2 Natural Resources

- Introduction
- Classification of Natural Resources
- Principal Natural Resources and their Problem
  - — Forest Resources
  - — Water Resources
  - — Mineral Resources
  - — Food Resources
  - — Energy Resources
  - — Land Resources
  - — Land Degradation
- Role of Individual in Conservation of Natural Resources
  - — Conservation of water
  - — Conservation of Energy
  - — Conservation of Soil
- Equitable use of Resources for Sustainable Life Styles
- Important Terms

INTRODUCTION

The word 'resource' means a source of supply or support that is generally held in reserve. In other words *'the natural resources are the materials, which living organisms can take from nature for the sustenance of their life'* or *'any component of the natural environment that can be utilized by man to promote his welfare is considered as a natural resource'*. A natural resource can be a substance, an energy unit or a natural process or phenomenon. *e.g.*, land, soil, water, forests, grassland etc. Some of the resources such as soil, water, etc. are important components of life supporting system. The natural resources are not only sources of food, fodder and shelter, they also provide recreational opportunities, solace and even inspiration to mankind.

The nature of resources varies from society to society. The variation is related to the culture, the level of development and the nature of work of a society. A substance present in nature, but not utilized, is not a resource. For Onge tribal society of the Andaman group of islands do not use uranium, gold and silver, which are therefore, not resources for them. Similarly, uranium was not of much importance earlier but has now become valuable resource because of its use in nuclear energy.

Natural resources have been exploited by humans since the beginning of civilization or even before. However, since the resources were abundant than relative to human population, no significant depletion occurred. But due to considerable increase in human population during the last millennia, a serious damage or destruction has been caused to the natural resources.

CLASSIFICATION OF NATURAL RESOURCES

The quantity and quality of natural resources vary greatly in their location. For instance, particular types of forest and grassland may occur only in certain countries. The geographical

area covered by forest and grasslands, and the quality of their produce also differ widely in different countries. Depending upon the availability and abundance, natural resources are of two types : inexhaustible and exhaustible (*Fig. 2.1*).

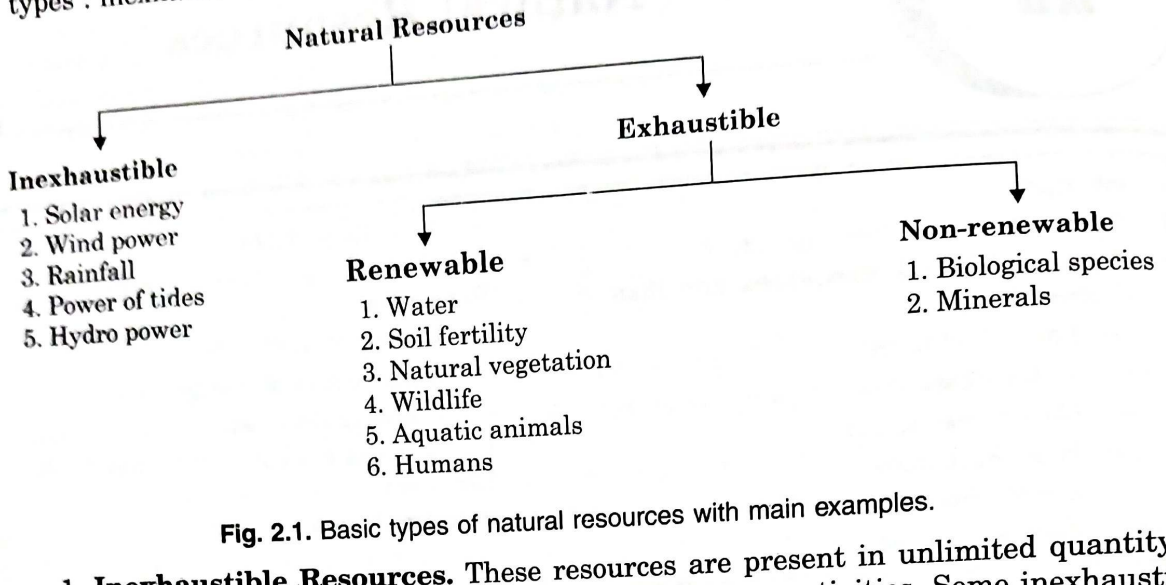


Fig. 2.1. Basic types of natural resources with main examples.

1. **Inexhaustible Resources.** These resources are present in unlimited quantity in the nature and they are not likely to be exhausted by human activities. Some inexhaustible resources remain unaffected by human activities, while many others may show some changes in their quality. Solar energy, wind power, tidal power, rainfall, and even atomic energy are classified as inexhaustible resources. These resources cannot be exhausted significantly at global level due to human activities. Some resources may sometimes be affected locally by human activities. *e.g.* the quality of air is changed due to pollution.

