingly using the water from wells. The crisis can be attributed to lack of adequate water conservation methods, inefficient use of water, poor ground water recharge and lack of quality in fresh water sources. The water pollution is marked by excess fluoride, arsenic, iron, salt and organic matter.

Source: *http://edugreen.teri.res.in/explore/water/water/ground.html*

The surface water includes the streams, ponds, lakes, human-made reservoirs and canals, and freshwater wetlands. As part of water cycle the surface water bodies are considered renewable resources though they are dependent on other parts of water cycle.

Agriculture is by far the biggest consumer of water. Almost 70% of available water is consumed every year in agricultural production worldwide. In Asia, it accounts for 86% of total annual water withdrawal, compared with 49% in North and Central America and 38% in Europe. The Green Revolution in India ushered in an era of energy and resource intensive agriculture. Water was a critical input to the Green Revolution, through irrigation, flood control, and drainage, and it has contributed most to the growth in wheat and rice production for the past 40 years.

Implications for future agricultural production are to develop water efficient measures giving more productivity per unit of water input. This would require efficient operation of irrigation systems; technologies that reduce water consumption, appropriate soil and water conservation measures, changes in cropping patterns and the ways in which crops are grown, so as to use water more efficiently.

Similar standards would need to be set and enforced for industries to cut down on water use and prevent them for discharging polluting effluents into water bodies.

4.3.4 Degradation of Water Sources

The depletion of water resources and their contamination making them unfit as a source of water for human consumption. It is a major problem today. Most of our water bodies like rivers, lakes, oceans, estuaries and ground water bodies are facing severe pollution due to intensive agriculture, urbanisation, industrialisation and deforestation. Siltation of rivers and lakes due to soil erosion progressively reduces their water holding capacity resulting in ravaging floods year after year. Today we are faced with the paradoxical situation of lack of safe drinking water in above-average rainfall areas and regions having abundant water bodies.

Discharge of sewage and industrial effluents into water bodies not only pollute water but often lead to an increase in the growth of aquatic plants and algal blooms in water bodies, ultimately causing them to disappear. This may also cause the decay and destruction of various organisms in water, e.g., fish.

4.3.5 Floods and Droughts

Floods are the most common of all natural calamities. Floods regularly claim over 20 thousand lives and adversely affect 75 million people annually world wide. Bangladesh alone accounts for about two-third of global loss of life due to floods. India accounts one fifth of global death count and loss of Rs. 600 million every year on an average. More than the loss of life and damage to property, millions of people are displaced every year due to floods in the South Asian countries.

A flood is the discharge of water that exceeds the canal capacity of the river. Floods are caused by different factors that include:

It is possible to reduce the adverse effects of floods by:

- construction of dams and reservoirs at appropriate places;

- strengthening the embankments on rivers and canals;
- improving the carrying capacities of rivers, canals and reservoirs by periodical desilting and deepening operations;
- diversion of flood waters from a river or a channel into other canals and channels;
- introducing flood plain management techniques; and
- preparing ponds, reservoirs, tanks and leading channels by removing obstructions and avoiding constructions.

It is now easy to predict or forecast onset of floods before hand by the advancement in science and technology. The damage to property and loss of life or displacement of people can be reduced if only the concerned agencies coordinate their activities and act in time to address the calamity.

Like flood a **'drought'** can be defined as a prolonged period of unusually dry weather, with little rainfall, in a region where rains are normally expected. As such a drought differs from a dry climate which is usually associated with a region that is normally or seasonally dry. Droughts often last for years. Drought is a creeping calamity because it develops slowly and has a prolonged existence. Droughts are not confined to any particular tectonic or topographic setting and their impact often extends over large areas and regions. The impact of drought affects the developing countries more severely than the developed countries. Crop losses hunger and malnutrition cause immense misery to the poor people.

Box 4.2 : A Case Study of Drought in Rajasthan

Rajasthan, the largest State in India with a land area of 342,239 sq. km and an estimated population of about **54 million** was in the grip of a **severe drought in the year 2000.** Out of the 32 total districts in the State drought was prevalent in 31 districts and among these 25 districts were affected severely. 73.64% villages were under the clutches of drought; affecting nearly 33.04 million people and 39.97 million cattle. The severity of the drought can be judged from the fact that **out of a total of 2647 major water reservoirs only 300 were filled up. Also, nearly 75 to 100% of crops was destroyed due to water scarcity.** All this caused loss of livelihood leading to mass migration in search of employment.

Source: *http://www.un.org.in/UNDMT/states/rajas/dstatus.html*

Though climate is usually the prime trigger of drought, the situation is often made worse by the way people use the water resources. Felling trees for firewood, denuding the forest for agricultural or housing purpose, mining, unscientific farming methods and indiscriminate drawing of ground water cause drought. It is argued that serious droughts in developing countries are more a function of global developmental policies than climatic conditions.

Droughts produce series of direct and indirect impacts that usually extend far beyond the area that is experiencing the actual water shortage. These may be classified as:

- Economic – Loss of crop, dairy, livestock, fishery produce;
- Environmental – Damage to plant and animal species, erosion of soils; and
- Social – Food shortage, damage to health, conflicts between water users.

It is possible to take precautions in drought prone areas by constructing reservoirs, educating people in water conservation, scientific farming and optimal use of ground water resources. Since many parts of India are prone to drought, government agencies maintain a stock of food grain to meet the scarcity to crop failures.

Water Harvesting Measures: One of the effective measures to combat drought and resulting water shortage is to adopt rain water harvesting measures. Water harvesting can be undertaken through variety of ways by:

- capturing runoff from rooftops;
- capturing runoff from catchments;
- capturing seasonal floodwaters from local streams in ponds and reservoirs; and
- conserving water through watershed management.

These techniques can serve the following purpose:

- Provide drinking water
- Provide water for irrigation
- Increase groundwater recharge
- Reduce storm water discharges, urban floods and overloading of sewage treatment plants
- Reduce seawater ingress in coastal areas.

At the **local** level, several water management strategies are in use today, that offer practical and sometimes superior alternatives to the large-scale centralized, capital-intensive approaches to water management. They can also complement wider reaching water management approaches.

Several methods are being used in the traditional system of water harvesting in different regions of the country. For example, *johads*, *talaabs* as surface water bodies and *kunds* (underground tanks) are in vogue in many parts of the country. In the North-eastern Hills bamboo drip irrigation is practiced to conserve water (Fig. 4.3).

In a cold desert area like Spiti in Himachal Pradesh, *kul* irrigation is practiced since ancient times. *Kuls* (see Fig. 4.4) are diversion channels made to carry water from glaciers to villages. The *kuls* often span long distances, some being 10 km long and run down precipitous mountain slopes.

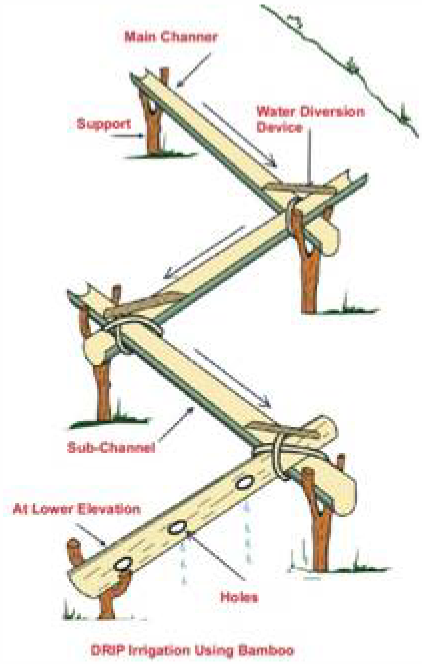

Fig. 4.3: Bamboo drip irrigation.

KUL

- *Kuls* are water channels found in precipitous mountain areas. These channels carry water from glaciers to villages in the Spiti valley of Himachal Pradesh & Jammu.
- Where the terrain is muddy, the *kul* is lined with rocks to keep it from becoming clogged.
- Some *kuls* are 10 km long, and have existed for centuries.
- The crucial portion of a *kul* is its head at the glacier, which is to be tapped. This must be kept free of debris.
- In the village, the *kul* leads to a circular tank from which the flow of water can be regulated.

Fig. 4.4: Kuls in the Spiti area.

Several methods are being followed by individuals, and communities in urban as well as rural areas to harvest rain water. One such scheme is operational in the Rashtrapati Bhavan.

In Rashtrapati Bhavan an underground tank of 1 lakh litre capacity has been constructed to store water for low quality use (see Fig. 4.5). Rainwater from the northern side of roof and paved areas surrounding Rashtrapati Bhavan is diverted to it.

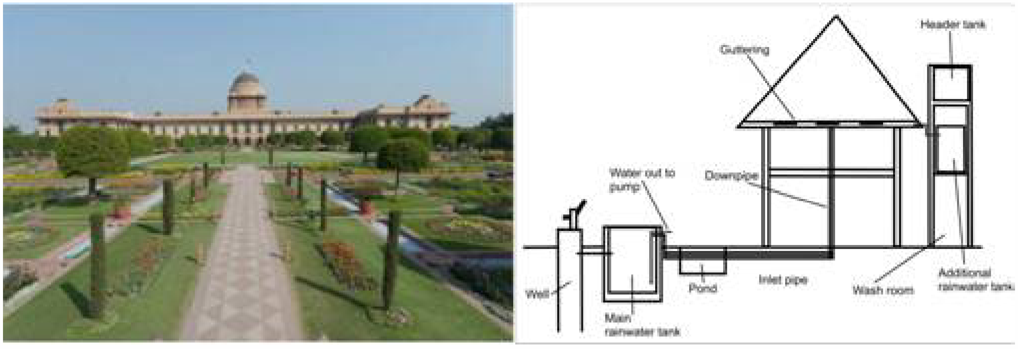

Fig. 4.5: Rainwater harvesting in Rashtrapati Bhawan.

Two dugwells are used to store overflow from the 1 lakh litre rainwater storage tank. Another dry open well is recharged with rainwater from the southern side of the roof and runoff from the staff residential area. A desilting tank is used to remove pollutants from the water passing into the recharge well. (see fig. 4.6)

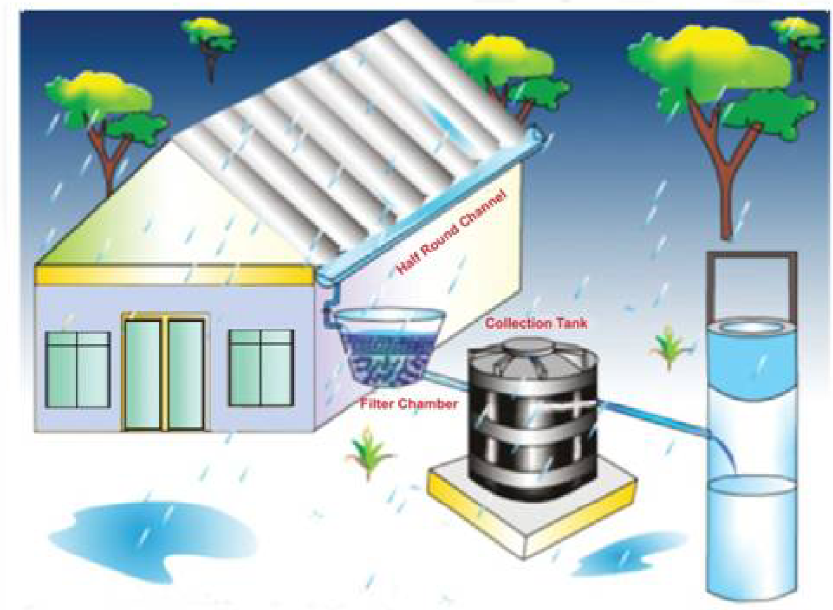

Fig. 4.6: Rain water harvestig.

Box 4.3 : Water Harvesting measures by Hyderabad Metropolitan Water Supply and Sewerage Board

The Hyderabad Metropolitan Water Supply and Sewerage Board (HMWSSB) has set up an ambitious plan of taking up several water harvesting measures in twin cities of Hyderabad and Secunderabad and its vicinity through active involvement of people to improve the ground water level. The Water Harvesting measures, under the Neeru-Meeru (Water and You) Programme, include construction of a recharge pits or a mini-treatment units, planting saplings or any other action that would improve water recharge and green cover which ultimately increase the ground water levels. Different opinion makers like ex servicemen, retired officials, women's groups and NGOs were sensitised on motivational aspects and techniques of various water harvesting structures. The trained groups would in turn reach out to communities and motivate the people highlighting the importance of rainwater harvesting and its benefits. As part of the strategy, the Board has recently created water soldiers, by sensitising ex-servicemen recently. It had also proposed to involve the student community in a big way so that the schools and colleges and other institutions would contribute to the cause of improving ground water table.

Source: http://www.hyderabadwatr.gov.in/RWH_Note.html

4.3.6 Conservation and Management of Water Resources

Water is increasingly becoming a scarce commodity. Its scarcity threatens us all - jeopardizing our livelihoods, and sometimes endangering our lives. For many millions of people, freshwater scarcity is defined as much by *poor quality* as by *insufficient quantity*. As reported in 2001 by the United Nations Population Fund (UNFPA), within the next 25 years, one-third of the world's population will experience severe water scarcity. Right now, more than 1 billion people lack access to safe drinking water and 3 billion people (half of the Earth's population) lack access to basic sewage systems. More than 90 % of all the sewage produced in the developing countries returns untreated to land and water. Unless water resources are managed properly, we will keep facing paradoxical situations like lack of drinking water due to pollution even in above-average rainfall areas.

As populations increase and economic development intensifies, critical policy decisions would need to be taken on a long-term basis for **regenerating, regulating**, **allocating**, and **using** water resources. In future, conflicting demands will increasingly be felt between the needs for safe drinking water and sanitation as well as industrial and agricultural activities.

Management of water resources means a programme to provide an adequate supply of good quality of water for various uses without endangering the life of the source or the reserve of water. In other words, efforts should be made to see that: (i) water of the right quality is available for all kind of uses and (ii) there is no misuse or wastage of this precious resource.

Water management includes recharging the reserves of groundwater and diverting supply from an area of surplus to the region of scarcity.

Recharging of groundwater is the most important aspect of the water management. In the mountains and hills, the watersheds are covered with vegetation. The litter-covered soil of the watershed allows infiltration of rain water, which finds its way to the aquifers.

In urban and rural areas, storm water, used water or domestic drains can be fed into pits, trenches, or any depression, where it can filter underground. Flood water can be injected into aquifers through a series of deep pits or it can be spread on the fields through a network of ditches.

The excess flow of normal as well as flood water can be diverted to areas where there is scarcity of water. This will not only remove the danger of damage caused by floods but will also benefit the regions of scarcity.

By proper treatment of the domestic and municipal waste water, one can obtain a supply fit for many industrial and agricultural purposes. The treatment of waste water involves removal of pollutants, germs, and toxic elements as you have already studied in the previous section.

Desalination of sea water

By use of solar energy, sea water can be distilled, thus fresh water of good quality can be obtained. This method of desalination of sea water is being used in our country at places like Bhavnagar in Gujarat (Fig. 4.7) and Churu in Rajasthan.

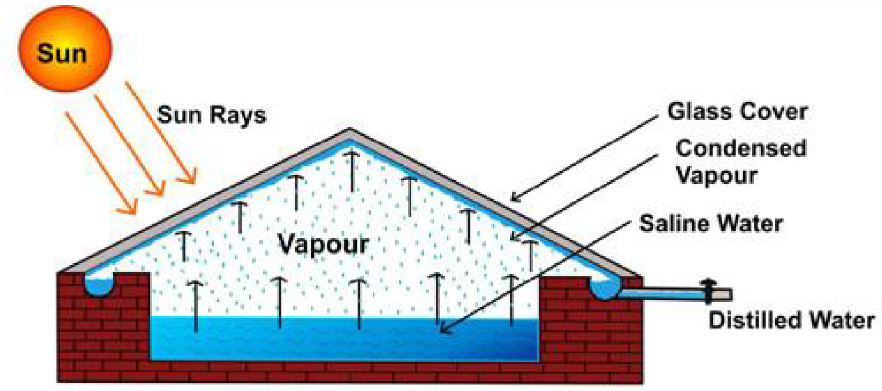

Fig. 4.7: Desalination of sea water by use of solar energy.

Reducing over consumption

Using more water than necessary is an unpardonable waste of the precious and scarce resource. In our country, a lot of water is wasted due to leaking taps and bad plumbing. There is also need for a check on excessive irrigation.

Waste water

Domestic and municipal waste water is rich in organic nutrients. If this kind of water is made free from disease carrying germs and poisonous elements, it can be used for irrigation of farms, gardens and other vegetations (Fig. 4.8).

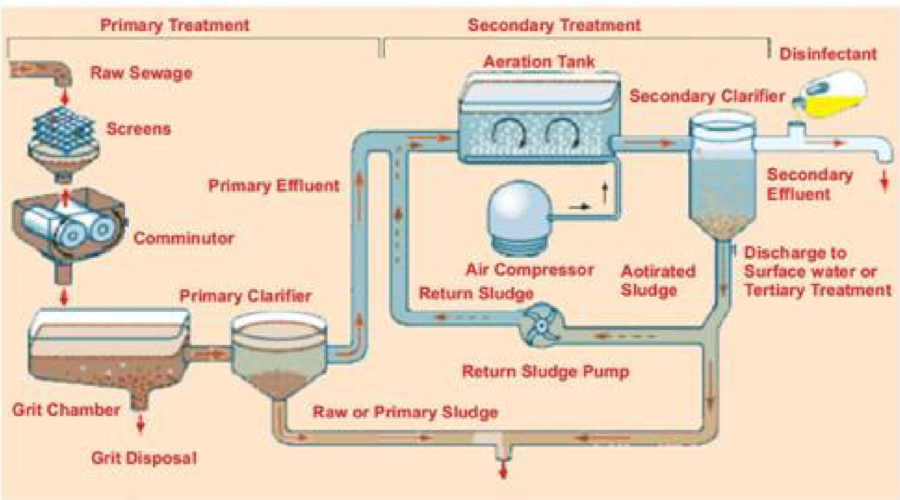

Fig. 4.8: Domestic and municipal waste water treatment.

For the removal of germs and toxic elements, the waste water or sewage is treated in a tank or in ponds for several days. In doing so, the heavy particles settle down to the bottom by themselves, while the finer particles are made to settle down by adding alum and caustic soda. The clear liquid is then allowed to pass through filters or sand or earth and finally air is blown through it. This treatment not only removes carbon dioxide and hydrogen sulphide which is generally dissolved in waste water, but also adds oxygen to the filtered water, thus helping in purification. Treatment of water with appropriate doses of chlorine, known as chlorination, kills all the harmful germs and makes water usable. Growing of algae or water hyacinth, a wild plant that grows in floating masses in rivers and lakes serves a double purpose. It cleans the water of pollutants like phosphates and nitrates that act as nutrients for these plants, and these plants can also be utilised for the production of biogas.

SAQ 1

Fill in the blanks with appropriate words and check your answer given at the end of this unit:

i) ……………… is one of the most important substances for sustaining human life.

ii) Movement of water on the ……………… is continuous.

iii) Water a universal ……………… invariably contains many soluble ………………

iv) Agriculture is by far the biggest ……………… of water.

v) A ……………… is the discharge of water that exceeds the canal capacity of the ………………

vi) The Krishna ……………… reached its decision in 1973.

vii) ……………… methods are being used in tradition system of water ……

4.4 NON-RENEWABLE LAND RESOURCE

After learning about the renewable resources like water and forests, you would like to know what are our non-renewable resources such as land, mineral oceanic resources. These resources can neither be regenerated nor expanded.

Land resources

Land is a basic resource for us. As you have learnt in the previous section, it is, in fact, the foundation on which the entire ecological system rests and it is the living ground (habitat) for all terrestrial plants and animals. The capability of land to support life and various activities of man and animals is dependent both on its biological productivity, and load bearing capacity of the soil and rocks.

Land is under great pressure due to increase in population. Our land mass which was, in 1901, inhabited by 238 million people, is now shared by more than 1200 million people. Mismanagement of the land resource as a result of indiscriminate cutting of trees or deforestation has caused considerable damage to the quality of the soil and landscapes.

Soil resources

Soil, which forms the uppermost layer of the land, is the most precious of all resources, because it supports the whole life system, provides food and fodder in the form of vegetation and stores water essential for life. It contains sand, silt and clays, mixed with air and moisture. It possesses rich organic and mineral nutrients.

The type of soil varies from place to place. Those soils which are rich in organic matter are fertile. Fertility is also dependent on the capacity of the soil to retain water and oxygen. The following major types of soil are shown in the outline map of India (Fig. 4.9).

