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:

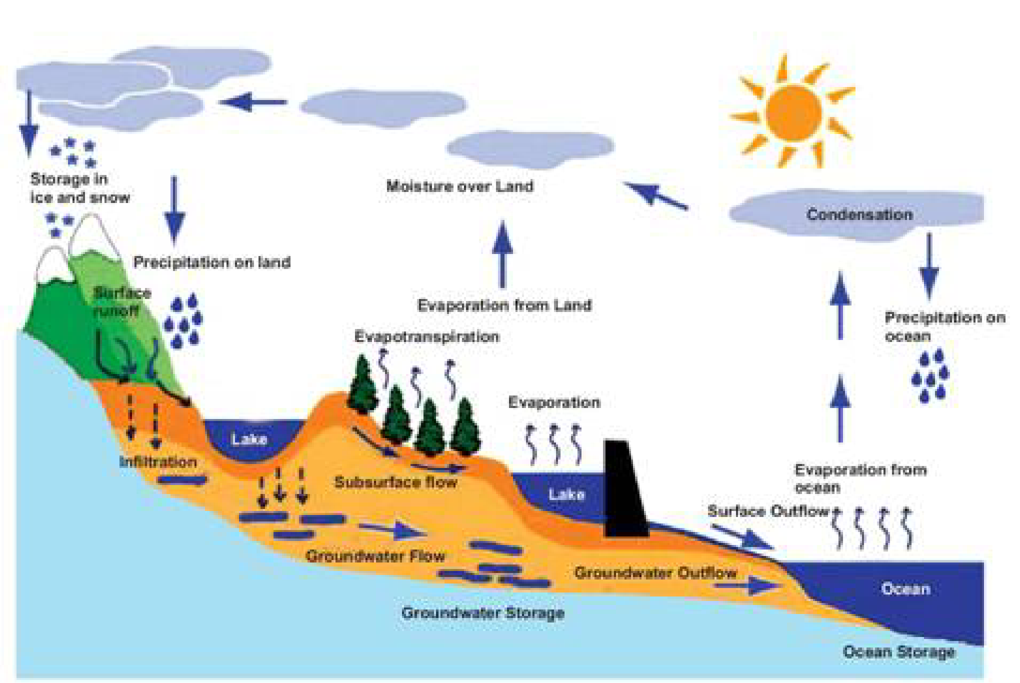

Fig. 4.1: Hydrological cycle.

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.