2. **Exhaustible Resources.** These resources have limited supply on the earth, and are, therefore, liable to be exhausted if used indiscriminately. Exhaustible resources are of two types : renewable and non-renewable.

(*i*) ***Renewable Resources.*** These resources have the capacity to reappear or replenish themselves by quick recycling, reproduction and replacement within a reasonable time. Soil, water and living beings (*i.e.* plants, animals and micro-organisms) are renewable resources. The growth and reproduction of living beings can be successfully managed so that these resources are continuously regenerated. However, if the consumption of these resources continues to exceed their rate of renewal, not only their quality becomes affected, they may even totally exhausted.

There are different renewable products in different ecosystems. Some important ecosystems and their renewable resources are given in *Table 2.1*.

Table 2.1. Important Ecosystems and their Renewable Products

Ecosystems	*Renewable Products*
Forests	Yield timber and other plant products.
Range lands (Grassland)	Sustain grazing animals for milk, meat and wool products
Wildlife	Maintain food chain
Agricultural systems	Yield food and fibre
Marine and fresh water systems	Yield various foods from plants and animals.

(*ii*) ***Non-Renewable Resources.*** These resources lack the ability of recycling and replacement. The substances with a very long recycling time are also regarded as non-renewable resources.

Many abiotic resources are non-renewable. The fossil fuels (coal, petroleum and natural gas) and metals once extracted cannot be regenerated at the place of extraction. After unlimited extraction and use, the fossil fuels will definitely get exhausted. Some biotic resources are also non-renewable. The biological species, which have evolved in nature during the coarse millions of years are considered non-renewable. A biological species which becomes extinct from the earth cannot be created again.

PRINCIPAL NATURAL RESOURCES AND THEIR PROBLEMS

Forest Resources

A forest is a biotic community which is predominantly composed of trees, shrubs or any woody vegetation and often with a closed canopy (over-hanging covering). Approximately one third of the earth's total land area is covered by forests. Forests are the valuable wealth of a country. They are store houses of biodiversity and provide important environmental services to mankind. To offer these services, forests have following three types of functions:

1. **Productive Functions.** The productive functions of forests include the production of timber, bamboos, food and a wide variety of compounds, such as resins, alkaloids, essential oils, latex, pharmaceuticals etc. (*Fig. 2.2*).

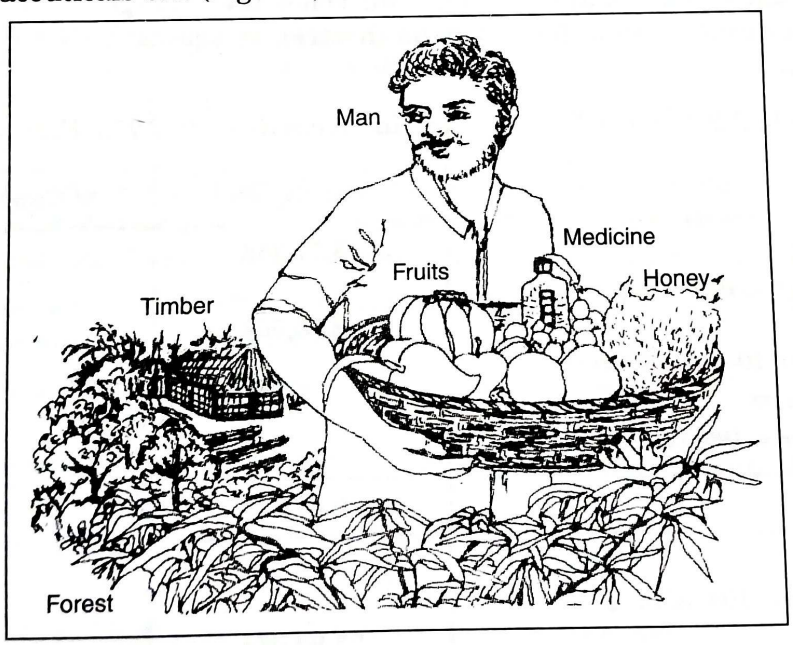


Fig. 2.2. Forest products.

Natural forests provide local people with a variety of products, if the forest is used carefully. The forest products, collected by people include food like fruits, roots, herbs and medicinal plants. People depend on fuel wood to cook food ; collect fodder for domestic animals and cut building material for housing ; collect medicinal plants that have been known for generations to treat several ailments. Forest dwellers and rural folk use these goods directly, while other people get them indirectly from the market.

2. **Protective Functions.** These functions include conservation of soil and water, prevention of drought and protection against wind, cold, radiation, noise, sights and smells, etc.