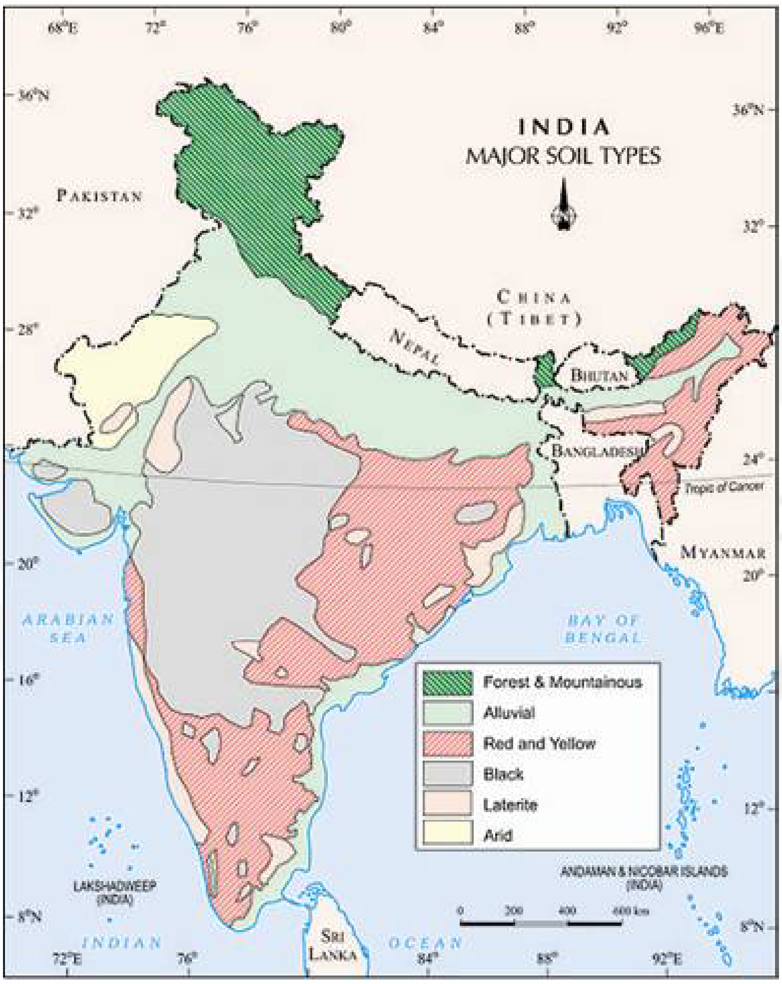

Fig. 4.9: Major Soil types of India.

1. **Red soil** is found on plateaux and lowland areas of eastern Bihar, Madhya Pradesh, Jharkand, Chhatisgarh, Odissha, Kerala, Karnataka and Andhra Pradesh, where rainfall is between 100-300 cm/year and temperature remains above 22°C. The soil supports rain forests and grasslands and is good for cultivation of potatoes, bananas, pineapples and rubber.

2. The type of soil found on the Deccan and Malwa plateaux of western and

central India has a cover of clay and is **loamy and black**. It is very fertile and supports mixed grasslands, forests, crops of sugarcane, groundnut, soyabean, cotton and rice.

3. The **soils of the desert region** of western and north-western India are low in organic matter and generally considered to have low fertility. However, if water is provided they can be made very fertile.

4. Another type of soil forms part of the Indo-Gangetic plains extending in the delta regions on the coasts of Bengal, Odisha, Andhra Pradesh, Tamil Nadu, Kerala and Gujarat. This soil is characterised by **loamy texture, dry composition** and variability of thickness from place to place. The soil is highly productive and supports crops of all kind.

5. The soil that forms part of the low-lying wetlands or marshy land in the deltas of Ganga, Godavari, Krishna, Kaveri and in the river basins of Kerala, contains rich organic matter such as decomposed farmyard manure (dung) and plant material (wood peat), and as such is very fertile.

6. The soil found on the mountainous Himalayan region, which is ash **grey to pale yellow-brown in colour**, has low fertility and supports oak and coniferous plants such as pines and deodar.

4.4.1 Processes Involved in the Soil Formation

The processes which are involved in the formation of soils can be studied under the following headings:

Weathering of Rocks

The processes involved in the formation of soil are slow, gradual and continuous. The sum total of natural processes resulting in the disintegration of parent rocks is collectively known as 'weathering', and it involves physical, chemical and biological agencies.

Physical Weathering

Mechanical forces acting upon the rocks cause physical weathering. Temperature fluctuations cause expansion and contraction of rock surface resulting in the formation of cracks and fissures. During cold weather, the water present in rock crevices gets frozen and the formation of ice results in its expansion. The force of expansion causes breaking up of rock. Broken rock fragments roll down the slopes and break further into smaller pieces. Hails, rainfall and fast flowing streams are important agents of physical weathering. Wind is another agent of physical weathering particularly when it carries sand particles which causes abrasion of rock surface, due to friction. In the Vindhyan hill forests, it is commonly seen that tree roots often penetrate through the rock crevices and in course of time, with the radial growth of roots, the rocks get disintegrated.

Chemical Weathering

The rocks while getting disintegrated may also undergo chemical change.

Water is an important agent in bringing about chemical changes due to dissolution or reaction of one or more components of rock materials. Presence of dissolved materials and warm temperature favour chemical weathering. Another very important process of chemical weathering is through hydrolysis in which water dissociates (particularly in the presence of carbon dioxide and organic acids) into H^+ and OH^- ions which act on silicates like orthoclase to produce silicate clays. Oxidation and reduction reactions and carbonation are other important means of chemical weathering.

Mineralisation and Humification

As a result of physical weathering, the rocks are broken down into smaller particles. But this is not the true soil, and plants cannot grow well in the disintegrated rock material alone. The weathered material, however, undergoes further changes, that you would study in this section. You might have noticed that during weathering, mostly physical and chemical factors are involved. For the further development of soil, that is mineralisation and humification, mainly the biological agents are involved.

During the early stages of soil formation, organic matter in the soil is not very high, as the vegetation and the soil fauna are not much developed. In such soils, algae, lichens, mosses, and other small form of plants grow and contribute organic matter through their death and decay. In due course of time, various types of plants, animals and microorganisms colonise such soils. They also contribute organic matter to the soil, in the form of wastes or their dead remains. This organic debris then break down into simpler products. This breakdown process, also known as decomposition, is brought about by different kinds of microorganisms such as bacteria and fungi. They break the organic substances into various compounds such as polysaccharides, proteins, fats, lignins, waxes, resins and their derivatives. These compounds are further broken down into simple products such as carbon dioxide, water and minerals. This latter process is called mineralisation. The residual, incompletely decomposed organic matter left after mineralisation is called **humus** and the process of its formation as humification. Humus is an amorphous, colloidal and dark substance that is the source of energy and nutrients for most soil microorganisms. Humus is important, as it gives the soil a loose texture ensuring better aeration. Being colloidal in nature, it has a great capacity for imbibing and retaining water and nutrients. Humus greatly improves the soil fertility.

4.4.2 Changes Caused by Agriculture and Overgrazing

The changes in environment caused by man through his agro-pastoral activities can be divided into two types for the sake of simplicity: (a) changes brought about by traditional agriculture; (b) changes brought about by modern agriculture. The characteristics of traditional agriculture include defacement of land, deforestation coupled with loss of soil structure, soil erosion and depletion of soil nutrients. Overgrazing, is also a bye-product of efforts to exploit the land resources for maximum livestock production. While modern agriculture continues to share the disruptive effects of traditional agriculture on environment. It also affects certain changes in environment characteristic only of modem agricultural practices. For example, excessive irrigation causes twin problems of salinisation and water logging resulting from rise in water table apart from causing depletion of ground water resources. Similarly, addition of chemical fertilisers increases the rate of depletion of micronutrients from soils and eutrophication of water bodies and nitrosoamenia in children. The use of plant protection chemicals poisons the food products and sometimes kills non-target friendly organisms. Likewise, use of high yielding varieties makes the agriculture market-oriented, encourages monoculture causing eruption of epidemics and depletion of genetic diversity.

4.4.3 Land Degradation

Land degradation refers to the process of deterioration in the quality of land (Fig.4.10). In a general way, it has been defined as a reduction in the capacity of the soil to produce in terms of quality, quantity, goods and services. Human activities which result in land degradation include **deforestation, farming, damming of rivers, industrialisation, mining, developmental works such as human settlements, roads and highways, and networks for transport and communication.**

Fig.4.10: Land degradation due to agricultural mismanagement and deforestation.

Natural disasters, such as droughts, floods, landslides and earthquakes also contribute to land degradation. Land use has undergone tremendous change as human societies evolved through the ages. However, in the pre-industrial era, nature’s restorative ability could take care of these changes. In recent times, the over exploitative use of land and soil degradation have assumed alarming proportions. Table 4.2 gives the extent and causes of major land degradation in the world.

Table 4.2: Extent and causes of land degradation of the world

Extent of Degradation	Causes of land degradation
580 million ha	**Deforestation**-Vast reserves of forests have been degraded by large scale logging and clearance for farm and urban use. More than 200 million ha of tropical forests were destroyed during 1975-1990, mainly for food production.
680 million ha	**Overgrazing** – About 20 per cent of the world's pasture and rangelands have been damaged. Recent losses have been most severe in Africa and Asia.
137 million ha	**Fuel wood consumption** – About 1730 million m^3 of fuel wood is harvested annually from fomrests and plantations.
550 million ha	**Agricultural mismanagement** – Loss of soil due to water erosion is estimated at 25,000 million tonnes annually. Soil salinization, water logging, chemical degradation and desertification affect about 40 million ha of land globally.
19.5 million ha	**Industrialization and urbanization** – Urban growth, road construction, mining and industry are major factors in land degradation in different regions. Valuable agricultural land is often lost.

Source: FAO, 1996

Land and Soil

Environmental degradation has not only led to lowering of water tables but also to land degradation, soil erosion, and desertification. Table 4.3 gives the worldwide statistics for land use. Notice that only about 10 per cent of the world's land area is arable (able to be tilled for crops) or under permanent crops such as orchards, plantations or vineyards. The remaining area is too steep, too cold, too hot, too wet, or too dry for cultivation.

Table 4.3: World land use, 1972 and 1987.

Land Use	World Area (1000 ha)	
	1972	1987
Total area	13,389,001	13,389,055
Land area	13,073,849	13,076,536
Arable and permanent crops	1,413,990	1,473,699
arable	1,322,797	1,373,200

Permanent crops	91,193	100,499
Permanent pasture	3,226,013	3,214,352
Forest and woodland	4,195,500	4,068,536
Other land	4,238,344	4,519,949

Source: Food and Agriculture Organization, *Production Yearbook 1989*, vol. 42, Statistics Series 88, Rome.

In India, between 30 and 50 per cent of private and common land is estimated to be ecologically degraded to varying degrees and is generally referred to as "wasteland", that is land not producing its potential of biomass due to ecological degradation, over exploitation or the absence of a clear management system.

Wasteland development involves *regenerating the land through a variety of soil and water management practices, planting appropriate plant species, protecting them and sharing the benefits*.

The following programmes are being implemented currently as part of the national effort towards wasteland development:

- Integrated Wastelands Development Project (IWDP) schemes
- Technology development extension and training scheme
- Support to NGOs/Voluntary agencies (grant-in-aid) scheme
- Investment promotional schemes (IPS)
- Wastelands development task force (WDTF)

The Society of Promotion of Wasteland Development (SPWD) has undertaken Charagah development in Rajasthan as one of its major activities. Charagahs are common lands allotted for cattle grazing in a village. In dry land areas like Rajasthan, the role of common lands is crucial in the maintenance of cattle population. Small farmers depend on Charagahs as fodder availability on their own lands is poor especially in the months when no fodder is available at all. Thus, the development of Charagahs assumes importance. The following experiences reflect a measure of success in development of wasteland through voluntary effort supported by government agencies.

Box 4.4 : The Case of Prayatna Samiti

Prayatna Samiti is an NGO involved in regenerating forestland and panchayat lands in villages of Gudli-Bambora region of Girwa block in Udaipur district, Rajasthan. Its work on Charagah protection was started by constructing cattle proof trenches/stone walls around the common land. Appropriate soil and water conservation measures and plantation were undertaken along with dibbling of seeds (grass and trees). The market value of grass produced in these Charagahs in four years was to the tune of Rs.32.5 lakhs. Apart from making fodder available, these efforts led to regeneration of local species and greatly reduced levels of soil erosion. More information about this effort can be obtained from

Source : http:/www.humanscapeindia.net/humanscape/new/june02/thecostof.html.

Box 4.5: The Case of Hanuman Van Vikas Samiti

The Society for Promotion of Wastelands Development works with Hanuman Van Vikas Samiti in Tonk village of Udaipur district since 1994. Due to soapstone mining in the charagah land by local residents, it was badly degraded. In addition, a major portion of the land was encroached upon by some influential people. Meetings were held with the village community to create awareness, remove encroachment and to stop mining. Self-help groups formed by Hanuman Van Vikas Samiti played a vital role in facilitating community action. A charagah management committee was formed to manage this work. Financial support was provided for the **boundary wall, trench, pit digging, gully plugs/check dam, plantation, dibbling of grass and tree seeds**. The employment generated through these activities was to the tune of around 4,500 human days. In comparison, a similar period of soapstone mining would provide 2000 human days/year. Grass production from the charagah increased from 6 to 44 tonnes. The per family grass availability was 155 kg while the per animal availability was 27 kg during 2000-2001. An investment of Rs.3.77 lakh was made for the development of fifty hectares of land. Hence, the average cost per hectare with local contribution was Rs.7,540. At the prevailing rate of grass, its total value is estimated to be Rs.1.93 lakhs.

More information about this effort can be obtained from:

Source : http:/www.humanscapeindia.net/humanscape/new/june02/thecostof.html.

Soil is literally the material we live on. It is the material that supports what we build, treats our waste, and purifies our water. Use of soil for any purpose changes it - some of these changes may be good, many are not. Some of the severest challenges confronting agriculturists today are soil erosion, soil salinity, soil pollution and maintenance of soil fertility.

Soil Erosion is the process in which the top layers of soil are removed and carried away from one place to another by wind or water. In this process, mineral particles, organic matter, and nutrients from the soil are removed, reducing its thickness and water-holding capacity. Eroded soil may then become a pollutant in streams and reservoirs. The time required to form new soil is so long that from human viewpoint, soil lost through erosion is lost forever. A host of practices such as bunding, mulching and soil moisture conservation needs to be adopted at a large scale to prevent soil erosion.

One way of achieving and maintaining a fertile soil is to apply organic material in the form of green manures, straw or as manure which has already undergone a high degree of fermentation. This improves the cohesiveness of the soil, increases its water retention capacity and promotes a stable aggregate structure.

In arid and semi-arid regions, too much or too little irrigation can lead to an increase in soluble salts, rendering the soil **saline** or **alkaline** and thus unfavourable for plant growth. As water evaporates from the soil, salts such as chlorides, sulfates, and bicarbonates of sodium, calcisum and magnesium accumulate in it. The most effective treatment of alkaline soils is to apply "gypsum". A good drainage system must also be provided to assist with washing out the sodium from saline soils. Only the most salt-tolerant species can be grown in areas with severe soil salinity.

4.4.4 Land Use Planning and Management

Land is an exhaustible resource and is very sensitive to changes in climate and physical processes. Land should be used according to its suitability and capability. As you have studied in earlier sections, suitability and capability of land is assessed in terms of its load bearing ability and fertility.

Since food for an increasing population requires more land for cultivation, the encroachment of fertile agricultural lands for non-agricultural purposes like construction of roads and buildings should be reduced to the minimum. Extreme care should be taken in selecting sites for development of industries, construction of dams and water reservoirs and mining so that the environment and socio-economic conditions of the people living in that area are not disturbed.

Hill areas, as far as possible, should be put under forest cover because forests serve as a resource for fuel, fodder, and timber, and provide space for animal farming (Fig. 4.11). Besides, forests help in increasing the ground water, since they impede the free surface run-off, thus allowing water to be absorbed by the ground. In this process, soil erosion is minimised and flooding can be avoided.

Fig. 4.11: An ideal land use in the hill region.

Let us see what are the essential components of land management.

Soil Management

As we have said before, soil is a precious resource which takes millions of years to form, and hence proper management of soil is very necessary. The management of the soil is two-fold i.e. (a) to minimise or check soil erosion and (b) restore productivity of the soil.

(a) (b) (c)

Fig. 4.12: a) Drainage system for preventing uncontrolled flow of water; b) & c) Check dams for preventing the flow of running water.

Control of soil erosion

The most significant measures for control of soil erosion are: growth of grasses, shrubs and trees on soils i.e; construction of a drainage system which can prevent free, uncontrolled flow of water (Fig. 4.12a). Water flow causes formation of narrow channels or gullies and leads to development of deep narrow valleys leading to ravine land. The famous Chambal ravines (Fig. 4.13) have been formed as a result of deep soil erosion and the process is still continuing. This can be controlled by constructing a series of check dams which prevent the flow of running water and widening of gullies (Fig. 4.12b & c). Formation of a broad wall of stone along the coasts of Maharashtra, Kerala, Andhra Pradesh and Odisha has proved to be very effective in controlling erosion by sea waves and currents. Movement of sand by gusts of wind in the deserts and sandy coasts can be prevented by putting barriers of trees and shrubs across the path of wind (Fig. 4.14). In the mountain and hilly areas, planting of stems and branches of self propagating trees and shrubs, not only strengthens the slope of the terrace but also provides fuel wood and fodder to the farmers.

Fig. 4.13: Chambal ravines.

Fig. 4.14: Checking movement of sand gust by erecting barriers of trees and shrubs.

On the vulnerable slopes, a cover of vegetation is provided and in the beginning, seeds are covered with coir netting pegged firmly to the ground (as shown in Fig. 4.15). Netting checks erosion, holds the soil material together and adds nutrients. The quick growth of grass stabilises the soil.

Fig. 4.15: Plantation of vegetation cover and brush wood or coir netting on the slopes of mountain.

Treatment of soil sickness

Due to overuse without rest, soil becomes deficient in the requisite nutrients and loses its fertility. Rotation of vegetables, such as peas and beans, helps to remove the deficiency of nutrients. Legume plants such as peas add nitrogen to the soil and thus increase its binding property as well as productivity. The roots and off-shoots of the crops and their remains are left in the field for a certain period of time to protect the soil from erosion.

It is found that excessive irrigation causes complete saturation or water logging of the soil, which consequently loses productivity, partially or completely. As a result of over irrigation in some areas, salinity and alkalinity of the soil increases, making it "sick". This kind of soil sickness can be controlled by, first of all, sealing off all points of leakage canals, reservoirs, tanks and ponds, and use of only the required amount of water.

SAQ 2

Fill in the blanks with appropriate words and check your answer given in the end of this unit:

i) …………….. forms the upper most layer of ……………..

ii) Mechanical forces acting upon the rocks cause physical ……………..

iii) …………….. is a by-product of efforts to exploit the land resources for maximum …………….. production.

iv) Land ………..… refers to the process of deterioration in the quality of land.

v) ………… are common lands allotted for cattle grazing in a ……………..

vi) Land should be used according to its …………….. and ……………..

vii) Excessive irrigation course complete …………….. or water logging of the ……………..

4.5 SUMMARY

In this unit we have tried to view the natural resources land and water and principle of their management and conservation.

- Water is renewable resource whereas land is a non-renewable resource.
- Degradation in physical resources such as land and water results mainly due to exploitative activates of humans in the fields of agriculture, industry and urbanisation.
- Conservation in agriculture can be affected by changes in land use pattern, conservation of irrigation water, minimising use of pesticides and fertilisers and implementation of innovative and environmentally sound agricultural techniques.

4.6 TERMINAL QUESTIONS

1. What are renewable and non-renewable resources? Explain with the help of examples.
2. Discuss the various ways of water conservation.
3. Describe the essential components of land management.

4.7 ANSWERS

Self-Assessment Questions

1. i) Fresh water; ii) Earth; iii) Solvent, Salts; iv) Consumer;

   v) Flood, River; vi) Tribunal; vii) Several, Harvesting

2. i) Soil, Land; ii) Weathering; iii) overgrazing, Livestock; iv) Degradation
   v) Charagahs, Village; vi) Suitability, Capability; vii) Saturation, Soil

Terminal Questions

1. Refer to Section 4.2 for its answer.
2. Refer to Sub Section 4.3.6.
3. Refer to Section 4.4.4

4.8 FURTHER READING

1. Bharucha, E. (2005) *Textbook of Environmental Studies for Undergraduate Courses,* Hyderabad: Universities Press (India) Private Limited.
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5. Wright, R. T. (2008) *Environmental Science: Towards a Sustainable Future* New Delhi: PHL Learning Private Ltd.

Acknowledgement

1. Fig. 4.4: Kuls in the Spiti area.

   (Source: <https://image.slidesharecdn.com/ traditionalwaterharvestinginindia1-130531120014-phpapp01/95 /traditional-water-harvesting-in-india-part-1-12-638.jpg?cb=1370002112>;

   Source: http://www.rainwaterharvesting.org/methods/traditional /kul2.jpg)

2. Fig. 4.9: Major Soil types of India.

   (Source: https://upload.wikimedia.org/wikipedia/commons/b/be/Major_soil_types_in_India.jpg)

3. Fig. 4.10 Land degradation due to agricultural mismanagement and deforestation Source:https://en.wikipedia.org/wiki/Land_degradation#/media/File:Karst_following_phosphate_mining_on_Nauru.jpg

4. Fig. 4.11: An ideal land use in the hill region.

   (Source: https://upload.wikimedia. org/wikipedia/commons/thumb/7/78/080110_zell_mosel.JPG/1200px-080110_zell_mosel.JPG)

5. Fig. 4.12: (a) Drainage system for preventing uncontrolled flow of water, (b) & (c) Check dams for preventing the flow of running water.