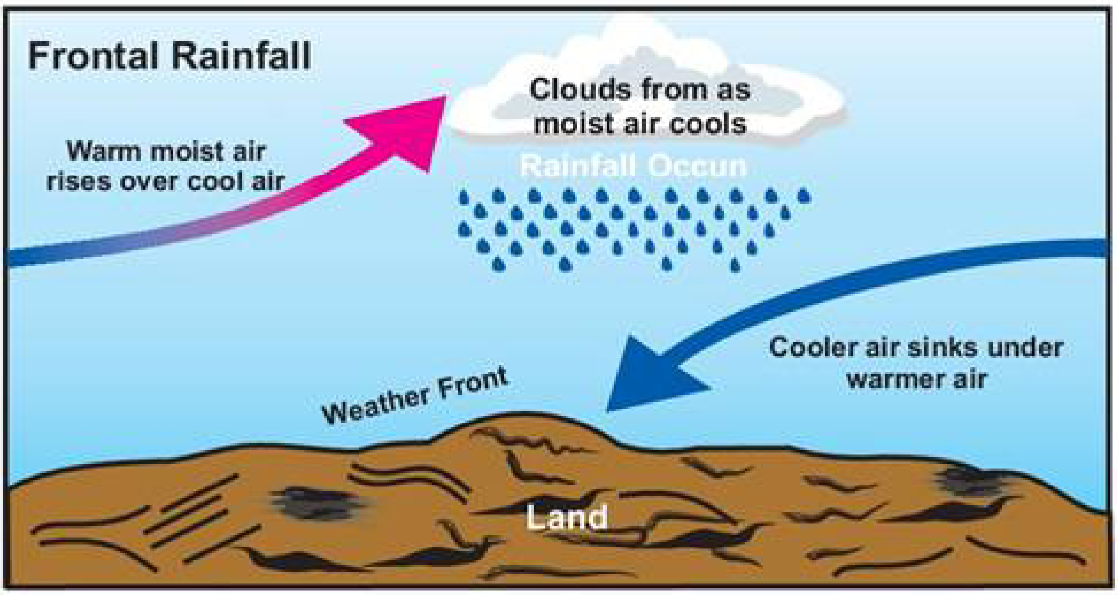

Fig. 4.2: Relative humidity for a given parcel of moisture laden air varies with temperature.

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.

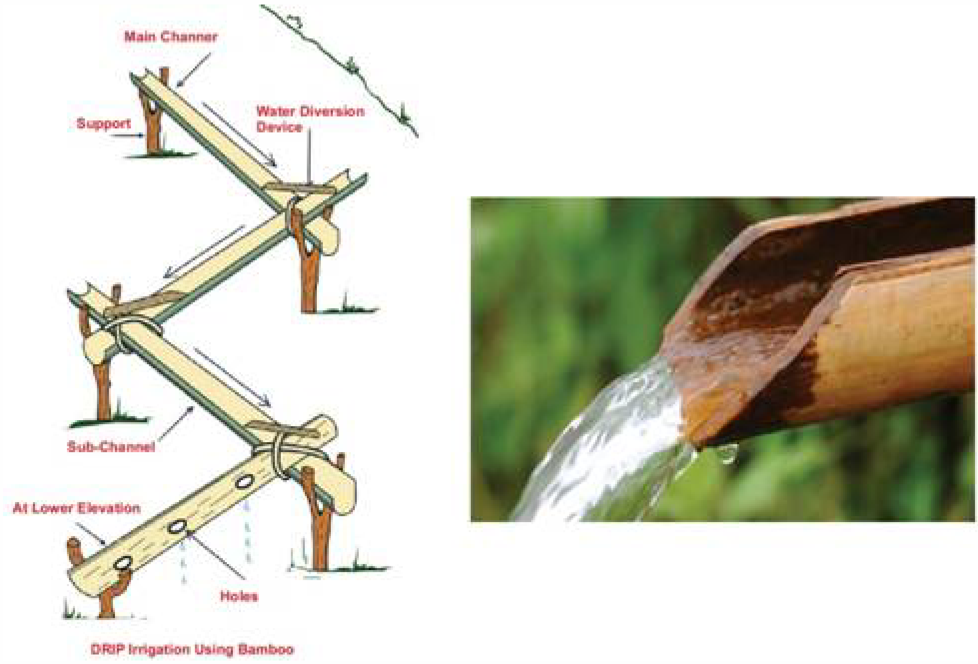

Fig. 4.3: Bamboo drip irrigation.