Forests control the flow of water in streams and rivers. Forest cover reduces the surface run off of rainwater and allows ground water to be stored. Forests also prevent the erosion of soil. Once soil is lost by erosion, it can take thousands of years to reform.

3. **Regulative Functions.** The regulative functions include absorption, storage and release of gases (like CO_2 and O_2), water, mineral elements and radiant energy. Floods, draughts and global biogeochemical cycles, particularly of carbon is also regulated by forests. The regulative functions of forests improve atmospheric and temperature conditions, and enhance the economic and environmental value of the landscape.

Forests regulate the local temperature. It is cooler and moister under the shade of the trees in the forest.

Forest Area in India. India had abundant forests in ancient times. Chandra Gupta Maurya and Kautilya took keen interest in forest management. Ashoka's stone edicts prescribed tree planting. But increase in population, lack of foresight and unplanned felling have drastically reduced the area and quality of forests in India today. At the beginning of the 20th century about 30 per cent of land in India was covered with forests. But by the end of the 20th century the forest cover was reduced to 19.4 per cent. This is far less than the optimum area of forests recommended by the **National Forest Policy** (1988). The National Forest Policy has recommented 33 per cent forest area for the plains and 67 per cent for the hills. Of the existing forests, less than two third are dense forests, and the rest are open degraded forests (*Table 2.2*). In India, the per capita forests area available far below the average of the world. Today, per capita forest area available in India is 0.06 ha (hactre), as against 0.64 ha of the world's per capita forest area.

Table 2.2. Forest Cover in India According to 1999 Estimate

Class	*Area (sq. km)*	*% Geographical Area*
Dense forest (*Canopy cover > 40% of land*)	3,77,358	11.5
Open forest (*Canopy cover 10–40% of land*)	2,55,064	7.8
Mangrove forest (*Canopy cover < 10% of land*)	4,871	0.1
Sub-total	6,37,293	19.4
Scrub (*Canopy cover < 10% of land*)	5,896	1.6
Non forest (*Other land use*)	25,98,074	79.0
Total	32,87,263	100.0

Deforestation

Destruction of forests is a formidable threat to the quality of life, country's economy and future development. World's forest cover has been shrinking rapidly, especially in the developing countries located in tropics. While the temperate forests have lost only 1 per cent or less of its area, the tropics have lost more than 40 per cent of the forest cover due to deforestation. The current rate of deforestation is estimated to be more than 10 million ha per year. If this rate of deforestation continues, it is feared that the remaining tropical forests may disappear within a century.

Causes of Deforestation

The main causes of deforestation are as follows:

1. **Shifting Cultivation (Jhum).** The jhum or shifting cultivation is a traditional agro-forestry system widely practiced in the north eastern region of our country. It involves felling and burning of forests followed by cultivation of crops for few years, and abandoning cultivation to allow forest's regrowth. This type of cultivation is always meant to fulfil local needs but this method causes extreme damage to forests.

2. **Explosion of Human Population.** Due to overpopulation of human beings, requirement of timber, fuel, paper, wood etc. has been increased. Man has cleared large areas of forests for agriculture, housing, factories, roads and railway tracks (*Fig. 2.3*).

3. **Demand of Wood for Industries.** Wood is used for several industrial processes, such as making boxes, crates, packing cases, furniture, match boxes, paper, plywood etc. The requirement of wood for industries has increased tremendously in the country in the recent years. Today, the country's annual requirement for industrial wood is about 40 Mm^3 (Mega cubic metre), whereas only 13 Mm^3 is available.

4. **Construction of Roads.** Construction of roads along the mountains which cover nearly 30,000 km in ecologically fragile area is another cause of forest degradation.

5. **Mining Operations.** Mining operations have a serious impact on forest areas. Large areas of forest are cleared and laid barren as a result of open cast mining of mica, coal, manganese, limestone, etc. This results in turning of forest into pastures. For example:

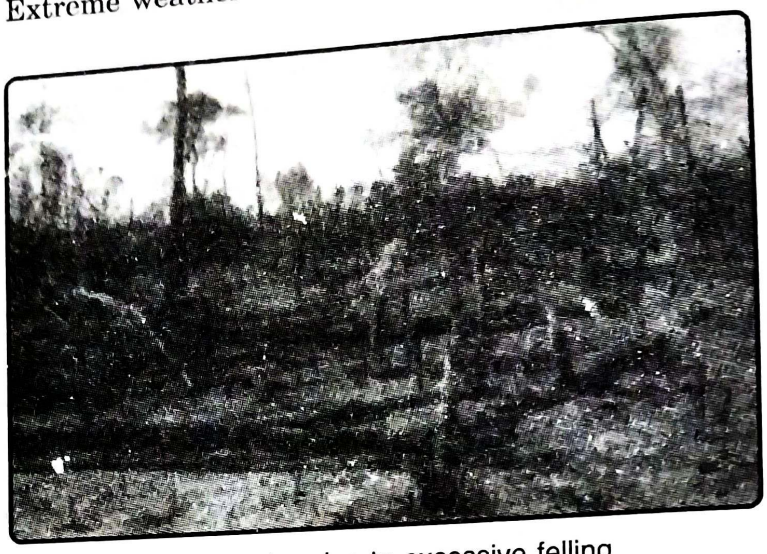
- Large scale deforestation has been reported in Mussorie and Dehradun valley due to indiscriminate mining of limestone.
- Indiscriminate mining in forests in Goa has destroyed more than 50,000 ha of forest land.
- Coal mining in Jharia, Raniganj and Singrauli areas have caused extensive deforestation in Jharkhand.
- The rich forests of Western Ghats are also facing the same threat due to mining projects for extraction of copper and bauxite.

6. **Overgrazing.** Overgrazing of forests by livestock has resulted in large scale degradation of forests.

7. **Pests.** Many kinds of insects and pests destroy trees by eating up leaves, boring into shoots and spreading diseases.

8. **Fires.** Fire is the worst enemy of forest. It destroys the full grown trees, seedlings, seeds and even humus. It also causes large scale damage to animal life.

9. **Weather.** Extreme weather conditions such as frost, storms and heat also destroy forests.



Deforestation due to excessive felling

Destruction of forest due to mining activity

Fig. 2.3. Causes of deforestation.

10. **Dams and Hydroelectric Projects.** Dams, reservoirs and hydroelectric projects submerge forest, displace local people cause water logging and siltation and may result in earthquakes. Such projects displace large number of tribal people and cause great damage to the forests, which are the main source of their livelihood. The relief and rehabilitation programmes offered by the government always seems inadequate.

Effects of Deforestation

Deforestation affects human life in several ways (*Fig. 2.4*). The main effects of deforestation are as follows:

1. Forests, particularly on mountains, provide considerable protection from floods by trapping and absorbing precipitation (*i.e.* rain, snow etc.) and slowly releasing it later. When the forest is removed, the amount of runoff water flowing into rivers and streams increases several fold causing frequent floods.

2. Deforestation results in increased soil erosion and decreased soil fertility. In drier areas, deforestation can lead to the formation of deserts.

3. Deforestation causes the extinction of forest dwelling plant, animal and microbial species resulting into a loss of irreplaceable genetic resources.

4. Deforestation also threatens indigenous (tribal) people whose culture and physical survival depend upon the forests.

5. Deforestation induces regional and global climate change. The climate has become warmer due to lack of humidity in the deforested regions.

6. The pattern of rainfall has changed in deforested areas. The rainfall has declined and droughts have become common.

7. Deforestation also contributes to global warming by releasing stored carbon into the atmosphere as carbon dioxide, which is a greenhouse gas.