   (a) Source: https://pixabay.com/photos/white-water-cascade-flow-stream-983997/

   (b) Source:https://en.wikipedia.org/wiki/Manimuthar_Dam#/media/File:Manimuthar_Dam_f.jpg

   (c) https://en.wikipedia.org/wiki/Dam#/media/File:Lake_Parramatta,New_South_Wales.jpg

UNIT 5

FOREST RESOURCES

Structure

5.1 INTRODUCTION

In the previous unit, you have studied about land and water as resources. In the present unit we shall discuss about the forest as a resource. You must have read in your Social Sciences text book about the early humans who were basically wanderers in the forest. They used to derive food, clothing and shelter from the forest. Later on, human being started settled life by clearing forest. But, life was still highly dependent on forests in a symbiotic manner. After industrial revolution in 18th century, humans began to exploit forest in a ruthless manner without considering its negative impact on the earth and its environment.

In this unit, we will describe economic, ecological and socio-cultural significance of forest as a resource in section 5.2. In section 5.3, explanation for various causes and consequences of deforestation are presented followed by some selected case studies in section 5.4 and 5.5. In the final section i.e. Section 5.6, methods of conservation and management of forest resources are being described.

Expected Learning Outcomes

After studying this unit you will be able to:

- ❖ describe significance of forest as a resource;
- ❖ explain various causes and consequences of deforestation;
- ❖ analyse impact of mining, dam building and other developmental activities on environment, forest and biodiversity;
- ❖ highlight the impact of mining and dam building and other developmental activities on forested People and their rights through various case studies; and
- ❖ describe various methods of conservation and management of forest resources.

5.2 FOREST AS A RESOURCE

Forests are our treasures which provide us a wide variety of commodities such as timber, fuel wood, fodder, fibre, fruits, herbal drugs, cosmetics and many types of raw materials used by the industries. A great variety of mammals and birds which live in the forests, serve as useful living resources (Fig. 5.1). Forests play a great role in soil formation, water conservation and regenerating of oxygen. Trees fix CO_2 in their biomass and through transpiration (loss of moisture to atmosphere) they moderate the climate. Can you imagine what would happen if forest does not exist in the world. As mentioned above, it performs certain functions which can be directly observed. But there are certain functions which cannot be directly observed like purification of air, carbon sink etc.

Fig. 5.1: Forest Supports many Forms of Life. a) A Nilgai Antelope Calf; b) Elephant Feeding on Yellow-bark Acacia Tree.

Broadly, all the above mentioned functions performed by the forest can be categorised under three major headings: economic, ecological and social.

i) Economic Significance

Forest is one of the largest available renewable resources on the planet earth. It provides a wide variety of goods and services which include food, fodder and fuel. Wood is used for making houses, furniture, matches, ploughs, bridges and boats. Forest products such as tannins, gums, spices, waxes, honey, musk, and hides are all provided by the flora and fauna of forests.Fruits, leaves, roots and tubers of plants form the food of forest tribes.Wood and bamboo pulp are used for manufacturing paper and rayon. The flora and fauna of the forest also holds the key to numerous life sustaining products such as pharmaceuticals, insecticides and pesticides. These substances should be harvested sustainably so that it could enhance the long term resource value of the forest.

ii) Ecological Significance:

As mentioned above forest performs certain function like moderation of global climate, supporting natural ecological systems and processes. Let us discuss them in detail:

a) **Moderation of global climate:** Forests stabilise global climate in a significant manner by influencing natural cycles such as hydrological and carbon cycles. You might have read about these cycles when you were in school. As you know, spatial as well as temporal patterns of rainfall are greatly influenced by forest. How much of water is retained in the soil, and how much flows away, sometime causing floods, also depends on tree cover. Similarly forest can also influence the atmospheric carbon dioxide level. Tree biomass holds carbon dioxide in a fixed state. Therefore, forest acts as a major source of carbon sink i.e. ability to absorb carbon dioxide from the atmosphere.In other words, a carbon sink is a natural or artificial reservoir that accumulates and stores some carbon-containing chemical compound for an indefinite period. When wood is burnt CO_2 is released in the atmosphere. This has a direct impact on the extent of greenhouse effect and global warming. In other words, more forests lead to greater removal of atmospheric carbon dioxide during photosynthesis resulting reduction of the greenhouse gases in the atmosphere. Therefore, large-scale afforestation has been adopted as a measure to reduce greenhouse effect.

b) **Protection of biodiversity:**Forests are the greatest repository of biodiversity on the land as they provide ideal conditions for the survival and growth of living organisms. The number of species per unit area is much greater in a forest than in any other terrestrial ecosystem. For example, the tropical rainforest covers less than 7% of the earth's land surface but accounts for more than 50% of all known species. About 62% of all known plants are found in these rainforests. That is why there has been a growing campaign for saving the rain forest in Amazon and Nile basin. The growing awareness about the importance and necessity to conserve biodiversity is helping human being to realise the significance of forest. Do you think this awareness or campaign is sufficient to protect rain forest? Think about it? We will discuss some of the conservation measures in the last section of this unit.

c) **Supporting natural ecological systems and processes:** As mentioned earlier forests perform certain activities which are crucial for supporting ecological systems and processes directly. Some of these functions and processes are as follows:

- Forests check the soil erosion by preventing the action of winds and water thereby preserves the fertile top soil.
- It prevents landslides and reduces the intensity of cyclones and floods.
- By preventing soil erosion, forests reduce silting of water bodies including reservoirs.
- Forest improves air quality by absorbing toxic gases and particulate matter.
- It protect watersheds and ensure perennial supplies of fresh water.

iii) **Socio-cultural significance:** As mentioned in the introduction, forests have been part of our social and cultural ethos since the inception of civilization. We find signs of such cultural bonds even in today's modern and materialistic life. This is largely because forests have significant aesthetic, recreational and spiritual value.

I am sure, till now, you must have realised the importance of forest as a resource. You might be reading in the newspapers or might have watched in the television about clearing of forests for urbanisation, mining, establishing industries, construction of dams, railway lines, roads etc. Do you know rate of deforestation is so high the world over that it has started affecting our life. In the following section we will discuss about extent, causes and consequences of deforestation.

SAQ 1

Answer the below given question within 30 words.

i) How does the forest act as a carbon sink?

ii) State any three socio-cultural significance of forest.

5.3 DEFORESTATION: CAUSES AND CONSEQUENCES

Deforestation refers to the permanent removal or destruction of indigenous forests. Today, it has been roughly estimated that the indigenous forest cover constitutes 21% of the earth's land surface. According to the World Resources Institute, deforestation is regarded as one of the world's most pressing land-use problems. Another major concern is the rate at which deforestation is occurring. Currently, 12 million hectares of forests are cleared annually. Almost all of this deforestation occurs in the moist forests and open woodlands of the tropics. It has been predicted that if deforestation continues at this rate then all the moist tropical forest could be lost by the year 2050, except for isolated areas in the Amazon and the Zaire basin, as well as a few protected areas within reserves and parks.

In India, forests cover 24.39 percent of the total geographical area. However, it is assessed that the country needs 33% of its area under forests to meet the ecological and economic needs.

5.3.1 Causes of Deforestation

Let us discuss some of the major causes of deforestation all ouer the world in general and India In specitic.

i. **Population Explosion:**Increasing human population is one of the major causes of deforestation. It poses a major threat to the environment. Vast areas of forest land are cleared (Fig. 5.2) to reclaim land for expansion of farming land, mining activities, creation of new and expansion of existing human settlements, and development of infrastructure like roads and railway tracks. Growth of population increases the demand for forest products like timber, firewood, paper and other valuable products of importance, all necessitating felling of trees.

ii. **Forest Fires:** This is also another major cause of deforestation. Forest fires occur either naturally or are human induced. Some of the major causes of forest fires are as follows:

Fig. 5.2: Logging operation in the forest .

- Dry humus and organic matter forming a thick cover over the forest floor provides ideal condition for ground or carelessly surface fires.Throwing burning cigarette stubbs on dried foliage can light a fire.
- Crown fire takes place in densely populated forests where tree tops may catch fire by heat produced by the constant rubbing against each other.

Fire destroys fully grown trees, results in killing and scorching of the seeds, humus, ground flora and animal life.

iii) **Grazing of Animals:** Trampling of the forest soil in the course of overgrazing by livestock has far reaching effects such as loss of porosity of soil, soil erosion and desertification reduced productivity of the previously fertile forest area.

iv) **Pest Attacks:** Pests destroy trees by eating up the leaves, boring into shoots and by spreading diseases.

5.3.2 Consequences of Deforestation

Forests are closely related with climate, biological diversity, wild animals, crops and medicinal plants. Large scale deforestation has far-reaching consequences:

i) Habitat destruction of wild animals. Tree-using animals are deprived of food and shelter.

ii) Increased soil erosion due to reduction of vegetation cover.

iii) Reduction in the oxygen liberated by plants through photosynthesis.

iv) Increase in pollution due to burning of wood and due to reduction in carbon dioxide fixation by plants.

v) Decrease in availability of forest products.

vi) Loss of plant, animal and microbial diversity.

vii) Scarcity of fuel wood and deterioration in economy and quality of life of people residing near forests.

viii) Lowering of the water table due to more run-off, and resultant increased use of the underground water.

ix) Rise in carbon dioxide level in the air due to burning of vegetation has caused global warming resulting in melting of ice caps and glaciers and consequent flooding of coastal areas.

SAQ 2

Fill in the blanks with appropriate words

i) In India, forests cover _______ percentages of the total geographical area but the country needs _____ percentages of its area under forests to meet the ecological and economic needs.

ii) ___________ fire takes place in densely populated forests.

iii) Deforestation leads to reduction in the _________ liberated by plants through _____________

5.4 IMPACT OF MINING AND DAM BUILDING ON ENVIRONMENT, FOREST AND BIODIVERSITY

Timber extraction, mining and construction of dams are invariably parts of the needs of a developing country like India. Unfortunately forests are located in areas where there are rich mineral resources. Mineral based industries like iron and steel, aluminia refinaries etc. are also located in these areas. Out of the top mineral producing districts in the country, almost half of the districts are predominantly tribal dominated. The average forest cover in these districts is 28 per cent, much more than the national average of 20.9 per cent (Centre for Science and Environment, 2008). Forests also cover the steep embankments of river valleys, which are ideally suited to develop hydel and irrigation projects. Thus, there is a constant conflict of interest between conservation and development. What needs to be understood is that long-term ecological gains cannot be sacrificed for short-term economic gains that unfortunately lead to deforestation. These forests where development projects are planned can displace thousands of tribal people who lose their homes when these plans are executed.

Floods, droughts and landslides become more prevalent in such areas. Forests are the repositories of invaluable gifts of nature in the form of biodiversity and by destroying them, we are going to lose these species even before knowing their significance as well as benefits. These species could be having marvellous economic or medicinal value and deforestation results in loss of this storehouse of species which have evolved over millions of years in a single stroke.

5.5 EFFECT ON TRIBAL POPULATION AND THEIR RIGHTS

Poverty amidst plenty, nature is bountiful but tribals are poor. This statement explains the conditions of majority of tribal population in our country. Tribal dominated areas of the country have rich forest cover, mineral bearing areas, and significant number of watersheds of key rivers. Forest provides food, medicine and other products needed for tribal people and plays a vital role in the life and economy of tribes living in the forest. As mentioned in the previous section, due to developmental activities like construction of dams, mining, establishment of mineral based industries etc. alienated tribal people from their own land. This alienation deprived them from their livelihoods. Most of them are dependent upon natural resources based informal economy. Their natural resource based informal economy is mostly dependant on agriculture, both settled and jhum and on the other non-timber forest product (NTFP) such as medicinal herbs, edible flowers, leaves and fruits. They also get their small timber and firewood from the forest.

Hence development is bound to affect their agricultural and forest land which is the primary source of their livelihood. The development process pushes them from an informal to a formal economy that is new to them without any preparation. They had depended on agricultural land and forests, both of which they loose to the project. When they receive compensation it is monetary with which most communities living in the informal economy are nor familiar. As mentioned above in most cases the Common Property Resources are not compensated. Therefore, there was a need to address these problems. Government of India passed an act in the Parliament titled 'The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006' to address this anomaly (See Box 5.1).

Boc 5.1 : The Scheduled Tribes and Other Traditional Forest Dwellers Act, 2006

An Act to recognize and vest the forest rights and occupation in forest land in forest dwelling Scheduled Tribes and other traditional forest dwellers who have been residing in such forests for generations but whose rights could not be recorded; to provide for a framework for recording the forest rights so vested and the nature of evidence required for such recognition and vesting in respect of forest land.

And whereas, the recognised rights of the forest dwelling Scheduled Tribes and other traditional forest dwellers include the responsibilities and authority for sustainable use, conservation of biodiversity and maintenance of ecological balance and thereby strengthening the conservation regime of the forests while ensuring livelihood and food security of the forest dwellings Scheduled Tribes and other traditional forest dwellers;

And whereas, the forest rights on ancestral lands and their habitat were not adequately recognised in the consolidation of state forests during the colonial period as well as in independent India resulting in historical injustice to the forest dwelling Scheduled Tribes and other traditional forest dwellers who are integral to the very survival and sustainability of the forest ecosystem.

And wherea, it has become necessary to address the long standing insecurity of tenurial and access rights of forest dwelling Scheduled Tribes and other traditional forest dwellers including those who were forced to relocate their dwelling due to state development interventions.

Source : https://indiacode.nic.in/bitstrean/123456789/2070/1/A/2007-02.pdf

SAQ 3

Answer the below given question within 30 words.

i) Name any four non-timber based forest product (NTFP).

ii) How do Forest Right Act 2006 enable tribals and other forest dwellers in strengthening the con servation of the forests while ensuring the livelihood and food security?

5.6 CONSERVATION AND MANAGEMENT OF FOREST RESOURCES

As a result of increased exploitation of forests for timber, firewood and other forest products, without putting in adequate efforts to regenerate them, the forests are known to be fast disappearing. This has caused an environmental imbalance. For example, most of the rainwater is lost as runoff which flows over the mountain slopes unchecked often causing floods. The excessive washing away of top soil results in low fertility and reduces crop yields. It is because of these consequences of deforestation, a strong forest policy has been adopted by our Indian Government to protect forests and to plant more trees. Some of the conservation measures practiced in India and other parts of the world are as follows:

i) **Increase in area of forest plantation:** The Tree plantation can be raised in vacant or unused lands and waste, degraded and marginal lands, especially on road side, along railway tracts, on contours and on land not suited for agricultural production. Planting trees outside forest areas will reduce pressure on forests for timber, fodder and fuel wood. Apart from this, the deforested areas need to be reforested.

ii) **Developing alternative sources and promoting the substitutes:** It has become necessary to find alternative fuels as well as raw materials to manufacture paper, sports goods, packing cases, furniture and beams used in buildings. Research is going on to develop alternate sources; in some cases, plastics and composite materials have been successful in replacing the use of timber.

iii) **Increase the area of forest permanently reserved for timber production:** The most serious impediment to sustainable forest management is the lack of dedicated forests specifically set aside for timber production. If the forest does not have a dedicated long-term tenure for timber production then there is no incentive to care for the long-term interests of the forest. FAO (2001) found that 89 per cent of forests in industrialized countries were under some form of management but only about six per cent were in developing countries. If 20 per cent could be set aside, not only could timber demand be sustainably met but buffer zones could be established to consolidate the protected areas.

iv) **Adoption and promotion of sustainable management of forest:** Achieving ecological sustainability means that the ecological values of the forest must not be degraded and if possible they should be improved. This means that **silviculture** and management should not reduce biodiversity, soil erosion should be controlled, soil fertility should not be lost, water quality on and off site should be maintained and that forest health and vitality should be safeguarded. However, management for environmental services alone is not economically and socially sustainable. It will not happen until or unless the developing nations have reached a stage of development and affluence so that they can accommodate the costs of doing so. There are vast areas of unused land some of which is degraded and of low fertility. Technological advances are being made to bring this land back into production. This should be a major priority since a significant proportion of cleared tropical forest will eventually end up as degraded land of low fertility.

v) **Developing a reliable mechanism of information base and regular monitoring**: Knowledge of how much forest, where it is and what it is comprised of seems to be straightforward. However, surprisingly, this most basic information is not always available. It is not possible to properly manage a forest ecosystem without first understanding it. Remote sensing technologies make it feasible and affordable to identify hotspots of deforestation. The international community could undertake monitoring efforts that would have immediate payoffs. A priority is to fund and coordinate basic monitoring on the rate, location and causes of global deforestation and forest poverty along with the impacts of project and policy interventions.

vi) Establishing an effective system of fighting forest fires:

vii) Strictly enforcing laws to deal with unauthorized cutting of trees.

viii) **Promoting agro-forestry and social forestry**: Rural people partly meet their needs for fire wood and small timber by growing fast growing trees planted within the limits of their village, along the footpaths, roadsides, alongside railway tracks, side roads or canals and streams, boundaries of fields and empty spaces. The aim of social forestry is to meet the needs of fuel, fodder, fruits, timber and other requirements of local people.

ix) **Participatory forest management and rights:** All stakeholders with an interest in the fate of the forest should be involved in planning, management and benefit sharing. The balance of rights can be tilted strongly toward society in the form of publicly owned strictly protected areas. State ownership and management can be retained but with sustainable timber extraction allowed. As of now much of the world's tropical forest are state owned but community participation in forest ownership and management needs to be encouraged. Land reform is essential in order to address the problem of deforestation. However an enduring shift in favour of the peasants is also needed for such reforms to endure. Moreover the rights of indigenous forest dwellers and others who depend on intact forests must be upheld. Therefore, the recognition of traditional laws of the indigenous peoples as indigenous rights will address the conflicts between customary and statutory laws and regulations related to forest ownership and natural resource use while ensuring conservation of forest resources. Keeping this in view various state Govenment in India has been implementating Joint Forest Management Programme after successful implementation in West Bengal and Haryana in 1970's.

Box 5.2 : Joint Forest Management

The need to include local communities in Forest Management has become a growing concern. Local people will only support greening an area if they can see some economic benefit from conservation. An informal arrangement between local communities and the Forest Department began in 1972, in Midnapore District of West Bengal. JFM has now evolved into a formal agreement which identifies and respects the local community's rights and benefits that they need from forest resources. Under JFM schemes, Forest Protection Committees from local community members are formed. They participate in restoring green cover and protect the area from being over exploited.

Fig. 5.3: Planting pine trees on the steep slopes of mountains.

SAQ 4

Answer the below given question within 30 words.

i) How can we address the conflicts between customary and statutory laws and regulations related to forest ownership and natural resource use?

ii) What is the aim of social forestry?

5.7 SUMMARY

- Functions performed by the forest as a resource can be categorised under three major headings: economic, ecological and social. Ecological functions include stabilising global climate, protect biodiversity and support global ecological system and processes. Forest has also socio-cultural significance in terms of providing ethical, spiritual, recreational and tourist value.

- There are various causes responsible for deforestation. Some of the immediate or explicit causes are logging for wood, land use and land cover change, forest fire and pest attack. Indirect or implicit cause is increasing population.

- Large scale deforestation has far-reaching consequences namely habitat destruction of wild animals and deprivation of food and shelter for tree-using animals; Increased soil erosion; reduction in the oxygen liberated by plants through photosynthesis; increase in pollution due to burning of wood and due to reduction in carbon dioxide fixation by plants; decrease in availability of forest products; loss of plant, animal and microbial diversity; scarcity of fuel wood and deterioration in economy and quality of life of people residing near forests; lowering of the water table due to more run-off, and resultant increased use of the underground water and rise in carbon dioxide level in the air due to burning of vegetation has caused global warming resulting in melting of ice caps and glaciers and consequent flooding of coastal areas.

- There is a constant conflict of interest's between conservation and development. What needs to be understood is that long-term ecological gains can not be sacrificed for short-term economic gains that unfortunately lead to deforestation.
- Developing alternative sources and promoting the substitutes, application of scientific methods, monitoring and management of growth of forests, establishing a system for controlling and preventing forest fire and by strictly implementing forest laws we can conserve our forest resources.

5.8 TERMINAL QUESTIONS

1. Describe the three major functions of forest as a resource.
2. Name the four major causes of deforestation.
3. State any five consequences of deforestation.
4. Why is there a constant conflict of inlerest between conservation and development? Explain with suitable examples.
5. Explain any five conservation measures for forest resources in India.

5.9 ANSWERS

Self-Assessment Questions

1. i. A carbon sink is a natural or artificial reservoir that accumulates and stores some carbon-containing chemical compound for an indefinite period.

   ii. Aesthetic, recreational and spititual value

2. i. 24, 33 percentages

   ii. Crown

   iii. Oxygen, photosynthesis

3. i. Medicinal herbs, edible flowers, leaves and fruits

   ii. The recognised rights of the forest dewelling Scheduled Tribes and ofther traditional forest dwellers include the responsibilities and authority for sustainable use, conservation of biodiversity and maintenance of ecological balance and thereby strengthening the conservation regime of the forests while ensuring livelihood and for security.

4. i. Recognition of traditional laws of the indigenous peoples as indigenous rights.

   ii. The aim of social forestry is to meet the needs of fuel, fodder, fruits, timber and other requirements.