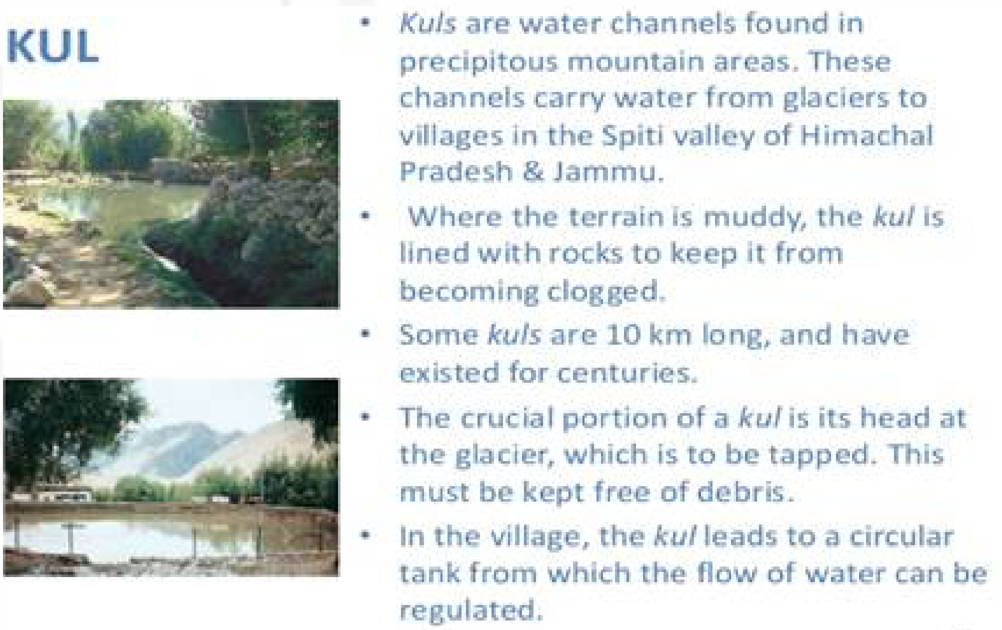

Fig. 4.4: Kuls in the Spiti area.

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.

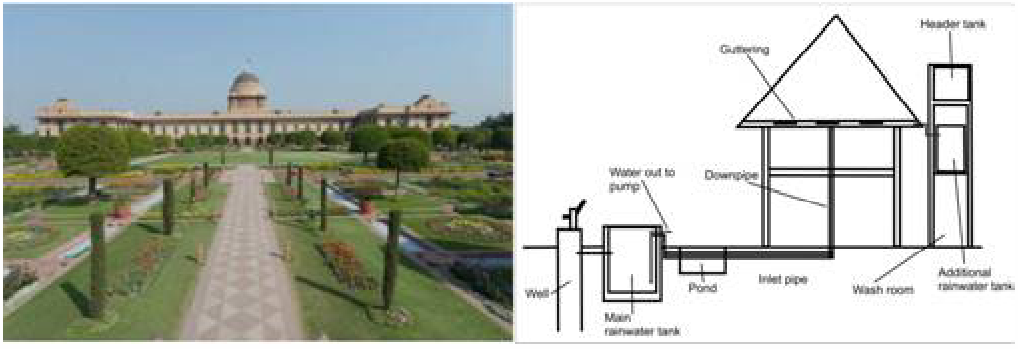

Fig. 4.5: Rainwater harvesting in Rashtrapati Bhawan.

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.

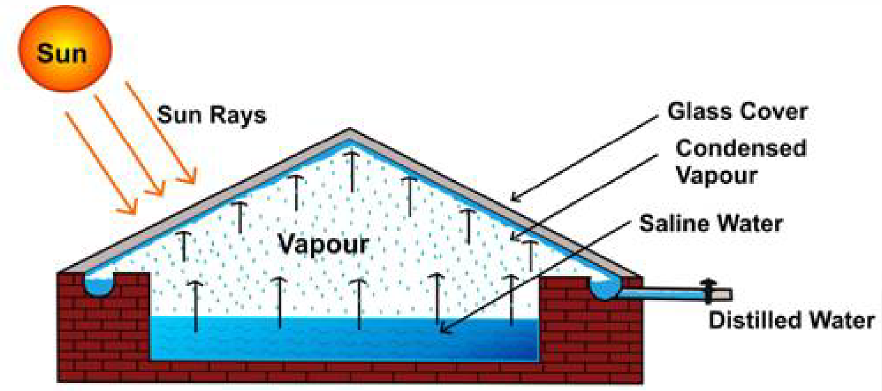

Fig. 4.7: Desalination of sea water by use of solar energy.

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).