8. Human beings are deprived of benefits of forest trees and wild animals.

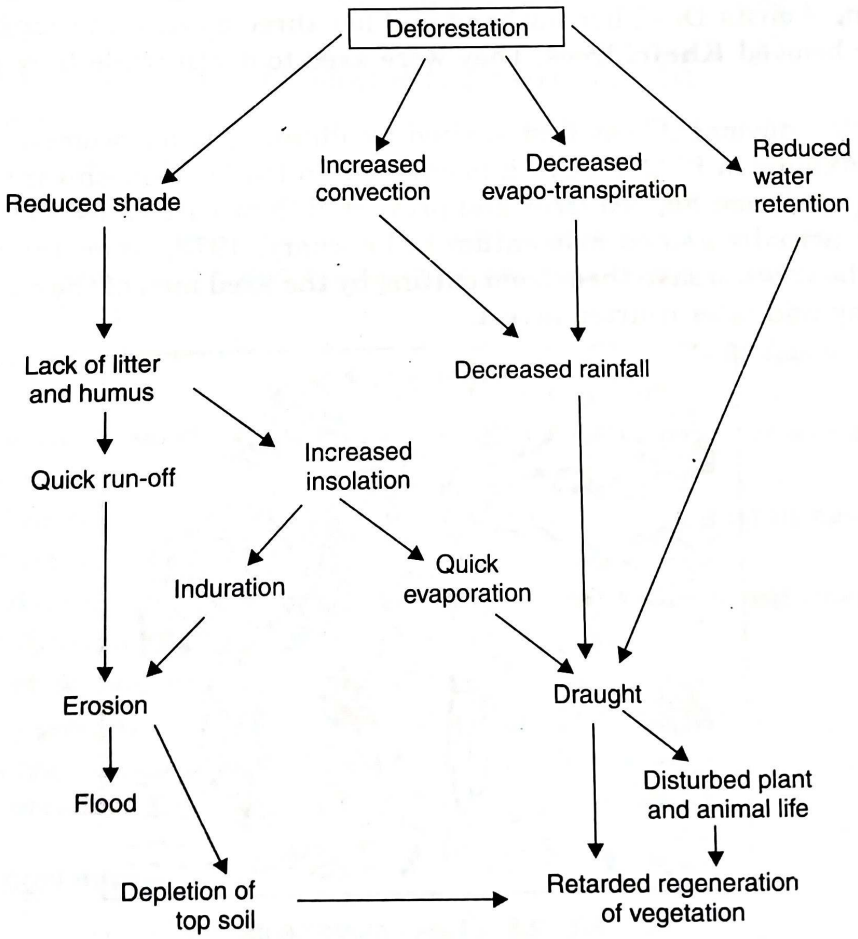


Fig. 2.4. Effects of deforestation.

Case Study

1. Desertification in Hilly Regions of the Himalayas. Degradation of once fertile land into desert like land is called desertification. A large scale cutting of forest trees in Himalayas and plantation of selected trees like *Pinus roxburghii* and *Educalyptus camaduiensis* (Safeda) have disturbed the ecosystem by changing the physical and biological properties of the soil. It has resulted in poor nutrient cycling, loss of original rich germplasm and invasion by exotic weeds. Consequently, the soil of these areas is losing fertility. Many hills of Himalayan region like West Khasi hills in Meghalayas, parts of Kumaon and Garhwal and Ladakh are now facing the problems of desertification due to large scale deforestation.

2. Sub-Normal Rainfall in Nilgiri Mountains. When the Nilgiri mountains had luxuriant forest cover, annual rainfall used to be quite high. However, during the last two decades the rainfall has declined to sub-normal due to decreased forest cover in this region.

Chipko Movement

Chipko (tree hugging) movement was a campaign in which some environment conscious people opposed the cruelties of man on the forest trees.

The first foremost movement against indiscriminate felling of trees in India was fought in 1731 by a Bisnoi woman, **Amrita Devi** of **Khejarili village**, 25 km from Jodhpur. 363 Bisnois including Amrita Devi, her husband and her three daughters sacrified their lives for protecting their beloved **Khejri** trees. They were axed to death while they were clasping the trees.

The Chipko movement was first started by illiterate tribal women in Tehri Garhwal district in Uttarakhand in 1972. It came into limelight in 1973 in Gopeshwar in Chamoli district when the local population hugged trees and prevented their cutting by a sports goods factory of Allahabad. It actually gained momentum in February, 1978, when the women of Advani village hugged the trees to save them from cutting by the axed men of the contractor (*Fig. 2.5*), faced police firing and later courted arrest.

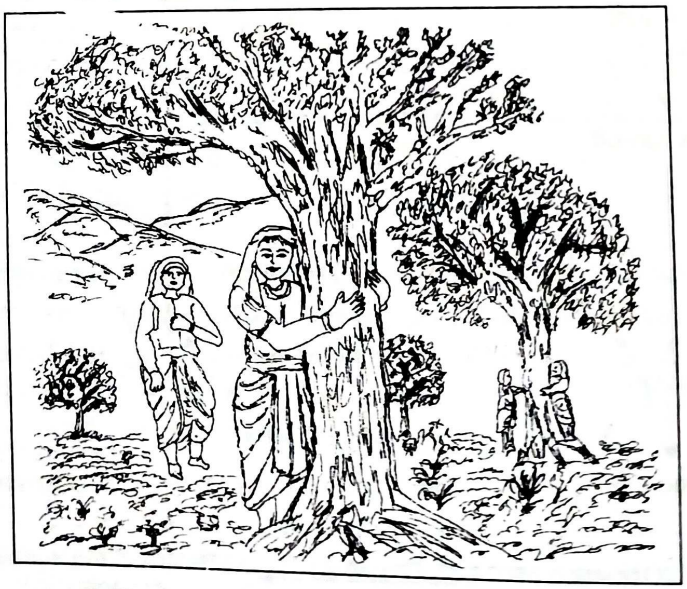


Fig. 2.5. Chipko movement.

The movement continued under the leadership of **Sh. Sunder Lal Bahuguna** (an environmentalist and journalist) and **Sh. Chandi Prasad Bhatt** in Tehri Garhwal region. Sh. Sunder Lal Bahuguna along with his workers undertook a peace march of about 3000 km

from Srinagar (*Kashmir*) to Siliguri (*West Bengal*) to protest against the felling of trees. Ultimately, the Chipko movement got the success with the following outcomes.