Terminal Questions

1. The three major functions of forest as a resource are economic, ecological and socio-cultural. Explain the three functions in detail with suitable examples. Refer Section 5.2

2. Four major causes of deforestation are : population explosion, forest fires, grazing of animals and pest attacks. Describe the four major causes in detail with suitable examples. Refer Section 5.3

3. Consequences of deforestation are habitat destruction of wild animals, increased soil erosion, reduction in the oxygen liberated by plants, increase in pollution, decrease in availability of forest products, loss of plant, animal and microbial diversity, scarcity of fuel wood and deterioration in economy and quality of life of people residing near forests, lowering of the water table and rise in carbon-di-oxide level in the air (any five)

4. Timber extraction, mining and construction of dams are invariably parts of the needs of a developing country like India. Unfortunately, forests are located in areas where there are rich mineral resources. Mineral based industries like iron and steel, alumina refineries etc. are also located in these areas. Out of the top 50 mineral producing districts in the country, almost half of the districts are predominantly tribal dominated. Forests also cover the steep embankments of river valleys which are ideally suited to develop hydel and irrigation projects.

5. Conservation measures adopted for forest resources in India are developing alternative sources and promoting the substitutes; Increase in area of forest plantation; increase the area of forest permanently reserved for timber production; adoption and promotion of sustainable management of forest; developing a reliable mechanism of information base and regular monitoring; establishing an effective system of fighting forest fires; strictly enforcing laws to deal with unauthorized cutting of trees; promoting agro forestry and social forestry; and participatory forest management and rights.

5.10 FURTHER READING

1. Bharucha, E. (2005) *Textbook of Environmental Studies for Undergraduate Courses,* Hyderabad: Universities Press (India) Private Limited.

2. Botkin, D. B. & Keler, E. A. 8th Ed. (2011) *Environmental Science: Earth as a Living Planet*, New Delhi: Wiley India Pvt. Ltd.

3. Centre for Science and Environment (2004) Rich Land and Poor People, New Delhi: Centre for Science and Environement.

4. Rajagopalan, R. 3rd Ed. (2015) *Environmental Studies*, New Delhi: Oxford University Press.

5. Wright, R. T. (2008) *Environmental Science: Towards a Sustainable Future,* New Delhi: PHL Learning Private Ltd.

Acknowledgement

Fig. 5.1: Forest supports many forms of life a) A Nilgai antelop calf; b) Elephant feeding on yellow bark Acacia tree

Source :

a) https://thefarmatwalnutcreek.com/deer-elk-nilgai-html

b) https://www.countrylife.co.za/conservation/elephant-survivors-damaraland

Fig. 5.2: Logging operations in the forest

Source: https://en.wikipedia.org/wiki/File:Logging Operation on BLSF.jpg

Fig. 5.3: Planting pine trees on the steep slopes of mountains

Source: https://www.denbow.com/wp-content/uploads/2016/10/steep-slopes-1000.jpg

UNIT 6

BIODIVERSITY: VALUE AND SERVICES

Structure

6.1 INTRODUCTION

The earth's biodiversity has taken more than 3000 million years to evolve, and today, it forms the basis for survival of the human species and other life forms on our planet. When we speak of global biodiversity we speak of the totality of genetic strains, species and ecosystems in the entire world.

Many of these ecosystems coexist in larger units called biogeographic regions. W.A. Rodgers and H.S. Panwar of the Wildlife Institute of India grouped India's natural habitats into 10 major biogeographic zones. The climate and biodiversity of ten zones are discussed in this unit. Endangered and endemic species of these zones are also mentioned.

Global biodiversity hot spots, including those in India, which is a megabiodiverse country are also discussed in this Unit.

One way would be to understand the "resource" or "use" value of various components of biodiversity which are used by humans. Biodiversity has also, however, great "non-resource" or "non-use" value such as maintaining ecosystem functions.

Expected Learning Outcomes

After completing the study of this unit you should be able to:

- define biodiversity;
- explain different levels of biodiversity i.e. genetic diversity, species diversity, ecosystem diversity;
- enumerate and analyse the wild life species that occur in the different biogeographic zones of India;
- list global biodiversity hot spots and reasons for varied biodiversity in different ecosystems/countries and discuss the criteria for identifying global biodiversity hot spots; and
- explain the value of diversity in terms of direct vs. indirect use, extractive vs. non-extractive use and resource vs. non-resource use.

6.2 DEFINING BIODIVERSITY

Biodiversity is the diversity of and in living nature. Diversity, at its heart, implies the number of different kind of objects, such as species. However, defining biodiversity or measures of biodiversity is not so simple.

The 1992 Earth Summit in Rio de Janeiro defined biodiversity as:

The variability among living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems.

SAQ 1

Define biodiversity.

6.3 LEVELS OF BIODIVERSITY

There are three levels of diversity viz. **genetic**, **species** and **ecosystem** diversity. In effect, these levels cannot be separated. Each is important, interacting with and influencing the others. A change at one level can cause changes at the other levels.

6.3.1 Genetic Diversity

Genetic diversity is the "fundamental currency of diversity" that is responsible for variation. This is the diversity of basic units of hereditary information which are passed down generations found within a species (e.g. different varieties of the same species). Different varieties of mango or rice are examples of genetic diversity within species.

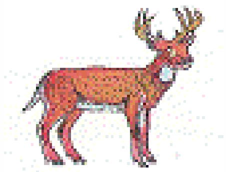
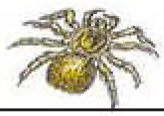
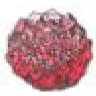
It is genetic diversity that allows a species to adapt to changing environmental conditions such as a lower rainfall, or a higher temperature year round.

6.3.2 Species Diversity

Species diversity means the differences between species (both domesticated and wild). It is the most visible component of biodiversity as implied by the word 'species' which literally means outward or visible form. This is why we often tend to describe biological diversity in terms of the number of species in a particular area or at the global level.

There are different estimates of extant (i.e. currently existing) species on earth which range from about five to 100 million, but a figure of about **12.5 million** is the most widely accepted. Of these, only about **1.7 million species have been described** as yet. In terms of sheer numbers alone, **insects and micro-organisms are the most abundant life forms on earth**. **(Box 6.1)**

Box 6.1: Known species of flora and fauna in the world

	4,500 species of mammals
	10,000 species of birds
	12,000 species of amphibians and reptiles
	22,000 species of fish
	400,000 species of invertebrates (excluding insects)
	960,000 species of insects, approximately 600,000 of which are beetles
	270,000 species of plants
	70,000 species of fungi
	4,000 species of bacteria
	5,000 species of viruses

6.3.3 Ecosystem Diversity

Ecosystem diversity means the variation between different types of ecosystems. Different species of animals, plants and micro-organisms interact with each other and their physical environment (such as water or minerals). Groups of organisms and their nonliving environment, and the interactions between them, form functional dynamic and complex units that are termed ecosystems. These systems help maintain life processes vital for organisms to survive on earth.

Species are not evenly distributed around the globe. Some ecosystems such as tropical rain forests and coral reefs are very complex and host a large number of species. Other ecosystems such as deserts and arctic regions have less biodiversity but are equally important.

It is believed that there is a positive relationship between species diversity and an ecosystem's stability and resilience (i.e. ability to resist disturbances).

An ecosystem having higher diversity means the number of species and interactions between them which constitute the food web, is large (Fig.6.1a). In such a situation, the elimination of one species would have little effect on ecosystem balance. In sharp contrast, the number of species in the food web of a simple ecosystem is small (Fig.6.1b). So loss of any one species has far more serious repercussions for the integrity of the ecosystem itself.

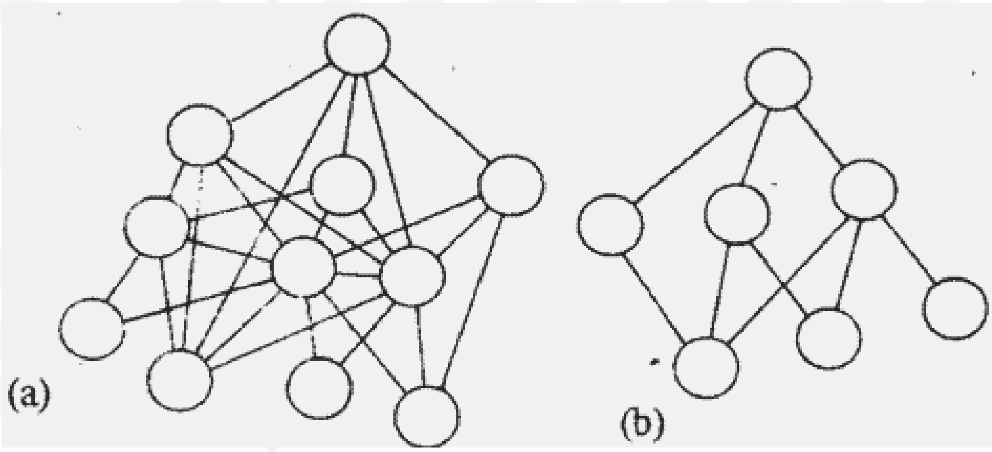


Fig. 6.1: The two illustrations give comparative picture of ecosystems with high: a) and low; b) species diversity. The circles represent. organisms. Note: The complex, linkage in (a) only a few links in (b). The increased numbers of links are believed to confer stability to the ecosystem.

SAQ 2

Differentiate between genetic and species diversity.

6.4 THE BIOGEOGRAPHIC ZONES OF INDIA AND THEIR BIODIVERSITY

The country has been divided into ten biogeographic zones: *Trans-Himalayas, Himalayas, Indian Desert, Semi-Arid, Western Ghats, Deccan Peninsula, Gangetic Plains, North-East India, Islands, and Coasts*. (Fig. 6.2). This classification was developed at the Wildlife institute of India by Rodgers & Panwar (1988) and it is being largely followed. What are these biogeographic zones? These represent the major species groupings. In addition, each of these ten zones indicates a distinctive set of physical, climatic and historical conditions. The Himalayas and Gangetic Plains are examples of two adjacent but obviously extremely different zones.

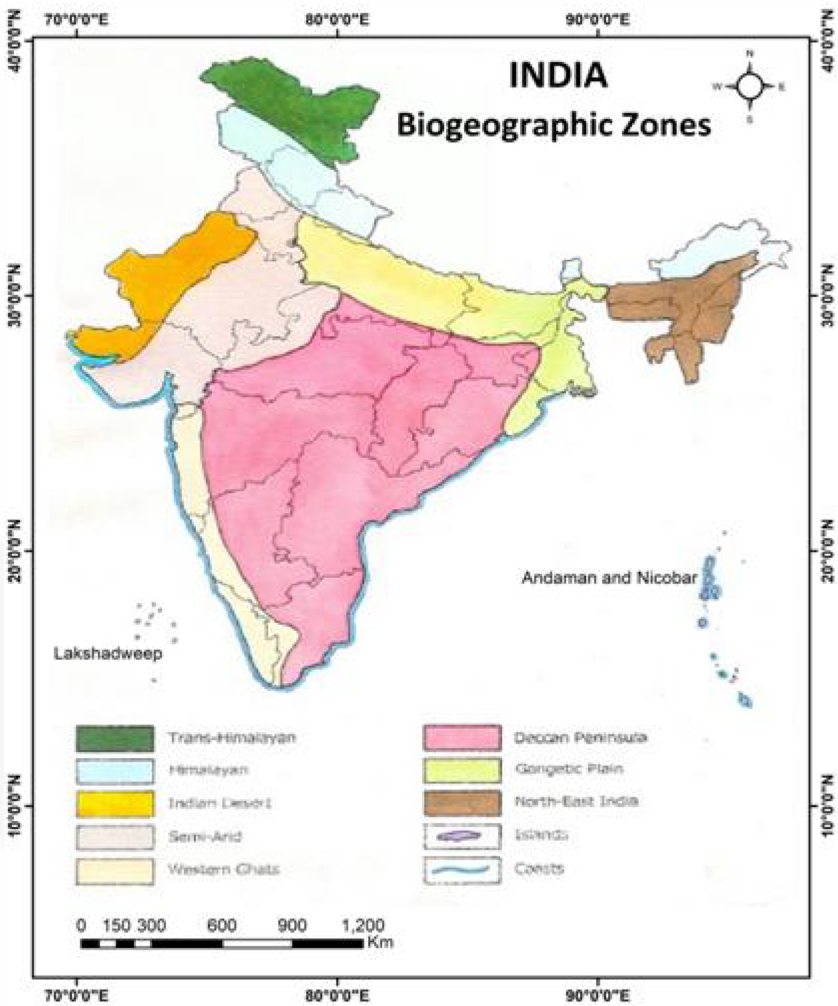


Fig.6.2: The biogeographic zones of India. From: W. A. Rodgers and H.S. Panwar, 1988. Planning a wildlife protected area network in India. Vol. 1, Department of Environment, Forests and Wildlife, Govt. of India.

6.4.1 Zone 1: The Trans-Himalayas

This zone has an area of about 1,86,200 sq. km and it covers mainly Ladakh and Lahul-Spiti. This zone is much more extensive than the area within India. Taking the topography into account, the area comes out to be around 2.6 million sq. km, with altitude between 4,500 and 6,000 m @mean sea level.

The Wildlife of the Trans-Himalayas Zone

This zone represents an extremely fragile ecosystem, because of its harsh climatic conditions and the inhospitable terrain.

The vegetation of Ladakh and Lahul-Spiti is largely a sparse alpine steppe. In addition, several endemic species also occur here. This area within India, along with Pakistan and Tibet, has the richest wild sheep and goat communities in the whole world. There are eight distinct species and sub-species of sheep (Fig. 6.3 a-d).

The flatter plateaux have a distinct grazing community comprising of Wild Yak, Tibetan Ass, Tibetan Gazelle, Ibex and Tibetan Antelope (see Fig. 6.4 a-e). In addition to these herbivores, there is an equally distinctive set of carnivores including Snow Leopard, Indian Wolf, Pallas's Cat, Fox and smaller animals like Marbled Pole Cat, Pika and Marmot (see Fig. 6.5 a-d). Of these the Pallas's Cat is endemic to this area. The lakes and marshes too, have a distinctive avifauna including the spectacular Black-necked Crane, which is a migratory bird. Avifauna refers to the birds of an area collectively.

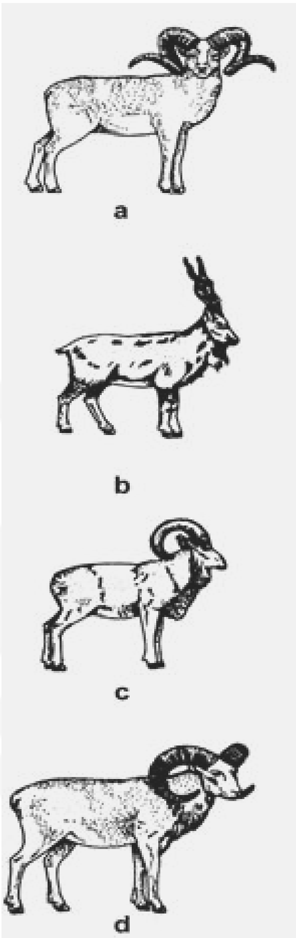


Fig. 6.3: Sheep species found in the Trans-Himalayan zone, a) Urial (*Ovis orientalis*); b) Nayan (*ovis ammon hodgsonii*); c) Marco polo (*Ovis ammon polii*); and d) Markhor (*Capra falconeri*).

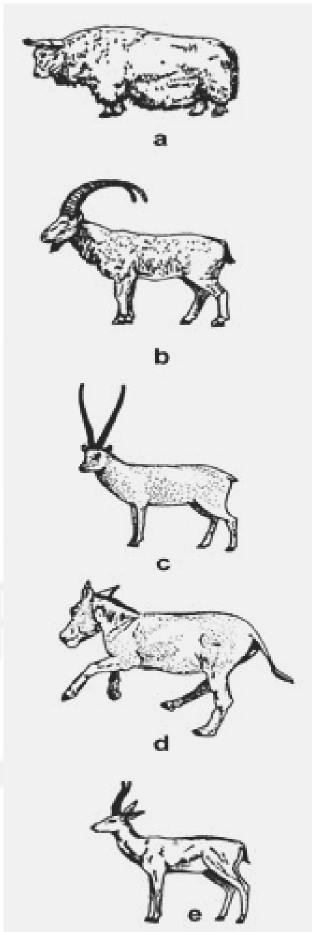


Fig. 6.4: Some herbivores of the trans-himalayan zone, a) Wild yak (*Bos grunniens*); b) Gazelle chinkara (*Gazella gazella*); c) Tibetan ass (*Equus hemionus*); d) Ibex (*Capra ibex*); and e) Tibetan antelope (*Pantholops hedgsoni*).

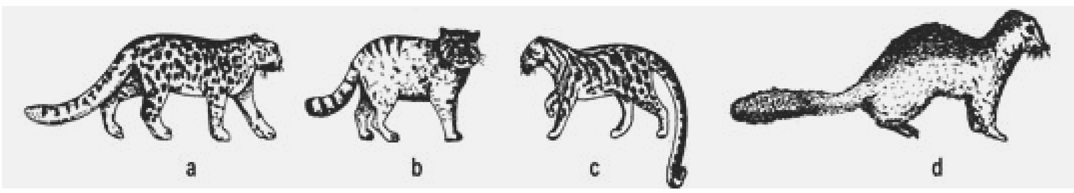


Fig. 6.5: Some carnivores of the trans-himalayan zone, Marmot (*Marmot caudate*).

6.4.2 Zone 2: The Himalayas

The Himalayan mountain ranges in India stretch for over 2,000 km from east to west.

The Wildlife of the Himalayan Zone

The Himalayan zone is one of the richest areas of India in terms of habitat and species diversity.

First let us look at the wildlife within the altitudinal and longitudinal range of Himalayas. These are:

i) The **lower sub-tropical foot-hills**. These have typical mixed deciduous community merging into Chir Pine (Fig. 6.6a) and then Ban Oak.

ii) The **temperate areas**. These lie below 3,500 m. This zone has a complex mixture of vegetation types with forests of Maples (Fig. 6.6b) and Walnuts, Moru and Oak (Fig. 6.6c), and a variety of conifers such as the Blue Pine, Fir and Spruce (Fig. 6.6d-g).

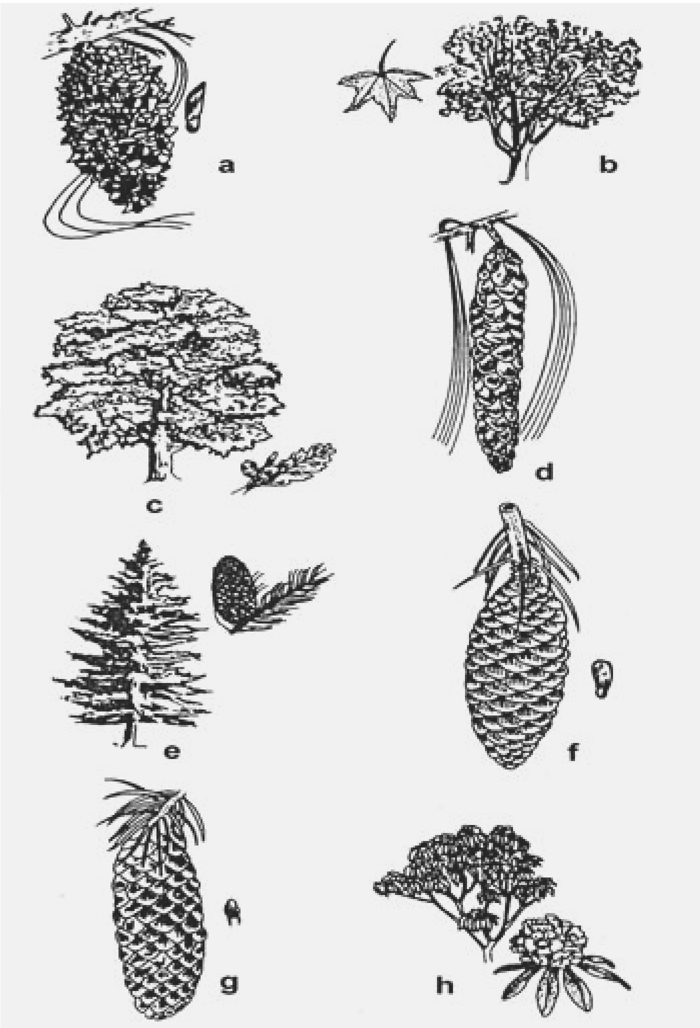


Fig. 6.6: Some representative members of the Himalayan vegetation, a) Chir pine (*Pinus roxburghii*) a cone; b) Maple (*Acer* sp.); c) Oak (*Quercus* sp.); d) Blue pine (*Pinus wallichiana*) a cone; e) Fir (*Abies* sp.). Tree and a cone; f) Spruce (*Pieea smithiana*) found in Western-Himalayas, a cone; g) Spruce (*Pieea spinulosa*) from Eastern Himalayas, a cone; h) Rhododendron (*Rhododendron* sp.)

iii) The **sub-alpine area**. This area has forest and scrub vegetation of Birch and Rhododendrons (Fig. 6.6h) interspersed with grasslands with several kinds of herbs.

iv) **The Western Zone**: This is a comparatively drier area with Deodars (Fig. 6.7) and Blue Pine.

v) **The Central Zone**: There is a poor representation of large herbivores. Ibex, Markhor and Hangul populations have dwindled significantly.

vi) **The Eastern Zone**: Mishmi Takin a herbivore, is found here (Fig. 6.8). This area has a higher tree line, and supports arboreal forest animals at higher altitudes.