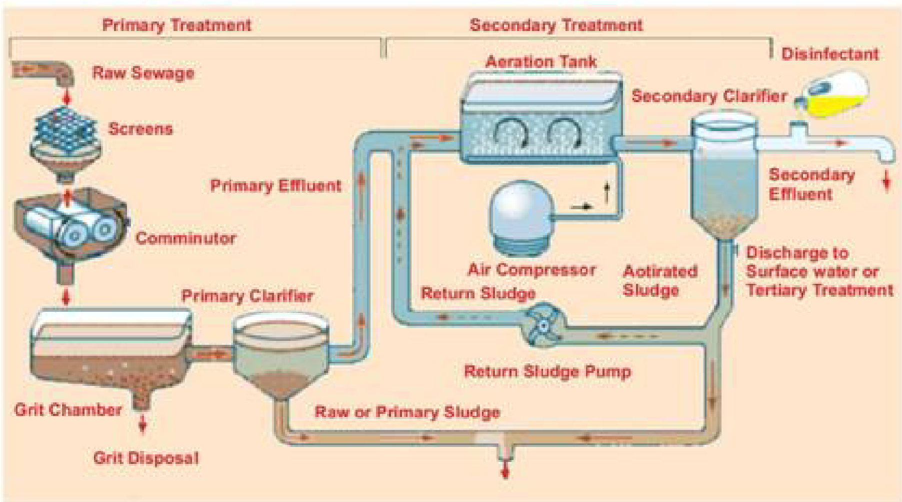

Fig. 4.8: Domestic and municipal waste water treatment.

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).

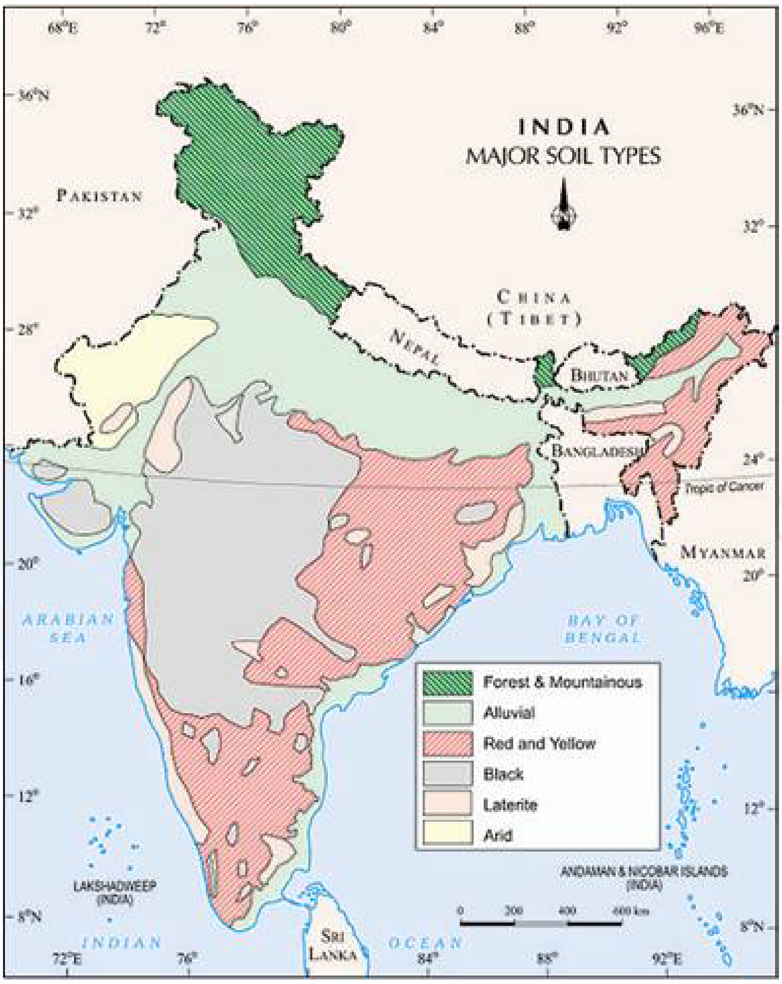

Fig. 4.9: Major Soil types of India.

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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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