1. The U.P. Government abolished the contractor system of tree felling.
2. Forest Development Corporation (*FDC*) department was formed which works for the welfare of the hilly areas and the people living there.
3. It slows down the process of deforestation.
4. It enlightened the people about the necessity of ecological balance in the nature.
5. It exposed the vested interests involved in the mass destruction of forests.

The Chipko movement flew from Tehri Garhwal (*Uttarakhand*) to various parts of the country, in the hilly districts of Karnataka, in the hills of central India, in Aravali's of Rajasthan and all over the Himalayas. In Karnataka, chipko movement is known as **Appiko movement**. It has three main objectives popularly known as *ulisu* (to conserve), *belesu* (to grow) and *balasu* (rational use). Appiko movement is trying to evolve a sustainable development strategy that conserves and improves forest resources.

Forest Conservation and Management

The forest conservation and management programmes are based on two basic principles.

(*i*) sustainable supply of tree products and services to people and industry.

(*ii*) maintenance of long term ecological balance through protection, restoration and conservation of forest cover.

Following measures should be adopted to conserve forests:

1. A tree removed from the forest for any purpose must be replaced by a new tree. Thus, tree felling should be matched by tree planting programmes as early as possible.
2. Afforestation should be done in areas unfit for agriculture, along highways and rivers, around playgrounds and parks. A special programme of trees plantation called **Van Mahotsava** is held in the months of August and February, every year in our country. It should be made more popular and effective.
3. Maximum economy should be observed in the use of timber and fuel wood by minimising the wastage.
4. The use of fire wood should be discouraged and alternative source of energy for cooking such as biogas, natural gas etc. should be made available.
5. Forest should be protected from fire. Modern fire fighting equipment should be used to extinguish accidental forest fire.
6. Pests and diseases of forest trees should be controlled by fumigation and aerial spray of fungicides and through biological method of pest control.
7. Grazing of cattles in the forests should be discouraged.
8. Modern methods of forest management should be adopted. These include, use of irrigation, fertilizers, bacterial and mycorrhizal inoculation, disease and pest management, control of weeds, breeding of elite trees and tissue culture techniques.

Afforestation Programmes

In order to save the diminishing forest cover, there is a dire need of extensive planting of trees through afforestation programmes. To achieve these goals the following forestry practices should be carefully integrated: (*i*) Protection or conservation forestry, and (*ii*) Production or commercial forestry.

(*i*) ***Protection or Conservation Forestry.*** It involves protection of degraded forests to allow recoupment of their flora and fauna. The forests which are well stocked are managed scientifically for producing timber and other forest products without causing any negative environmental impact on the forest. Many forest areas are designated as national parks and sancturies and are protected from human interference.

(*ii*) ***Production or Commercial Forestry.*** It involves intensive plantation of trees on available land or on land not under agriculture with the aim of fulfilling the commercial demand, without causing denudation of natural forests. Generally, fast growing trees (such as *Eucalyptus*, *Acacia*, etc.) are raised using modern techniques. The production forestry programmes include social forestry, agro-forestry and urban forestry programmes.

(*a*) *Social Forestry.* Social forestry programme involves raising of trees for firewood, fodder, agricultural implements and fruits on public and common lands, road and rail sides, etc., for the benefit of rural community. It reduces pressure on the existing forests. A number of indigeneous and/or exotic tree species which can meet the requirement of rural community are used for plantation in social forestry programme.

(*b*) *Agro Forestry.* This programme aims at surviving an ancient practice of using the same land for farming and forestry. Under this programme woody species are grown in combination with herbaceous crops, either at the same time or in time sequence. Two well known systems of agro forestry programmes are in practice in our country. These are **taungya system** and **jhum cultivation**. The taungya system involves growing agricultural crops between rows of planted trees (sal, teak, etc.). The jhum or shifting cultivation is a traditional agro-forestry system widely practiced in the north eastern region of our country. It involves felling and burning of forests followed by cultivation of crops for few years, and abandoning cultivation to allow forest's regrowth.

(*c*) *Urban Forestry Programme.* It is aimed at growing ornamental and fruit trees in urban areas along roads, in private compounds, vacant lands and common parks. It has great aesthetic value for the citizens.

Case Study

Education in Nature—The Shantiniketan Model. Shri Rabindranath Tagore founded 'Shantiniketan' a university that taught an environment based philosophy. Tagore's philosophy of education focused upon the need for a harmonious association between human beings and their environment. To achieve this, he relied on exposing young people to nature. This went back to our roots where in ancient India, learning centres were established in remote forests. Tagore linked these concepts with celebrations of nature through music, dance, drama and poetry. At Shantiniketan, there were celebrations for each season and ceremonial tree planting. He started *'Vriksharopan'* way back in 1928. In fact much of what was initiated in Shantiniketan is now accepted as the route to environment education and sustainable living and is essentially based on preserving nature.