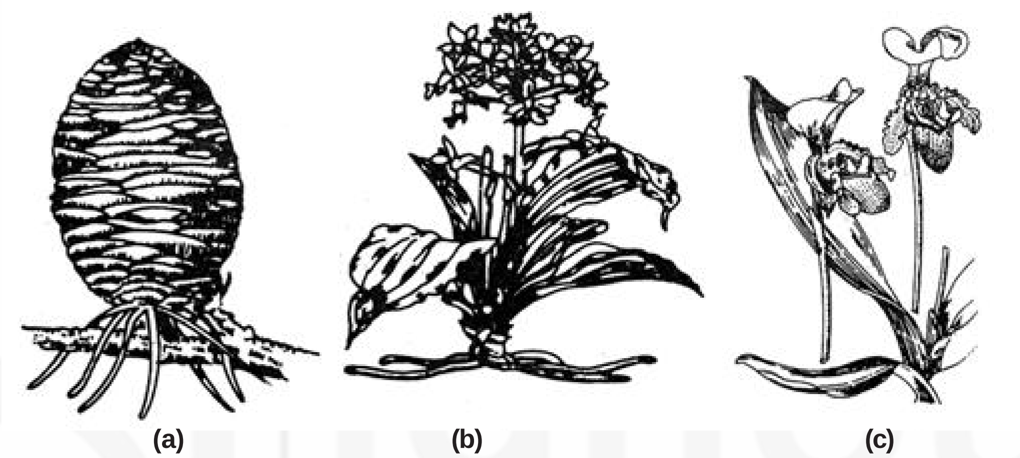


Fig. 6.7: Deodars, *Cedrus deodara* predominates the western zone of Himalayas, b,c) Orchids constitute characteristic vegetation of the Eastern Himalayan zone.

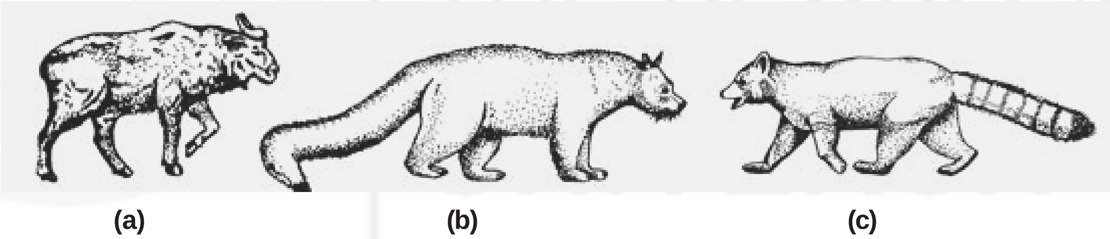


Fig. 6.8: Some animal species of the Eastern Himalaya, Takin (*Budorcas s.p.)*

Endemism is high in nearly all groups of plants and animals found here. In addition to the endemic species there are quite a few endangered species in high altitude region.

6.4.3 Zone 3: The Indian Desert

This zone is located in the western part of the country and is also known as the Thar desert. It covers west Gujarat and west Rajasthan. Parts of Punjab and Haryana were once a part of this desert, but the irrigated cultivation has changed the situation there.

The Wildlife of the Indian Desert

The wildlife of the desert zone is peculiar not because of its great diversity or density, but because of the extraordinary ecological adaptations to the desert conditions. Several of the species are endemic to Thar Desert. Desert Fox, Desert Cat (Fig. 6.9a), Houbara Bustard and some Sand Grouse species are restricted only to the Thar area. *Prosopis cineraria, Salvadora oleoides* are common trees of Indian desert.

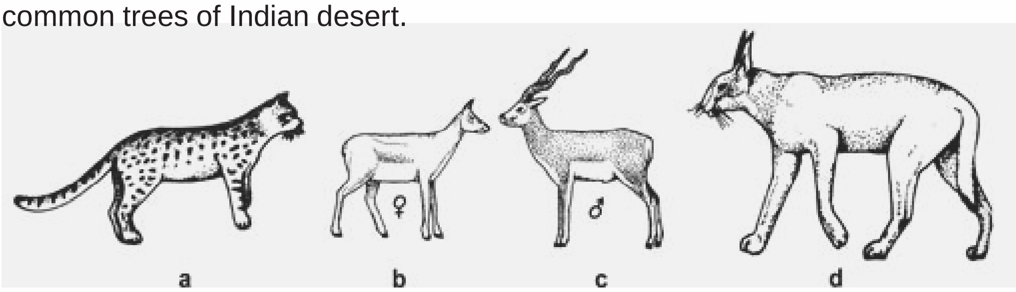


Fig. 6.9: Desert cat (*Felis libyca*).

6.4.4 Zone 4: The Semi-Arid

This zone with an area of 508,000 sq. km occupies 15% of the total area in our country. The presence of several grass species and palatable shrubs in these areas has made them a favourite of a vast number of wildlife species.

The Wildlife of the Semi-Arid Zone

This zone has strong biological links with western Asia, primarily with Pakistan, Iran, Middle-east and Northern Africa. Many of the plants found here show African affinity, e.g., *Acacia* sp. (see Fig. 6.10). The fauna consists of larger Lerbiveres-Blackbuck, Chowsingha, Gazelle and Nilgai. (Fig. 6.11)

Fig. 6.10: Plants of the semi-arid zone, *Acacia leucophloea (*Ronj).

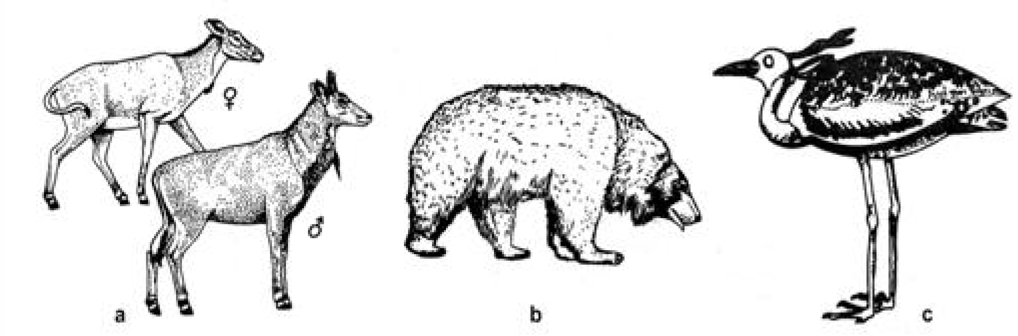


Fig. 6.11: Some faunal elements of the semi-arid zone, a) Nilgai (*Boselaphus tragocamelus*), female (♀) and male (♂) Sloth bear (*Malursus ursimus*), and c) Lesser florican (*Sypheotides indica*).

Fig. 6.12: A twig of *Myristica* along with a fruit.

6.4.5 Zone 5: The Western Ghats (Biodiversity Hot Spot)

The Western Ghats represent one of the major tropical evergreen forest regions in India. The total area of Western Ghats is about 160,000 sq. km. In the west, the zone is bound by the coast and in the east, it shares boundary with the Deccan peninsular zone. The tropical evergreen forests occupy about one third of the total area of this zone. In recent years, a large chunk of the forest cover has been lost and this zone is now of great conservation concern, more so because of its exceptional biological richness. About two-thirds of India's endemic plants are confined to this region. However, the potential of many of these species is yet to be tapped. Besides harbouring diverse biological communities, the forests in this zone also play an important role in maintaining the hydrological cycle.

The well known species found exclusively in Western Ghats include the following:

Among Primates – Nilgiri Langur and Lion-tailed Macaque (Fig.6.13b,c)

Rodents – Plataconthomys, the Spiny Dormouse

Squirrels – Several subspecies of *Ratufa indica* with separate forms in Maharashtra, Mysore, Malabar and Tamil Nadu Ghats. The Grizzled Squirrel is restricted to two localities in the drier Tamil Nadu forest.

Carnivores – Malabar Civet in southern evergreen forests, Rusty spotted Cat in northern deciduous forests.

Ungulates – Nilgiri Tahr (Fig. 6.13d) in Nilgiris to Agastyamalai montane grassland.

Hornbills – Malabar Grey Hornbill (Fig. 6.13e).

In addition to the above endemic species, the other species found are: Tiger, Leopard, Dhole (Fig. 6.13f), Sloth Bear, Indian Elephant and Gaur (Fig. 6.13g).

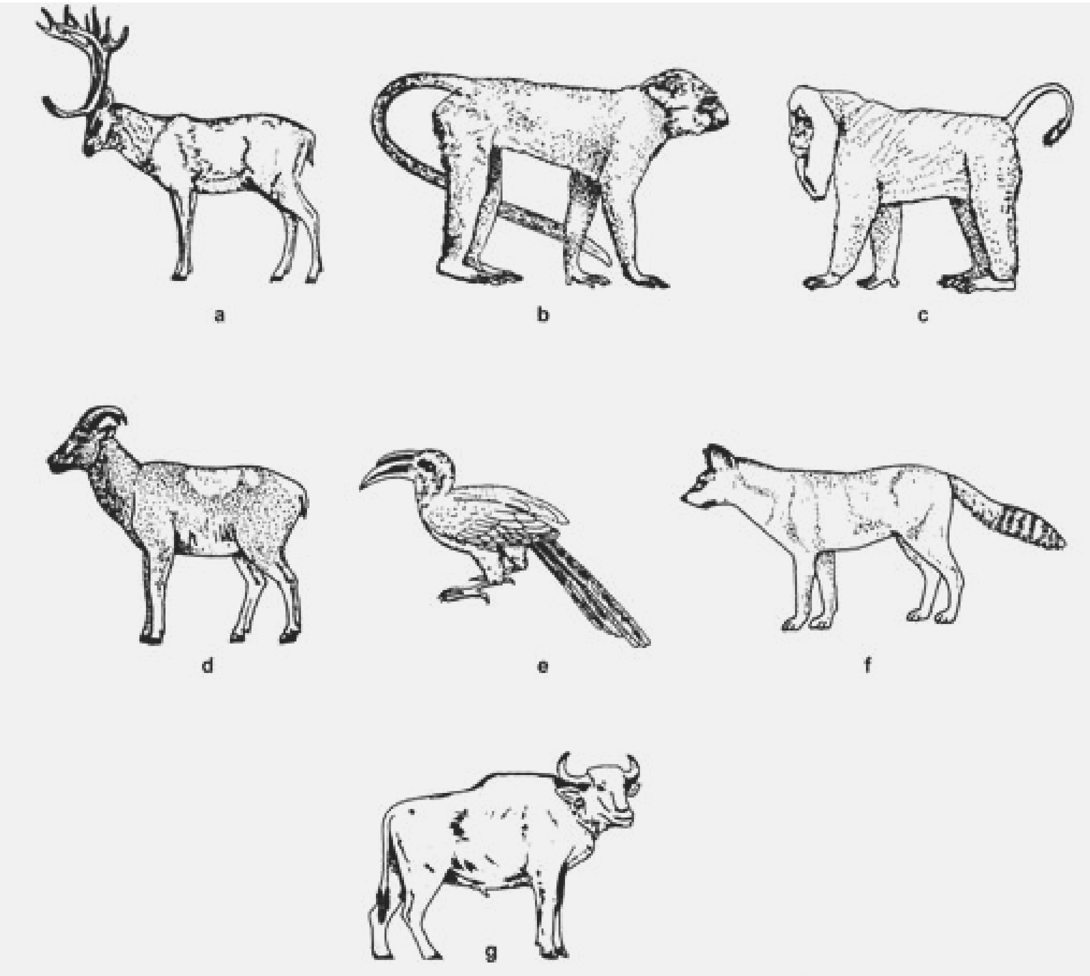


Fig. 6.13: The faunal elements of Western Ghats, a) Swamp deer (*Cervus duvauceli*); b) Nilgiri langur (*Presbytis johni*); c) Lion-tailed macaque (*Macaca silenus*); d) Nilgiri Tahr (*Hemitragus hylocrius*); e) Malabar grey hornbill (*Tockus birostris*); f) Dhole (*Cuon alpinus*); and g) Gaur (*Bos gaurus*).

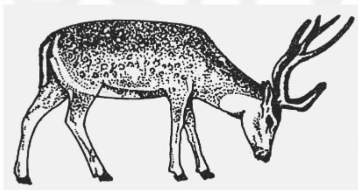


Fig. 6.14: Chital (*Axis axis*) found in the Deccan Peninsula.

6.4.6 Zone 6: The Deccan Peninsula

This zone covers the largest area in India that amounts to about 43% of the total land mass, and about 1,421,000 sq. km area. Though a large area of this zone has been greatly altered by humans, still some forest areas exist, particularly in Madhya Pradesh, Maharashtra and Odisha.

This zone has deciduous forest, thorn forests and degraded shrublands. There are small areas of semi-evergreen forests in the Eastern Ghats and, dry evergreen forests or thorn scrub on the coastal side of the plains of Andhra Pradesh and Tamil Nadu.

The faunal species are widespread throughout the whole zone, e.g., Chital (Fig. 6.14), Sambar, Nilgai, Chowsingha, Barking Deer, and Gaur. Some species such as the Blackbuck are restricted to dry open area. Small, relict populations of species also exist, e.g., Elephant (Bihar-Odisha, and Karnataka-Tamil Nadu) and Wild Buffalo (in a small area at the junction of Odisha, M.P. and Maharashtra).

6.4.7 Zone 7: The Gangetic Plain

This zone has one of the most fertile areas in the world, and it supports a dense and growing human population. It covers an area of about 359,400 sq km. The original vegetation found in most of the area is no longer there, as a major portion of this area has been brought under cultivation.

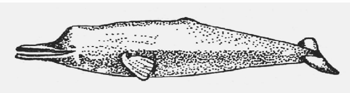


Fig. 6.15: Gangetic dolphin (*Platanista gangetica*)-found in the gangetic plains.

The Wildlife of the Gangetic Plains

Small relict populations of Nilgai, Blackbuck and Chinkara, interspersed with dense cultivation presently exist in the western areas.

The wetlands and rivers also contain Crocodile – Mugger and Gharial - populations, reflict populations of Gangetic Dolphin (Fig. 6.15) and a rich, fresh-water turtle community having over 20 species.

6.4.8 Zone 8: North-East India

North-East India represents the transition zone between the India, Indo-Malayan and Indo-Chinese regions as well as the meeting point of Himalayan mountains and Peninsular India. It is one of the most important zones in the Indian Subcontinent for its rich biological diversity and a large number of endemic species.

The Brahmaputra valley of this zone contains unique natural vegetation – swamps, grasslands and fringing woodlands and forests. The fauna consists of Rhinoceros, Buffalo, Swamp Deer, Hog Deer, Pygmy Hog and Hispid Hare. This area also contains the largest elephant populations. This is also the fly-way for waterfowl and other birds travelling between the warmth of the subcontinent and their summer grounds in Silberia and China.

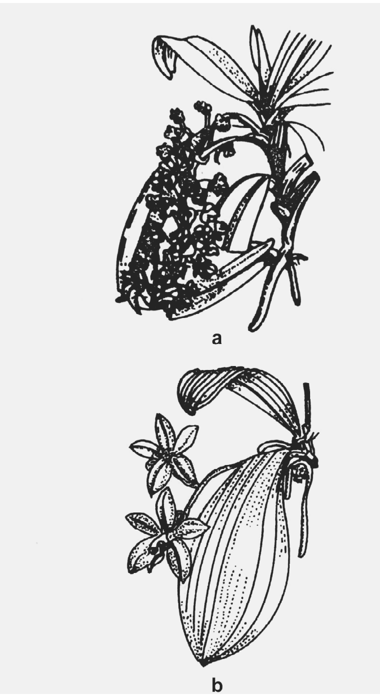


Fig. 6.16: Two orchid species of Andaman and Nicobar Islands; a) *Aerides emerici;* b) *Palaenopsis speciosa.*

6.4.9 Zone 9: The Islands

In this category we shall discuss the Andaman and Nicobar group of islands in the Bay of Bengal, and the Lakshadweep in the Arabian Sea. The Andaman and Nicobar islands are a long group of 348 north-south oriented islands.

The zone possesses a unique kind of plant and animal life exhibiting a high degree of endemism. One finds these islands with impoverished mammal fauna. This may be largely due to the isolation of Andaman and Nicobar islands and the small island size. Amongst mammals, species of rodents and bats dominate.

Out of the 15,000 species of flowering plants found in India, some 2,200 species are found in these islands (two such species are shown in Fig. 6.16). Over 200 are strict endemics.

6.4.10 Zone 10: The Coasts

India has a vast coastal stretch of about 5689 km (Srinivasan, 1969). On the west, the Arabian Sea washes the shores of Gujarat, Maharashtra, Goa, Karnataka and Kerala States. On the east, the Bay of Bengal washes the coasts of Sunderbans in West Bengal, Odisha, Andhra Pradesh and Tamil Nadu states. The southern promontory of Indian Peninsula is bathed by the Gulf of Manaar and Indian Ocean, along the coasts of southern portions of Tamil Nadu.

The Wildlife of Coasts

The geology of coasts is very varied and accordingly, five main communities have been described:

a) Mangroves – that have a variety of community types from seaward to landward facing areas of estuaries, lagoons and deltas.

b) Sandy beaches, including raised beaches and distinctive plant communities such as *Casuarina – Calophyllum – Pandanus*.

c) Mud flats with a range of successional stages to completely terrestrial vegetation.

d) Raised corals and rocky coast lines.

e) Marine angiosperm pastures

An endemic species is one that is restricted to a given area and is not found elsewhere.

Some of the interesting coastal wildlife species include: Dugong; Hump-back Dolphin of estuarine turbid waters; Estuarine or salt-water Crocodile; Olive Ridley, Green, Hawksbill, Leather and Loggerhead sea Turtles; the Estuarine Turtle – *Batagur basker* of Sunderbans and the huge Soft-shell Estuarine Turtle; *Pelochelys birbornii* off the Utkal-bengal Coast fish – mud skippers or semi-terrestrial Gobies, small Crabs in association with Anemones; avifaunal communities of mangrove, mud flats and lagoons. In the higher regions of mangroves, there are Spotted Deer, Pigs, Monitor Lizards, Monkeys, and the Sunderban Tiger.

6.5 BIODIVERSITY HOT SPOTS

Hot spots are areas that are extremely rich in species, have high endemism and are under constant threat.

Myers (1988) identified 18 regions or “Hot spots” around the world. Interestingly these areas contain nearly 50,000 endemic plant species, or 20% of the world’s plant species, in just 746,000 km^2, or 0.5% of the Earth’s total land surface. A subsequent study done by the World Conservation Monitoring Centre, U.K. identified 21 “hot spots”. A more recent study by Conservation International, which carries forward the work of Myers, has identified 34 global “biodiversity hot spots”. These 34 hot spots cover only 1.4 percent of the Earth’s land surface but contain about 44% of all vascular plants and 35% of vertebrates (excluding fishes), and 96% of the world’s most threatened primate species. Among the 34 hot spots of the world four are found in India

An endemic species is one that is restricted to a given area and is not found elsewhere.

Green Nations

Plants, insects anything mentioned in a biology text book qualifies as a bioresource. Countries with vast bioresources are called Mega-Diverse.

Mega Diverse countries

Eighteen countries that control 70 precent of the world’s bioresources have got together: India, China, Zaire, Indonesia, Columbia, Mexico, Ecuador, Kenya, Peru, Venezuela, Costa Rica, Bolivia, Malaysia, Madagascar. Philippines, South Africa, Congo and conservation priority in the selection of countries is based on species richness and species endemism extending into neighbouring countries – the Western Ghats/Sri Lanka Indo-Burma region (covering the Eastern Himalayas); the Himalayas; Sundaland (covers the Nicobar group of Islands) (Fig. 6.17). These areas are rich in floral wealth and endemism, not only in flowering plants but also in reptiles, amphibians, swallow tailed butterflies and mammals.

Tropical moist forests are believed to be the richest terrestrial ecosystems on earth. In the marine environment, coral reefs also possess extremely rich biodiversity. It is now suspected, however, that the richness of species diversity on sea floor may be equal or even greater than coral reefs.

Some countries are richer in biodiversity than others. Generally, the economically poor developing countries in tropical areas are richer in biodiversity than developed countries in temperate areas.

Small tropical oceanic islands have relatively fewer species due to their isolation, but they generally possess large number of endemics. Mauritius has a native flora of 878 higher plant species, of which 329 are endemic.

6.6 INDIA: A MEGA - BIODIVERSITY COUNTRY

Why India is one of the mega-diversity countries?

- Four hot spots out of 34 global biodiversity hot spots are in India with its neighbouring countries.
- The endemics of Indian biodiversity is high. About 33% of the recorded flora is endemic to the country. Of the 49,219 plant species, 5150 are endemic and distributed into 141 genera under 47 families corresponding to about 30% of the world's recorded flora.
- India has 26 recognised endemism centres that are home to nearly a third of all the flowering plants identified and described to date in the country.
- India has two major realms called the Palaeretic and the Indo-Malayan and three biomes i.e. tropical humid forests, tropical deciduous forests and the warm deserts/semi-deserts.
- India has ten biogeographic regions.
- India is one of the 12 centres of origin of cultivated plants.