Water Resources

Water is the main constituent of hydrosphere and is a renewable resources. Water is needed for daily use by organisms, for irrigation, navigation, industrial use, electricity production and domestic use. About three-fourth of the earth surface is occupied by oceans which contain about 97.5 per cent of the earth's water in strongly saline condition. The rest 2.5 per cent is fresh water and all of this is not available for direct human use.

Most of the fresh water (*i.e.* 1.97 per cent of the total water) is permanently frozen as polar or glacial ice. Remaining fresh water occurs as groundwater (0.5 per cent), water in lakes

and rivers (0.02 per cent), soil (0.01 per cent) and atmosphere (0.0001 per cent). Thus, only a small fraction of fresh water is available for human consumption. The distribution of fresh water is geographically uneven varying greatly from country to country and even within a country from one region to another.

Water cycle play an important role in maintaining different forms of water in nature. Water passes into the atmosphere by evaporation from the surface of moist earth, lakes, streams, oceans etc. Water vapour gets condensed and returns to the earth in the form of rain, hail and snow. There is a circulation of water from sea to land and back. At any given time, the amount of moisture in the air is only enough to meet a total rainfall requirement of 10 days. Thus, there is very fast movement of water from ocean and land into the atmosphere, and an average residence time of water in the air is only about 10 days. The ocean surface contributes about 84 per cent of the global evaporation and the remaining 16 per cent comes from land surface. About 77 per cent of the total rainfall on earth is received on the sea surface (as against 84% evaporation from this segment) and 23 per cent on land (against 16 per cent share of total evaporation to the atmosphere). Thus, there is not gain of 7 per cent rainfall water on land. This excess water is returned to the oceans by surface runoff through rivers and sub-surface water flows. As the total annual evaporation matches with annual precipitation, the hydrological cycle can be considered a perfectly balanced cycle.

Forms of Fresh Water

Fresh water mainly occurs in two forms: groundwater and surface water (Fig. 2.6).

1. Groundwater

Groundwater constitutes about 9.86 per cent of the total fresh water resource. It is about 35–50 times that of surface water supplies. The groundwater is contained in **aquifers.** An aquifer is a highly permeable layer of sediment or rock containing water. Layers of sand and gravel are good aquifers, while the clay and crystalline rocks (*e.g.* granite) having poor permeability are not good aquifers. Aquifers are of two types:

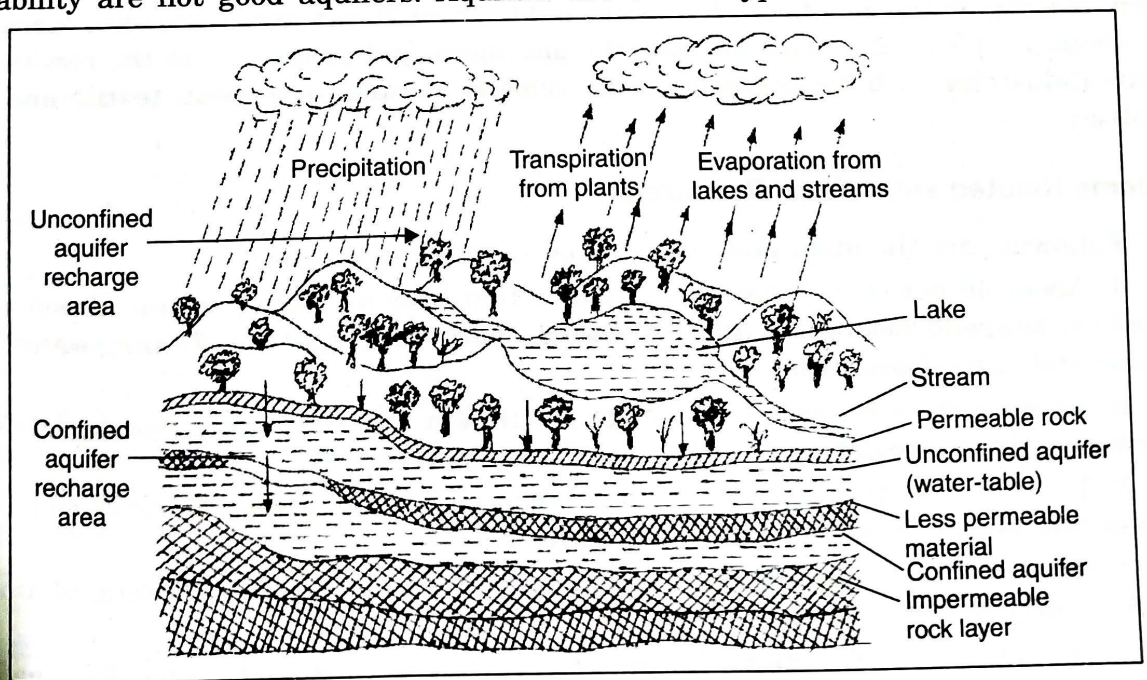


Fig. 2.6. Groundwater system: unconfined and confined aquifers and their recharging areas.