SAQ 3

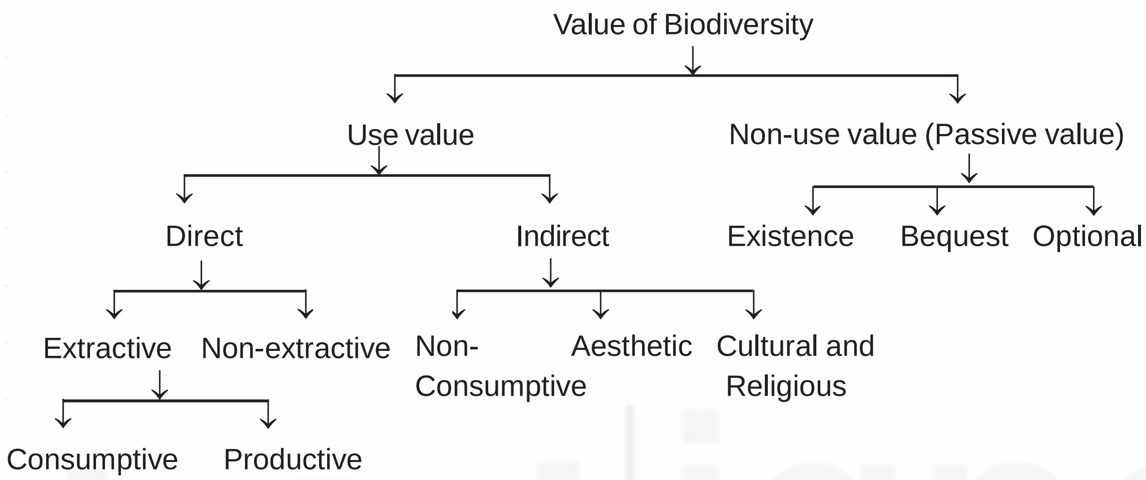
Which parameters place India in the list of mega biodiversity countries?

6.7 USE VALUES OF BIODIVERSITY

Despite its importance, determining the value or worth of biodiversity is complex and often a cause for debate. This is largely due to the fact that the worth placed on biodiversity is a reflection of underlying human values, and **these values vary dramatically both among societies and individuals**.

In this Unit, we include spiritual, cultural and aesthetic values as a subset of indirect values or services, as they provide a service by enriching our lives.

Classification of values of biodiversity is provided in a key form below for your easy understanding.



6.7.1 Direct Use Value

Direct use values are for those goods that are ensured directly e.g. food and timber. Maintaining a wide range of components of biological diversity can be of direct use, especially in the fields of agriculture, medicine and industry. Direct use can involve the use of forests, wetlands or other ecosystems for timber extraction, collection of non-timber products, fishing, etc. Direct use values could be due to **extractive use** where resources are extracted and consumed, or due to **non-extractive use** when there is no extraction or removal of the resource that is used (e.g. bird watching, scientific research in an ecosystem).

6.7.2 Indirect Use Value

Indirect use value is for those services that support the items that are consumed. You will study about various indirect use values in this section.

Non-consumptive value

This is concerned more with nature's services which also make vital contributions to the welfare of society and to ecological processes without which our planet would be uninhabitable.

Aesthetic value

The appreciation of the aesthetic aspect of biodiversity is reflected in the trouble people take to maintain their home gardens, and the number of people throughout the world who visit national parks, botanical and zoological gardens, aquaria and places where one can experience natural landscapes or view diverse species.

Cultural and religious values

In all cultures of world, species and nature have inspired songs, superstitious beliefs, stories and folktales, and dance and drama, poetry, traditional crafts, local and national cuisines, local rituals, names of places, and even family and Christian names. The cultural value of biodiversity in human societies is often expressed in the respect for life forms or symbols of components of biodiversity. In some countries the tiger, lion, lizard, turtles and bison are part of religious and spiritual beliefs. For instance, the hanuman langur (*Semnopithecus entellus*) is considered sacred in India.

Ethical values

The ethical values of biodiversity highlight the intrinsic value of biodiversity for its own sake and it is independent of the varied economic, social and cultural uses of the large number of species by human communities. It underscores the fact that humans are only one of the millions of species that inhabit the earth, while each species is unique and is the result of evolutionary processes without human intervention, so that every species has a natural right to exist.

6.7.3 Non-use Value

Values for those things/organisms/entities – that we don't use but would consider as a loss if they were to disappear. These include **potential or option value, bequest value** and **existence value.**

- **Optional use values**

  Optional values are associated with potential use in the future. Accordingly one opts to conserve biodiversity based on the hope that it could be used directly or indirectly in the future, perhaps as a source of genetic material, for pharmaceuticals, or for crop enhancement.

- **Bequest value**

- **Existence value**

  There may also be non-use existence values for components of biological diversity due to the value placed on biodiversity purely based on its continued existence, irrespective of whether or not it will ever be used.

SAQ 4

Discuss about direct and indirect use values of biodiversity.

6.8 SUMMARY

Let us summarize what you have learnt so far:

- The term biological diversity was coined by Thomas Lovejoy in 1980 and the term biodiversity was coined by E.O. Wilson. Biodiversity is a measure of the relative diversity among organisms present in different ecosystems. Biodiversity is the totality of genes, species and ecosystems of a region.

- There are three levels of diversity i.e. **genetic**, **species** and **ecosystem**. All these levels are interacting and influencing the others.
- Genetic diversity underlies the differences among individuals of a given species. Genetic diversity allows a species to adapt to changing environmental condition.
- Species diversity is the most visible component of biodiversity. It means the differences between species. There are about 12.5 million species in the world out of which 1.7 million species have been described.
- India has been divided into ten biogeographic zones viz; Trans-Himalayas, Himalayas, Indian Desert, Semi-arid, Western Ghats, Deccan Peninsula, Gangetic Plains, North East India, Islands and Coasts. Each of these zones has certain geographical as well as biological peculiarities.
- Biodiversity hot spots are areas that are extremely rich in species, have high endemism and are under constant threat. There are 34 hot spots in the world; 4 of which are found in India extending into neighbouring countries.
- India is among the world's mega biodiversity countries because of various reasons, viz. 4 hot spots, 26 recognised endemism centres, two major realms, three biomes and ten biogeographic regions.
- The value of biodiversity is often divided into two main categories i.e. **intrinsic** or **inherent value** and **extrinsic** or **utilitarian** value. Intrinsic value describes the worth of an organism, independent of its value to anyone or anything else. Utilitarian value refers to something's value as determined by its use or function.
- Use values can be direct or indirect. Direct use values are for those goods that are consumed directly, such as food or timber and indirect use value are for those services that support the items that are consumed, including ecosystem functions like nutrient cycling.
- Non-use or passive values are for those entities that we don't use but would consider as a loss if they were to disappear. These include **existence value, bequest value** and **option value.**

6.9 TERMINAL QUESTIONS

1. Define biodiversity. Explain different levels of biodiversity.
2. Enumerate and analyse the wild life species that occur in the different biogeographic zones of India.
3. Discuss the criteria for identifying global biodiversity hot spots.
4. Explain the use values of biodiversity.

6.10 ANSWERS

Self-Assessment Questions

1. The variability among living organisms from all sources, including, inter

alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems.

2. Genetic diversity is the diversity of basic units of hereditary information which are passed down generations found within a species (e.g. different varieties of the same species). Species diversity means the differences between species (both domesticated and wild).

3. Following parameters place India in the list of mega biodiversity countries:

   i) Four hot spots out of 34 global biodiversity hot spots are in India with its neighbouring countries

   ii) The endemics of Indian biodiversity is high. About 33% of the recorded flora is endemic to the country. Of the 49,219 plant species, 5150 are endemic and distributed into 141 genera under 47 families corresponding to about 30% of the world's recorded flora.

   iii) India has 26 recognised endemism centres that are home to nearly a third of all the flowering plants identified and described to date in the country.

   iv) India has two major realms called the Palaeretic and the Indo-Malayan and three biomes i.e. tropical humid forests, tropical deciduous forests and the warm deserts/semi-deserts.

   v) India has ten biogeographic regions.

   vi) India is one of the 12 centres of origin of cultivated plants.

4. Refer to Sub Sections 6.7.1 and 6.7.2.

Terminal Questions

1. Refer to Sections 6.2 and 6.3.
2. Refer to Section 6.4.
3. Refer to Section 6.5.
4. Refer to Section 6.7.

6.11 FURTHER READING

1. WCMC (1992) Global Biodiversity. Status of the earth's Living Resources. Chapman & Hall.
2. National Biodiversity Action Plan and Strategy of India, (Draft of 2002).
3. IUCN (1999) *Resource Material on Biodiversity for General Certificate of Education*.
4. Glowka, L. et. al., (1994) A Guide to the Convention on Biological Diversity. IUCN Gland and Cambridge.

Internet Sites

http://www.unep.ch/conventions/geclist.htm

http://www.epw.org.in

http://www.cites.org/eng/disc/what.shtml

UNIT 7

ENERGY RESOURCES

Structure

7.1 INTRODUCTION

Modem industrial societies are characterised by the intensive use of energy. Can you think of a day in your life without electricity or other sources of energy such as fuels for cooking and transport? Think, all the things that you use are driven by energy! Energy is required to produce food and goods and reach them to you. You will agree that energy has been a crucial factor in the current model of development. There is a close relationship between energy consumption and economic growth as measured in terms of the growth of Gross Domestic Product(GDP)in any country. It is now argued that the cost and availability of energy are two major factors in promoting economic growth of society or country as a whole.

However, as the energy intensive industrial economies have expanded, their adverse impact on the environment has grown. This aspect has come under closer scrutiny in the past few decades and an understanding of the role of energy in economic development will help us develop models of eco-friendly energy usage. Therefore, we begin our discussion of the energy as resource with an understanding of the multi-faceted role of energy in economic development. We will examine the energy resource base at our disposal and the various energy options available to us. Finally, we will analyse the carrying capacity of the Earth in relation to our energy demand with a view of switching over to renewable energy sources.

Expected Learning Outcomes

After studying this unit, you should be able to:

- ❖ discuss the role of energy as resource in economic growth;
- ❖ analyse the energy demand due to growing population andindustrialisation;
- ❖ describe the energy resource base of the Earth; and
- ❖ explain the management of energy with switching over to renewable sources.

7.2 ENERGY AS RESOURCE

The demand for energy doubles every 14 years and is taken as one of the indicators of development of a country. India, with 16% of the world's population consumes roughly 3% of the total energy produced in the world, in comparison of USA which has 6.25% of the world's population and utilizes 30% of the energy produced.Despite continuous increase in energy use, per capita consumption in India is still very low compared with other countries. Even today, about 80% of our population continues to depend on fuel wood, dung and agricultural wastes. We know that non-renewable sources of energy such as fossil fuels, coal and petroleum, are not going to last for long. Forests are also being depleted at the alarming rate due to indiscriminate felling of trees. It has become, therefore, necessary to think of alternative, non-conventional sources of energy.

Energy needs in India are met by harnessing two categories of energy sources as shown below.

Energy

Non-conventional

- Biomass energy
- Solar energy
- Fuel cells energy
- Geothermal energy
- Co-generation energy
- Wind energy

Conventional

- Oil (Fossil Fuel)
- Natural Gas
- Coal
- Hydropower
- Atomic Energy

7.2.1 Non-Conventional Sources

There are various non-conventional sources of energy which we will deliberate here.

Biomass energy

This is a renewable energy source derived from plant resources, animal waste and the waste of various human activities. It is also derived from the by-products of the timber industry, agricultural crops, raw material from the forest, major parts of household wastes and wood. Biomass is an important source of energy and the most important fuel worldwide after coal, oil and natural gas.

Biomass does not add net carbon dioxide to the atmosphere as it absorbs the same amount of carbon in growing as it releases when consumed as fuel. Its advantage is that it can be used to generate electricity with the same equipment or power plants that are now burning fossil fuels.

Biomass fuels used in India account for about one third of the total fuel used in the country. Over 90% of the rural households and about 15% of the urban households use biomass fuels (e.g. wood, cowdung cakes, crop residues and sawdust). The inefficient burning of such fuels in traditional chulhas is causing a serious problem of indoor air pollution and consequent health hazards. Moreover, the unsustainable level of consumption of fuel wood leads to deforestation and desertification, which degrades the environment. Thus proper management of biomass as a resource is very essential.

In this context, technological solutions, institutional arrangements, financial support and training schemes for ensuring adequate and affordable clean energy systems and services using biomass assume great significance. An initiative in this direction has come from the Ministry of Non-conventional Energy Sources (MNES). It has been promoting indigenously developed technologies for efficient utilization of biomass fuels with a focus on extraction of more energy, reduction of household consumption of firewood, generation of employment and improvement in the living standards of rural population.

Biomass gasifier is another technology in use for energy generation (Fig. 7.1). A biomass gasifier converts solid biomass, both woody and powdery, materials such as wood, agricultural and agro-industrial wastes into gas through thermochemical gasification process.Gasifier converts solid fuel into a more convenient-to-use gaseous form of fuel.

As much as 1890 Kcal of heat can be produced from half a kilo of dry plant tissue. This is equivalent to the heat available from 250 g coal.

It has been found to be more practical to compress biomass into briquettes (small hard blocks of different shapes used as fuel) and thereby improve its utility and convenience of use. In the dense briquetted form, biomass can either be used directly as fuel instead of coal in the traditional chulhas and furnaces or in the gasifier.

Fig. 7.1: Biomass gasifier.

Solar Energy

Solar energy is the most readily available abundant source of energy. It is free as it does not belong to anybody. It is also non-polluting (Fig. 7.2).

Solar run refrigerators have been developed for rural areas. These keep vegetables and fruits fresh for a longer period.

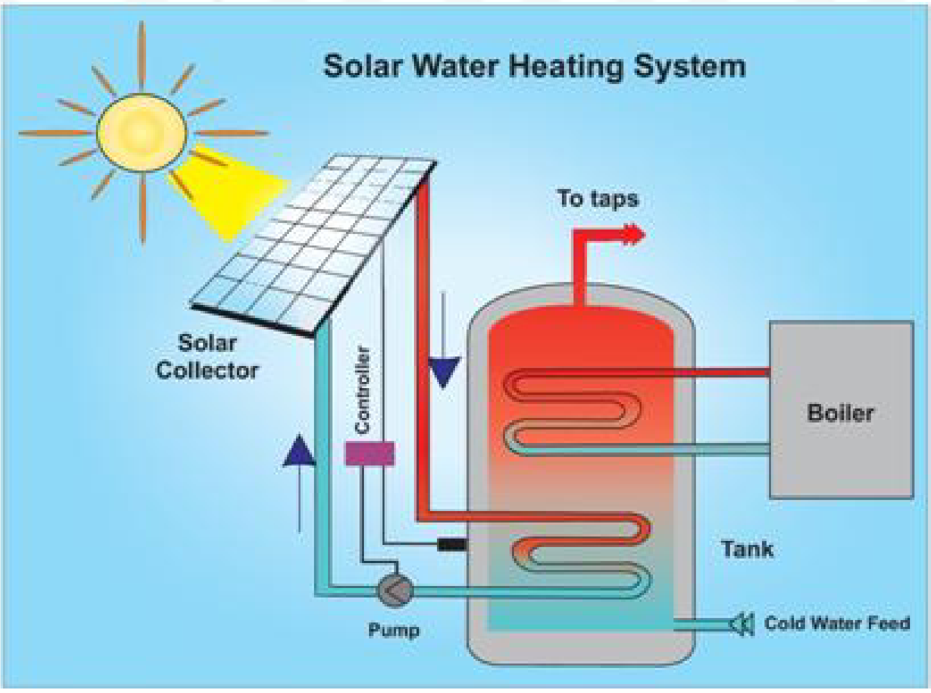


Fig.7.2: Solar energy being used for heating water.

The energy we get today from the fossil fuels like coal is in reality sun's energy, trapped in plants millions of years ago. Plants make their food and grow by using solar energy for photosynthesis. Millions of years ago, huge forests got buried in the earth's crust and they got transformed into coal and oil under great pressure and temperature therefore coal and oil are called fossil fuels.

Fig. 7.3: Solar run refrigerator.

Nowadays, we have learnt to harness solar energy for various purposes. Solar energy can be used directly to give us hot water during winter, or run a refrigerator (Fig. 7.3).It can be used, for room heating in colder regions (Fig. 7.4).Solar cookers are being used in many homes to cook food (Fig. 7.5). Solar energy can be used with the help of "photo voltaic cells" for producing electricity for driving vehicles and for illumination. Since this is an unfailing source of energy, it would be a great advantage to develop cheap and efficient photocells or photovoltaic devices to harness solar energy.

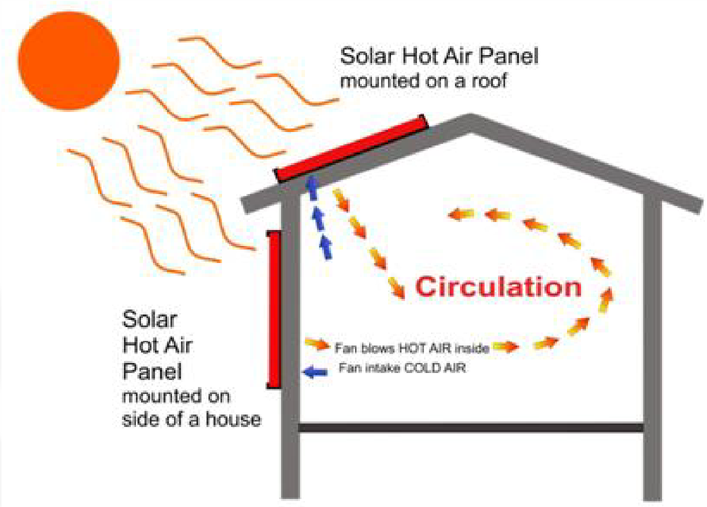


Fig. 7.4: Solar heated room.

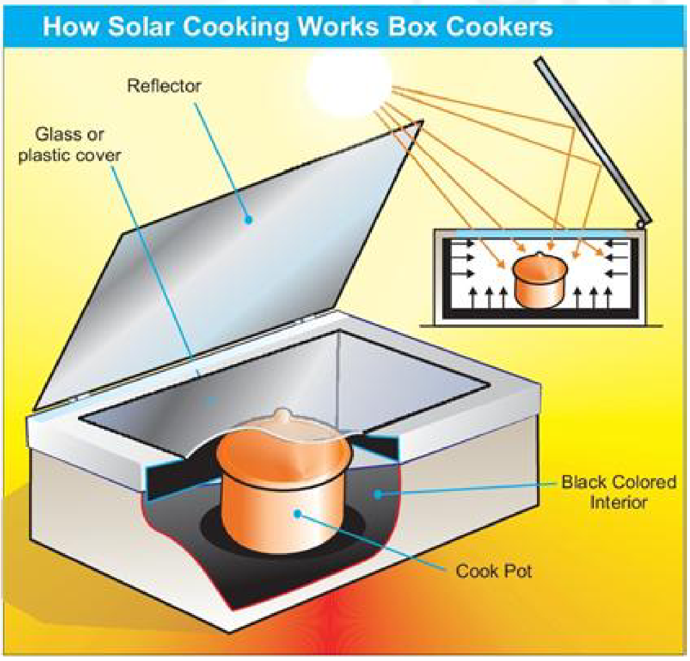


Fig. 7.5: Solar Cooker.

Solar radiation gets converted into electricity directly in Solar Photovoltaic (SPV) panels installed on buildings or in open spaces. This electricity can either be used as it is or can be stored in the battery to be used for domestic lighting, street lighting, village electrification, water pumping, desalination of salty water, powering of remote telecommunication repeater stations and railway signals. Solar passive buildings use solar energy in building designs and cut down on energy consumption for heating and cooling. This technology is fast gaining acceptance in urban architecture.

Fuel Cells

Fuel cells are electrochemical devices that convert the chemical energy of a fuel directly and very efficiently into electricity and heat, thus doing away with combustion (Fig. 7.6). A fuel cell consists of an electrolyte sandwiched between two electrodes. The most suitable fuel for such cells is hydrogen or a mixture of compounds containing hydrogen. Oxygen passes over one electrode and hydrogen over the other, and they react electrochemically to generate electricity, water and heat.

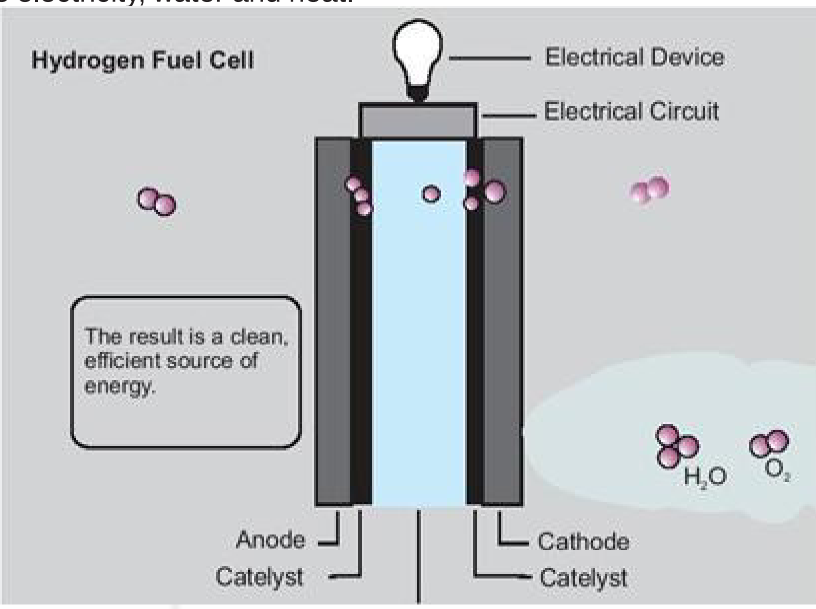


Fig. 7.6: Fuel Cells.

Fuel cells are being used in space flights and can be used in electric vehicles to dramatically reduce urban air pollution. Fuel-cell powered vehicles have very high energy conversion efficiency (almost double that of currently used engines). The emissions are significantly lower (CO_2 and water vapour being the only emissions). Fuel-cell-powered electric vehicles score over the battery operated ones in terms of increased efficiency and easier and faster refuelling. Fuel cell systems are excellent candidates for small-scale decentralized power generation for commercial buildings, hospitals and airports in remote locations.

On an average, the 60 million sq. km of tropical seas absorb solar radiation equivalent to the heat content of 245 billion barrels of oil.

Wave and Tidal Energy

Energy can also be obtained from **waves** and **tides**.These waves and tides are another source of energy which is perpetual and can be harnessed for generating electricity (Fig. 7.7), particularly where sea water can move into

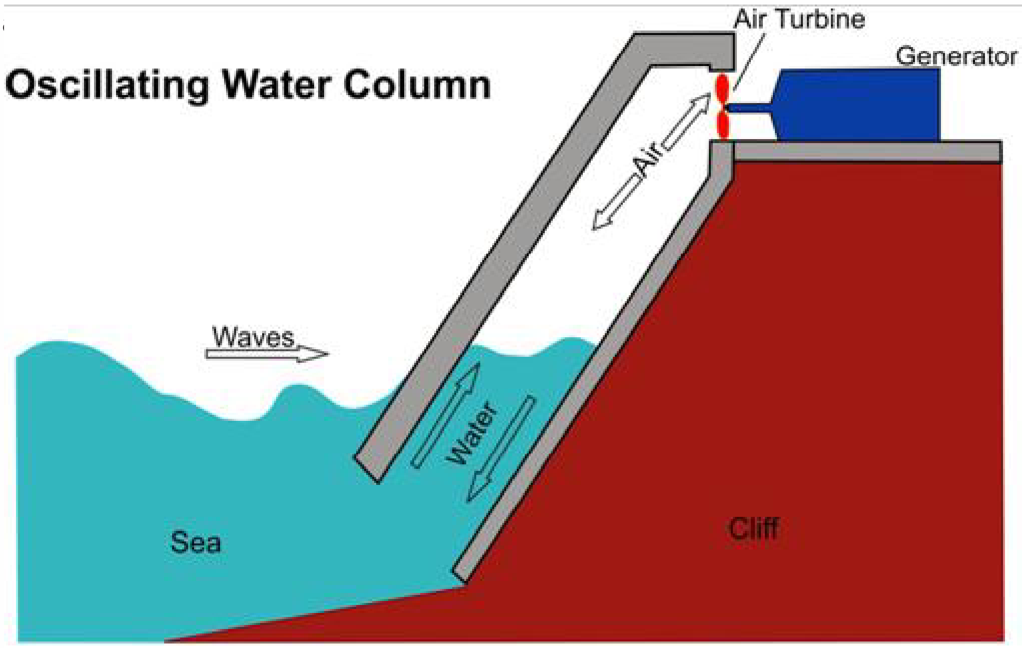


Fig.7.7: Tidal power station. Both incoming and outgoing tides are held back by a dam. The difference in water levels generates electricity in both directions as water runs through reversible turbogenerators.

Energy carried by water has also been widely used in India's hilly regions, since a wheel with pedals can be made to turn when it is put in a fast flowing stream. Flour mills of small size built on this principle were used in Kashmir fora long time. In fact, large "hydroelectric" power stations work on the same principle. A natural or artificial water fall is made to turn a modern kind of pedal wheel, called a turbine, which upon rotation generate electricity.

In India, the first wave energy project with a capacity of 150 MW, has been set up at Vizhinjam near Thiruvanathapurm. A major tidal wave power project costing Rs. 5000 crores, is proposed to be set up in the Hanthal Creek in the Gulf of Kachchh in Gujarat.

Geothermal Energy

Volcanoes, hot springs, and geysers, and methane under the water in the oceans and seas are sources of **geothermal** energy. **Geothermal** means heat from the earth. In some countries, such as in the USA, water is pumped from underground hot water deposits and used to heat people's houses.

Hot water and superheated steam of hot springs can be used to generate electricity (Fig. 7.8). In our country there are about 46 hydrothermal areas where the temperature of the spring water exceeds 150°C. The thermal energy of hot springs can be used for generating electricity, heating buildings and homes glass-houses in colder areas for growing vegetables.

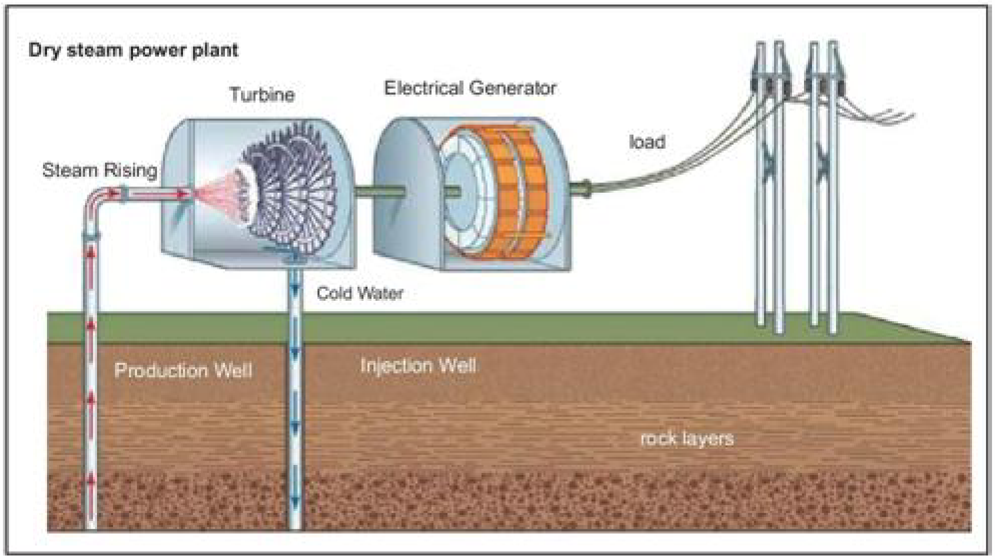


Fig.7.8: The geyser is the geothermal power operation and produces the energy directly from steam.

In India, the North-western Himalayas and the western coast are considered geothermal areas. Satellites like the IRS-1 have played an important role, through infrared photographs of the ground, in locating geothermal areas. The Geological Survey of India has already identified more than 350 hot spring sites, which can be explored as areas to tap geothermal energy. An experimental 1 KW generation project in the Puga valley in the Ladakh region is being used for poultry farming, mushroom cultivation and pashmina-wool processing, all of which need higher temperature.

Co-generation

This is the concept of producing two forms of energy from the fuel, one form being heat and the other being electrical or mechanical energy. In a conventional thermal power plant, high-pressure steam is generated by burning fuels. It is used to drive a turbine, which in turn drives an alternator to produce electric power. The exhaust steam is generally condensed to water which goes back to the boiler. (Fig. 7.9)

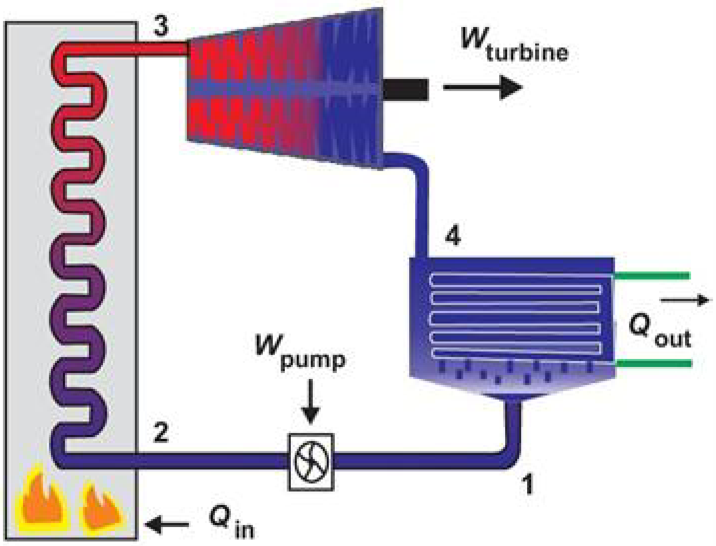


Fig. 7.9: Bagasse-based co-generation.

The efficiency of conventional power plants is only around 35% as a large amount of heat is lost in the process of condensing. In a co-generation plant, the low-pressure exhaust steam coming out of the turbine is not condensed, but used for heating purposes in factories or houses. Thus very high efficiency levels, in the range of 75-90% can be reached.The potential of power generation from co-generation in India is more than 20,000 MW even at conservative estimates.

Wind Energy

Wind Energy has been used for hundreds of years for sailing, grinding grain, and for irrigation. Wind energy systems convert the kinetic energy associated with the movement of air to more useful forms of power. Wind turbines transform the energy in the wind into mechanical power, which can then be used directly for grinding,lifting water or to generate electricity. Wind turbines can be used singly or in clusters called ‘wind farms’. Windmills have been used since long in many countries, but in India they have only been recently introduced (Fig. 7.10).

Fig. 7.10: Use of renewable energy as wind pump.

Biogas

You may have heard of the use of cattle dung for production of biogas which is a source of energy used for cooking (Fig. 7.11). Through a simple process cattle dung is used to produce a gas that contains 55-70% inflammable methane gas, and is clear and efficient fuel for use in rural areas. Water weeds like water hyacinth, water lettuce, salvinia, hydrilla, duck weeds and algae are found to be useful supplement to cattle dung. Biogas can also be used to raise steam, which in turn may be used for running engines or machines in factories or for running turbines to generate electricity. It has been found that large biogas plants can supply the needs of a number of families or even small villages. The residual dung or the digested slurry left after generating, biogas can be used as manure for agricultural purposes. This is an economical way of obtaining energy from organic wastes. In China and India, great efforts are being made to install tens of thousands of biogas plants in rural areas.

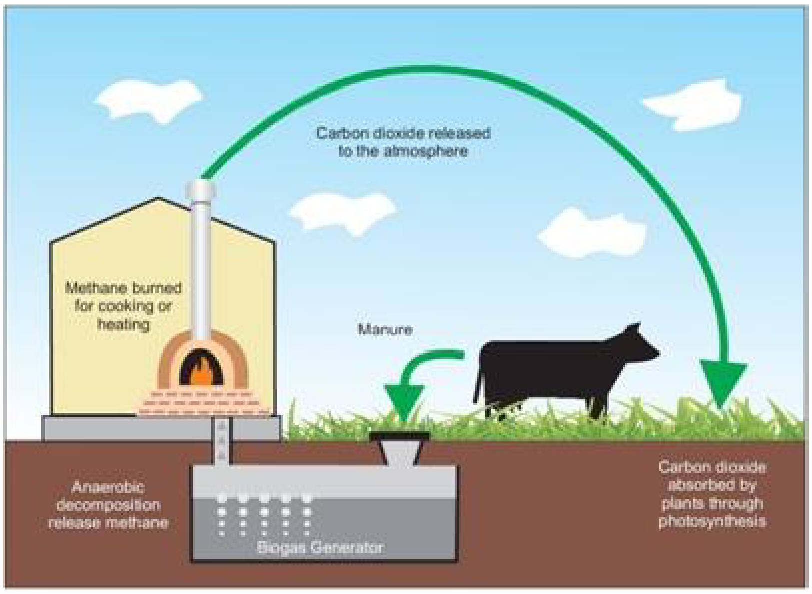


Fig. 7.11: Biogas Plant.

India has tremendous potential in non-conventional sources of energy. Our diverse geographical settings help in promotion of non-conventional energy sources of energy namely solar, wind and tidal. Looking at the future potential in generating solar energy, the International Solar Alliance was established in the year 2015. Major initiatives were taken by India for the establishment of this alliance. This would help us in developing clean and green energy that would address the problems emerging due to the use of conventional sources of energy like coal, petroleum and radio-active minerals. Therefore we can say these above mentioned non-conventional sources are the energy of future.

But, today our major energy sources are coal, fossil fuel, natural gas, hydro-power and atomic energy. These sources of energy are known as conventional sources of energy. Let us discuss these sources in detail in the following section.

7.2.2 Conventional Sources

The power production through conventional sources like oil, gas, coal and hydel lags far behind the current demand driven by growth in agriculture industry and the population. India's electricity sector currently faces problems of capacity, distribution losses, poor reliability, and frequent blackouts. Indian industry cites power supply as one of the biggest limitations on progress. One government estimate projects 8-10% annual growth in energy demand over the next 15 years if the economy grows as expected in the 7-8% per year range. The shortfall implies greater dependence on international markets.

Oil (Fossil Fuel)

Oil supplies nearly 30% of India's energy. Oil consumption in the country was approximately 1.93 million barrels per day (bpd) in 1999 and was about 4.7 million bpd in 2017. In 2017, India imported about 198 million tonnes of cruide oil and its products.

India draws most of its imports of oil from the Bombay High, Upper Assam, Cambay, Krishna-Godavari, and Cauvery basins. Oil reserves are estimated at 4.7 billion barrels. The Bombay High Field, India's largest producing field, generated 250,000 b/d in 1998 and 210,000 b/d in 1999.

Consumption of petroleum products rose from 57 million tonnes in 1991-1992 to 196 million tonnes in 2016. The India Hydrocarbon Vision 2025 report estimates future refinery demand at 368 million tons by 2025. Thus, India is becoming a major global market for petroleum products.

Natural Gas

About 7% of India's energy needs are met by **natural gas** especially in power generation, fertilizers, and petrochemicals production. Natural gas can serve to reduce dependence on foreign oil. Absence of sulphur dioxide and reduced levels of carbon dioxide and nitrogen oxide are major environmental benefits of using natural gas. Currently, India's natural gas consumption is 50 billion cubic metres (bcm) and is mostly met by domestic production. In 2017, India imported 27,570 million cubic metres of natural gas.

Coal (Fossil Fuel)

India depends on coal for more than half of its total energy needs. Nearly three quarters of the country's electricity and 63% of commercial energy comes from coal. India has huge coal reserves accounting for 8% of the world's total. It is the third leading coal producer in the world after China and the United States. Most of its coal demand is satisfied through domestic production with the only exception being coking coal that is in short supply. Despite India's wealth in coal reserves, only about 3% is coking coal so India's steel industry must import coking coal to meet about 25% of its annual needs.

Hydro Power

Hydro power is the cheapest, and cleanest and, hence, regarded the best source of energy (Fig. 7.12). However, obtaining electricity from mega dams has given rise to many controversies in recent times and small hydro power plants are emerging as viable alternatives. These plants serve the energy needs of remote and rural areas where the grid supply is not available.

Fig. 7.12: Hydro Power.

Atomic Energy

The energy released by splitting of atom in a controlled manner can be utilized for generation of electricity. The device used for this purpose is called an atomic reactor (Fig. 7.13). Nuclear reactors produce heat, which is used to generate steam, for rotating turbines for generating electricity. It is estimated that 1 kg of natural uranium, written as 235 U, generates energy equal to that produced by 35,000 kg of coal. Energy production from nuclear fuels like uranium is relatively clean, efficient, and can serve as a substitute for coal and petroleum. However, nuclear reactors need to be situated at places far away from human habitation. They have to be operated under strict safety control, to prevent any accidental leakages of radioactive material. The radioactive wastes have to be carefully disposed off. Currently, Nuclear Power Corporation of India Ltd.(NPCIL) is opening 21 nuclear power reactors with an installed capacity of 5780 MW at seven different sites.

Fig. 7.13: A view of atomic power station.

SAQ 1

Tick mark ( ) the correct options.

i. Solar energy is a

a) renewable non-conventional energy

b) non-renewable conventional energy

c) non-renewable energy

ii. Plant manufacture their food by using

a) Fossil fuel energy

b) solar energy

c) organic nutrient energy

iii. Use of non-conventional source of energy is

a) Cheap

b) Pollution free

c) Both cheap and pollution free

iv. Reactor generates

a) Biogas

b) Geothermal energy

c) Atomic energy

v. Energy we get from fossil fuels like coal is in reality

a) Geothermal energy

b) Sun's energy

c) non-conventional energy

7.3 THE CARRYING CAPACITY OF THE EARTH'S ENERGY BASE

The long-term sustainable carrying capacity for the human species on the earth varies with resource availability as well as culture and level of economic development. Thus, two measures of human carrying capacity arise:

- the biophysical carrying capacity; and
- the social carrying capacity.

The **biophysical carrying capacity** is the maximum population that can be supported by the resources of the planet at a given level of technology.

The **social carrying capacity** is the sustainable bio-physical carrying capacity within a given social organisation, including patterns of consumption and trade.

The social carrying capacity therefore must be less than the biophysical carrying capacity as it will account for the quality of life. Besides, it can give us an estimate of the number of humans that can be supported in a sustainable manner at a **given standard of living.**

In order to estimate the human population that can be sustained by the Earth, a standard of living or level of consumption must be selected or assumed. At this point, the introduction of social issues becomes important. For instance, very high global population could be supported at a very low level of food consumption, perhaps even on the brink of starvation. The result, however, could be a socially unstable situation. **A socially sustainable carrying capacity must be based on a level of consumption that meets basic human needs of food, water and space as well as provides opportunity to enjoy socio-political rights, health, education and well-being.**

Another important aspect of social sustainability is equitable distribution of resources. Inequitable distribution of wealth can lead to social instability and disruption.

SAQ 2

Fill in the blanks with appropriate words given is parentheses.

a. The carrying capacity of an ecosystem is defined as the …….. (minimum/ maximum) population size of a species that an area can support.

b. The amount of ……………. (heat/energy) consumed per person per year is a useful measure of standard of living.

c. North America's per capita energy use is …………….. (less/more) than twice that of Europeans.

d. A socially …………….. (non-sustainable/sustainable) carrying capacity must be based on level of consumption which meets basic human needs to food, water, and space as well as provides opportunity to enjoy socio-political right, health, education and well being.

7.4 ENERGY DEMAND DUE TO POPULATION GROWTH AND INDUSTRIALISATION

The human population of the developing world is predicted to increase from its current value of four billion to over eight billion by 2050, and by this time it will comprise almost ninety percent of the world population. Population growth' is one of the factors which drive the world-wide energy demand, especially the demand for electricity.

7.4.1 Energy Demand vis-à-vis Population Growth

The two main factors that lead to greatly increased world-wide demand for energy (especially electricity) during the next half-century are:

- population growth, and
- per capita economic growth in the less-developed countries.

Let us explain this further. Currently, the average person in the less-developed countries consumes only one sixth of the energy consumed by an average person in Western Europe or Japan (see Fig. 7.14).

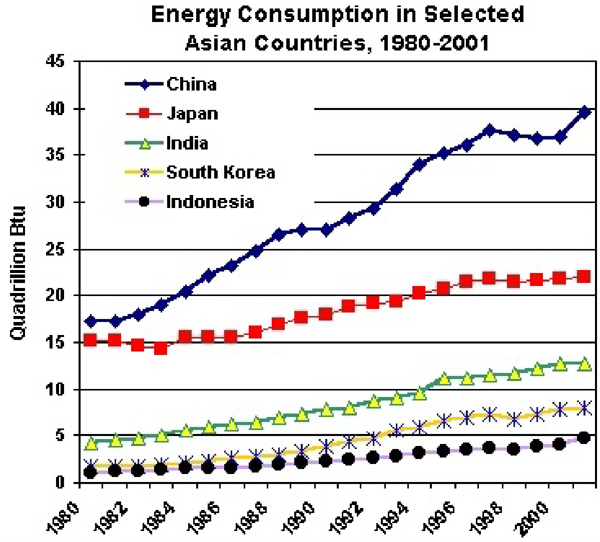


Fig.7.14: Energy consumption in selected Asian countries 1980-2001.

Doubling of per capita energy consumption in the less developed countries over the next 50 years would correspond to only a very modest degree of economic development. Yet, combined with the predicted population increase, it would lead to a two to three-fold increase in world energy consumption.

The actual increase in demand may be expected to be even greater. For example, there will be an increased demand from economic growth in the developed as well as developing countries. Improvements will undoubtedly occur in the efficiency of energy utilisation, but in the face of the expected increases in demand, these could only have relatively minor impact (Fig. 7.15).

Global energy and population

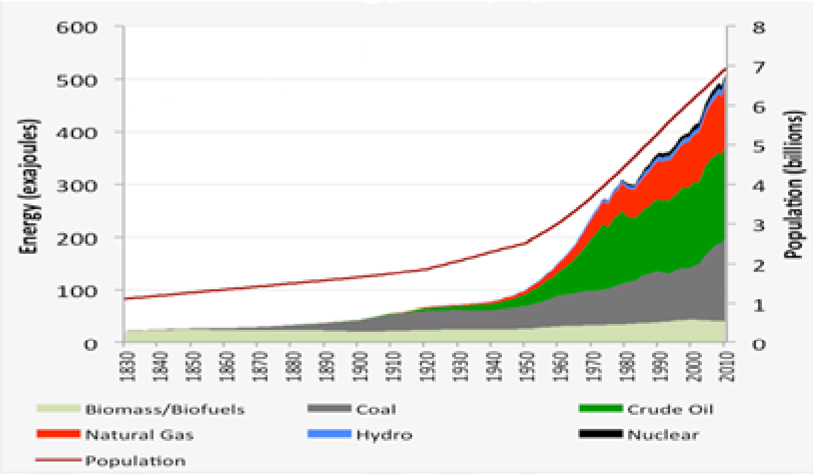


Fig.7.15: World population and global primary energy use projections to 2100. Notice that at present the world uses roughly 9 gtoe worth of energy per year.

GDP: It represents total dollar value of all goods and services produced over a specific time period.

It is one of the primary indictors used to gauge the health of country's economy.

7.4.2 Energy Demand in Industrialisation

During the initial stages of economic growth, the share of agriculture in total output falls and the share of industry rises. This is the industrialisation phase of development.In the later stages of development, the demand for services begins to increase rapidly,increasing its share of GDP (Gross Domestic Product). This latter stage is often referred to as the 'post-industrialised' society.

The growth of heavy industry (infrastructure development) during the industrialisation phase leads to enormous increases in energy consumption. Accordingly, the **energy intensity** of GDP **(defined as energy input per dollar of GDP)** increases as the share of industry in GDP increases. As development continues, however, the demand for financial services, communications, transportation, and consumer goods (light manufacturing) grows rapidly. As a result, the share of services and consumer goods increases, eventually accounting for over one-half of total output. Light industry (involved in the production of consumer goods) and services require less energy input per unit output than heavy industry. This leads to a reduction in overall energyintensity, i.e., the energy input per unit output (see Fig. 7.16).

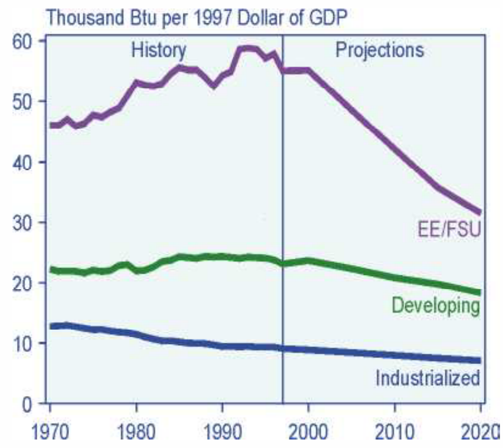


Fig.7.16: World energy intensity by region 1970-2020.

Although economic development leads to declining growth rates of per capita energy demand in the industrial sector, there is substantial growth in energy demand in the transportation, residential and commercial sectors.

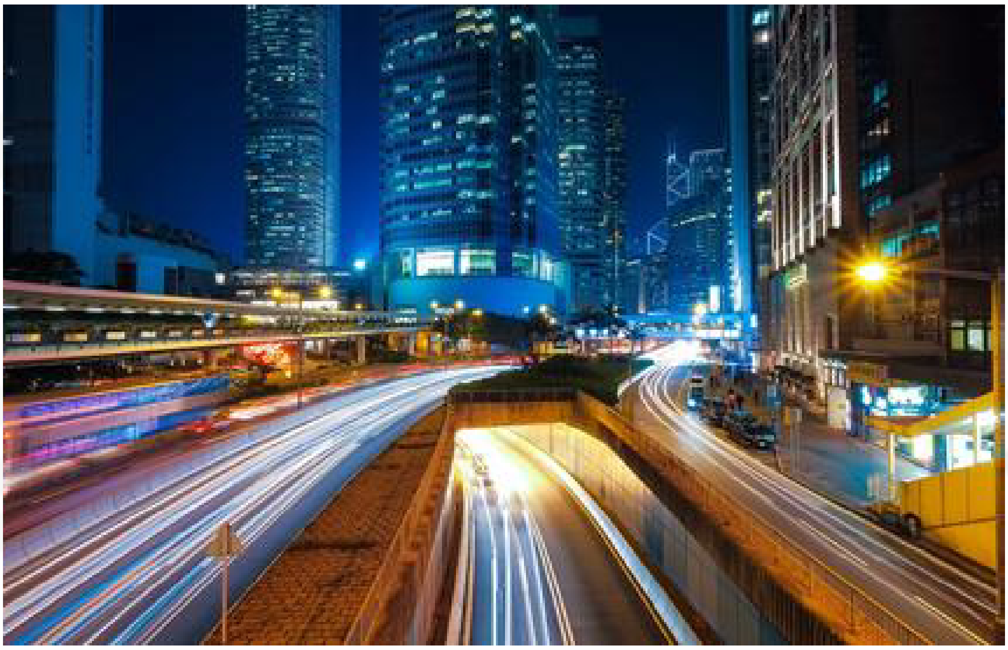


Fig.7.17: An illustration of energy consumption in the developed world.

In a recent study of the effect of economic development on end-use energy demand (Fig. 7.17), it was found that **energy demand grows at different rates in different, broadlydefined,end-use sectors (industrial, transport, residential** and **commercial).**Specifically, it was found that per capita industrial energy demand rises very rapidly at the onset of development, accounting for the maximum energy use. The growth of energy demand in industry, however, quickly declines, and energy use in the other sectors eventually takes a majority share of total end-use energy consumption. In fact,energy demand in the transportation sector continues to grow well into the post-industrial phase of development, accounting for more than half of all energy use. A simulation of energy demand by sector for an average country based on these results is depicted in Fig. 7.18.

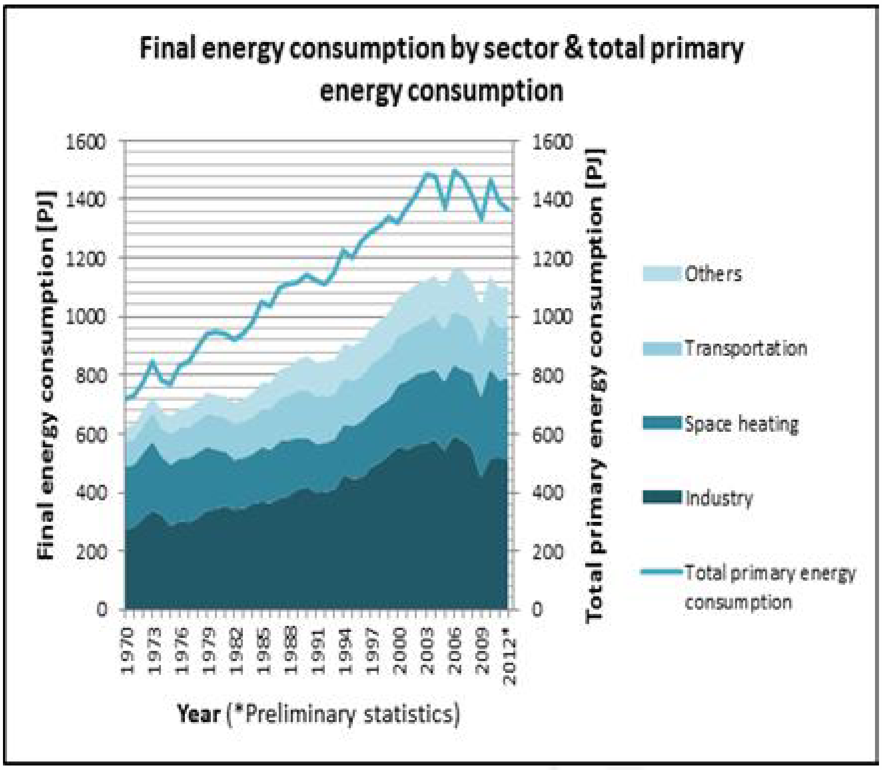


Fig.7.18: Simulated per capita end-use energy demand.

7.4.3 Energy Demand in Asian Developing Economies

Developing countries are playing an increasingly important role in the world energy markets, and their consumption of commercial energy has increased substantially over the past two decades. The increase has been particularly pronounced among the developing countries of East Asia and South East Asia and is expected to continue into the next century. However, the quantum of future energy demand by these lower-middle-income countries will depend on a host of factors, such as:

- the expected income levels;
- real energy prices;
- the continuing trend away from traditional non-commercial energy sources to commercial fuels; and
- the speed of shift toward energy-intensive activities due to urbanisation and industrialisation, increased motorisation, and household use of electrical appliances.

The growing concerns about the environment and the global nature of environmental problems have focused attention on the pattern and trend of energy demand in the developing economies. More than half of the total carbon dioxide emissions originate in the energy sector, and a large and increasing share of the flow of emissions in future will be from lower-middle-income countries. A detailed analysis of energydemand and the possibilities of inter-fuel substitution in the major coal-producingcountries, such as China and India, is very important. This is needed for a better understanding of global environmental problems and the energy needs of these economies.

SAQ 3

Discuss the trends in energy consumption from the 1950s onwards. How did the growth in population influence these trends?

7.5 FUTURE ENERGY NEEDS AND CONSERVATION

Energy is an essential input for industrial development. Energy is produced from commercial sources like coal, petroleum, hydroelectric schemes as well as from non-commercial sources like cow dung, fuel wood and agricultural wastes. Per capita consumption of commercial energy is sometimes used as an index of the economic advancement that a country has attained. India's per capita consumption of commercial energy, however, is very low. It is only one eighth of the world average.

Commercial energy accounts for a little over half of the total energy used in the country, the rest coming from non-commercial sources. Share of agriculture in commercial energy consumption has risen rapidly over the past two-and-a-half decades. Industry consumed about 78 per cent of the coal and 62 per cent of the electrical energy in the country in 1985-86. The transport sector accounted for 56 per cent of the total oil consumption during the year 1989. The energy consumption of these sectors as well as the household sector are increasing rapidly. The energy strategy, therefore, has to plan not only for an increase in indigenous availability but also aim at its efficient utilisation.

7.5.1 Conservation and Energy

Energy generation and environmental conservation are the twin issues arising from exploitative interaction of humans with natural resources.Excessive utilisation of coal and oil for generation of electricity leads to the multiple problems of acid rain, and rising carbon dioxide levels in the atmosphere. Huge dams can make substantial contributions to economic development in electricity in developing countries like India, but as in any large-scale electricity generating option, there are trade-offs. Reservoirs inundate forests, farmland and wildlife habitats and uproot entire communities of indigenous people.

The answer to the country's energy needs can only lie in adopting non-conventional sources of energy. A beginning is being made by Government of India to give the same type of resources and support to developing alternative sources of energy as have so far been extended to the development of conventional energy sources.

In the following sections we will study some of the important means of energy conservation through the incorporation of innovative and imaginative alternatives within conventional rural agricultural technologies.

7.5.2 Development of Non-Polluting Energy Systems in India

I) **Improved Chullahas:**In developing countries like India, the energy needs of rural poor are mostly met with by burning firewood. Traditional methods of cooking are very unhealthy for the cook, as they emit a lot of smoke. Also the heat released in burning is not efficiently utilised. Indian energy scientists have come up with smokeless stoves **(chulhas)** (Fig. 7.19) specially designed for Indian conditions. These 'Chulhas' are smokeless, permit shorter cooking time and there is also saving of fuel. In India, the overall renewable energy capacity targets have been raised from 35,776 MW in 2015 to 1,75,000 MW by 2022 (MOEF & CC, 2015). This comprises of 1,00,000 MW solar, 60,000 MW wind, 10,000 MW Biomass and 50,000 MW.

Fig. 7.19: smokeless stove (chulhas) .

The improved 'chulha' has invoked tremendous response and positive action from all concerned. Nearly 3,000 villages have been rendered 'smokeless' in the sense that in each house of these villages, either an improved 'chulha' or a biogas plant is used for cooking food. A trained work force of more than 50,000 persons, mainly women, was created to work as master craftsmen for constructing the improved chulhas.

II) **Energy from City Sewage:** The city sewage treatment plants use anaerobic digestion units for extracting methane from human night soil which is in the form of a sludge. The gas generated from the sludge is called sludge gas, which like biogas consists largely of methane. The Department of Non-Conventional Energy Sources has supported setting up sewage based biogas plants in Uttar Pradesh, MadhyaPradesh and Delhi.

One large size urban waste recycling plant is already operating at Okhla, Delhi. The plant comprises 15 digesters connected to 15 gas collectors. The total gas generation from the plant is about 0.6 million cubic feet per day having a heat value of 700-800"BTU" per cubic foot (equivalent to 500-570 cal per m3). The gas is being supplied to about 800 households over an area of four kilometers. The gas is about 50 per cent cheaper than the LPG gas. Another such project has been commissioned, recently at Pandraune in UP. Plants are under construction at Ayodhya in UP, Eshaopur in Delhi, and at Bhopal in MP. In Jabalpur, Municipal Corporation is setting up agarbage-based power plant to generate 7 MW electricity daily.

Many bio-organic wastes are released as by-products by distilleries in India. A new technology for waste recycling and disposal has been introduced for the first time in the country by a distillery in Gujarat. The technology, simultaneous with the treatment of 45,000 litres of waste, will generate energy equivalent to that given by10 tonnes of coal every day. The fuel is generated from the waste after fermenting the ash with yeast in a suitable culture medium. The 10 million litre capacity distillery can get 50 per cent of its fuel requirement from recycling its own waste. If all the 150 distilleries in the country adopt the technology there could be a saving of Rs 30 crores or **5,00,000** tonnes of coal annually. This will also result in an environmentally safe disposal of wastes.

III) **Solar Energy:** Biogas is a cheap and efficient fuel and its feedstock is renewable.More recently, other renewable sources for energy generation are being explored.Systematic efforts are being made to tap solar energy for meeting the demands of our rural poor. It is a decentralised energy system, which can be used to meet versatile needs of the Indian masses. Solar cooking, water heating, water desalination, space heating, crop drying, etc. are some of the modes of thermal conversion. Efforts are on to economically develop solar collectors for high temperature applications. More than 380 solar water heating systems are operating in the country. More than 1,000 large capacity water heating systems are under installation.

Solar energy can also be converted into electrical energy. Solar panels concentrate large amounts of light energy on photovoltaic cells which charge the batteries that serve as a source of electricity. This electricity can be used to run pumps, streetlighting system or even refrigerators. More than 160 solar photovoltaic pumps have been installed in the rural areas providing water for drinking and irrigation. Solar photovoltaic street lighting systems have been provided by Government of India in more than 150 villages on experimental basis. Installed in the remote villages, alsoknown as **Urjagrams**, far from power lines, solar energy makes electricity availableto people who would otherwise not be able to dream of thermal or hydel electrical energy.

IV) **Wind Energy:** Another renewable alternative source of energy is wind energy.Wind energy holds promise for systematic utilisation. The maximum exploitable potential has been estimated at about 3.2 xlo8 J/ year. It can be converted intomechanical and electrical energies and would be particularly useful in remote areas.Wind energy can be made to run turbine to generate electricity. According to Indian Meteorological Department average annual wind density of 3 kwh/m^2/day (read as kilo watt hours per square meter per day) is prevalent at a number of places in Peninsular and Central India. In some areas, the densities are higher than 10kwh/m^2/day during winter when energy requirements are very acute and 4kwh/m^2/day for 5-7 months in a year. At present this energy is being used to upwell ground water at four locations of Ajmer in Rajasthan. DNES has installed 924 wind pumps throughout the country. Wind electricity generators at appropriate locations(like Ladakh) are envisaged with aggregate capacity of 2 MW, for lighting and pumping water in addition to devising charging of batteries. In the 8th Plan, some 85 new wind-powered mills are proposed to be installed at various locations in India, where the aerodynamics of the area provides conditions suitable for this venture.

Today, there are more than 100 manufacturers in the country engaged in the production and development of different renewable energy systems and devices. It is estimated that by the end of this century, 20 per cent of the total energy demand will be met from the following non-conventional energy sources.

Try the following SAQ to see what you have understood of the various

non-conventional sources of energy. Compare your answers with those given ‘ at the end of this unit.

SAQ 4

a. What is the difference between commercial and non-commercial sources of energy?

b. State whether the following statements are correct or incorrect. Indicate youranswer by putting a ( ) or (x) in the boxes provided.

  i) City sewage cannot be used for generation of biogas.

  ii) Smokeless ‘Chulhas’ permit shorter cooking time along with saving of fuel.

  iii) Gobar gas or biogas can be used for cooking, lighting and power generation for running refrigerators or tube well pump sets.

  iv) Urjagrams are earmarked villages in which non-conventional alternate energy generating systems have been installed by Government on experimental basis.

c. Compare and contrast conventional versus alternate systems of energy generation.

7.6 SUMMARY

Let us summarise what we have learnt so far:

- Today’s modern industrial societies are characterised by the intensive use of energy. You cannot think of life without electricity or other source of energy.
- India consumes roughly 3% of world’s total energy.
- Mainly there are two sources of energy viz i) Non-conventional sources such as biomass, solar, fuel cell, geothermal, Co-generation and wind energy, ii) Conventional sources of energy like natural oil energy, gas, coal and hydro power energy.

- The amount of energy consumed per person each year is a useful measure of standard of living.
- Energy demand of developing countries is increasing due to population growth and industrialisation.
- Renewable energy sources are virtually inexhaustible. They generate with minimal pollution, causing no oil spill, nuclear meltdown, nuclear water, smog or acid rain. Renewable energy sources have no fuel costs and are freely available.
- Switching to clean, renewable energy will bring us cleaner air and water while improving human health and increasing energy security.
- Conservation of energy sources is urgently required as its excessive consumption is not only costly but also leads to multiple problems. Moreover, dependence of modern human on innovative and non-conventional sources of energy has become the only alternative.

7.7 TERMINAL QUESTIONS

1. What are the differences between conventional and non-conventional sources of energy?
2. How is biogas helpful in meeting the energy crisis of people living in rural areas?
3. Discuss any two non-conventional means of generating energy.

7.8 ANSWERS

Self-Assessment Questions

1. (i) a (ii) b (iii) c (iv) c (v) b
2. (a) maximum, b) energy, c) more, d) sustainable
3. Refer to section 7.4.
4. a) The sources of energy which are produced on a large-scale for the purpose of sale are called **commercial,** such as coal, petroleum, electricity. Those sources which serve only local needs and are not produced on a large-scale are called **non-commercial** sources such as firewood, cowdung and agricultural wastes.

   b) i) × ii) ✓ c) ✓ iv) ✓

   c) Conventional systems of energy generation are less efficient, more polluting and non-renewable whereas alternate sources of energy are innovations providing clean and efficient means of energy generation using renewable resources.

✓

Terminal Questions

1. The conventional sources of energy such as coal, petroleum are non-renewable; they make use of old technologies for energy generation and cause environmental damage. Non-conventional sources of energy such as solar energy, energy from biomass, are based on renewable resources; they make use of comparatively recent technologies and cause minimum damage to the environment. Non-conventional sources of energy are decentralised means of making energy available to rural poor located in remote areas.

2. Refer to section 7.2.

3. The two non-conventional methods of energy generation are: a) generation of electricity through solar cells, and b) generation of electricity through wind power. In the first case, solar panels collect solar radiation and reflect it on photovoltaic cells, which become charged and can be used as battery of cells. The second makes use of force of wind to rotate a motor which generates electricity.

7.9 FURTHER READING

1. Bharucha, E. (2005) *Textbook of Environmental Studies for Undergraduate Courses,* Hyderabad: Universities Press (India) Private Limited.

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Acknowledgement for Figures

1. Fig. 7.1: Biomass gasifier.

   (Source: https://i.ytimg.com/vi/837XxbF4_ss/hqdefault.jpg)

2. Fig. 7.10: Use of renewable energy as wind pump.

   https://en.wikipedia.org/wiki/File:Turbines-thar-india.jpg

3. Fig. 7.12: Hydro Power. (Source: http://www2.emersonprocess.com/SiteCollectionImages /News%20Images/Agua%20Verm080.jpg)

4. Fig. 7.13: A view of atomic power station. (Source: http://www.power-eng. com/content/dam/Pennenergy/online-articles/2013/February /Sequoyah-Nuclear-Plant.jpg)(Source: http://seco.cpa.state.tx.us/images/manure-biogas.gif)

5. Fig. 7.14: Energy consumption in selected Asian countries 1980-2001.
(Source: http://cdn0.wn.com/o25/ar/i/aa/d36e6ebee51ddd.jpg)

6. Fig. 7.15: World population and global primary energy use projections to 2100. Notice that at present the world uses roughly 9 gtoe worth of energy per year. (Source: http://www.euanmearns.com/wp-content/uploads /2014/07/world_energy_population.png)

7. Fig. 7.16: World energy intensity by region 1970-2020.(Source: http://web.fc2 .com/jump/?url=http://oilpeak.web.fc2.com/myenvironmentalism/technology /ieo2000/figure-11.jpg)

8. Fig. 7.17 An illustration of energy consumption in the developed world Source:https://pixabay.com/photos/hong-kong-city-urban-skyscrapers-1990268/