(*i*) ***Unconfined Aquifers.*** These are covered by permeable earth materials and are recharged by seeping down of water from rainfall and snowmelt.

(*ii*) ***Confined Aquifers.*** These are present between two impermeable layers of rock and are recharged only in those areas where the aquifer meets the land surface. The recharging area of many confined aquifers may be several kilometer away from the location of the well.

Effects of Overuse of Groundwater. Overuse of groundwater has following ill effects:

(*i*) ***Lowering of Water-Table.*** Excessive use of groundwater for drinking, irrigation and domestic purposes has resulted in rapid depletion of groundwater in various regions leading to lowering of water-table and drying of wells. The lowering of water-table would cause a sharp decline in future agricultural production.

(*ii*) ***Ground subsidence.*** When groundwater withdrawal is more than its recharge rate the sediments in the aquifer become compacted. It is called **ground subsidence**. It results in sinking of overlying land surface which may damage buildings, destroy water supply, reverse the flow of sewers and canals and tidal flooding.

2. Surface Water. Surface water occurs in the forms of streams, rivers, lakes, ponds, wetlands and artificial reservoirs. It comes through precipitation (rain fall, snow) and accumulated in the water bodies, if not percolated into the ground or not returned to the atmosphere as evaporation or transpiration loss. Surface water is mainly used for irrigation of crops, public water supply and industrial supply.

Water Use and Over Exploitation

Human beings depend on water for almost every developmental activity. Water is used for drinking irrigation transportation, washing, disposal of industrial wastes and as a coolant for thermal power plants.

A rapid rise in population and expansion in industry and agriculture have increased the demand for water manifold. The use of water has increased 4–8 per cent per year since 1950. The rate of consumption of water varies among different countries. Agriculture uses maximum amount of water in the world, which is estimated to about 70 per cent of the total consumption. Only about 1.1 per cent is used for domestic and municipal supplies, and the rest is used by various industries such as pharmaceutical, cement, mining, detergent, textile and leather industries.

Problems Related with Water Resources

Following are the main problems related to water resources:

1. About 40 per cent of the world's population lives in arid or semi-arid region. These people have to spend substantial amount of time, energy and effort in obtaining water for their domestic and agricultural use.

2. To meet the requirements of huge population, surface waters (ponds, lakes, rivers etc.) are over drawn, resulting in drying up of nearby wet lands.

3. The groundwater may also dry out, when more groundwater is removed for human use than can be recharged by rainfall or snowmelt.

4. Excessive irrigation in semi-arid and arid regions can cause salt accumulation in the soil, which may reduce crop productivity.

5. The continuous depletion of groundwater along the coastal regions often leads to the movement of saline sea water into fresh water wells spoiling their water quality. Estuaries also become more saline and hence less productive when surface water is over drawn.

6. Heavy rainfall on exposed soils results in rapid runoff causing soil erosion. It puts low land areas at extreme risk of destruction due to flooding. Soil erosion also results in sedimentation of water-ways that can harm aquatic life.

Floods

Inundation of a large land area with water for several days in continuation is called flood. Floods have been regular features of some parts of India and Bangladesh causing huge loss of agriculture, life and property. In India the worst affected states are Assam, West Bengal, Bihar, Orissa and Eastern Uttar Pradesh. Due to floods, the plains become silted with mud thus reducing the cultivable land areas (*Fig. 2.7*).

Fig. 2.7. A scene of a flooded highway.

During the last few decades there has been sharp rise in the incidence of floods. Floods are caused by both natural as well as anthropogenic (human) factors. Among natural factors, the important are prolonged downpour, blocking of free flow of the rivers due to siltation and landslides. The anthropogenic activities such as deforestation, overgrazing, construction activities, channel manipulation through diversion of river course etc. are contributing largely to the sharp rise in the incidence of floods.

Droughts

The condition of dryness for prolonged period is called drought (*Fig. 2.8*). It results when the average rainfall for an area drops below the normal. Droughts cause famine and starvation of human and animal population of the region concerned. Prolonged drought conditions in a region change the biotic components of the ecosystem due to death of several plant and animal species.

Human activities like deforestation, overgrazing, mining etc. are largely responsible for spreading of deserts, thereby converting more areas to drought affected areas. In the last twenty years, India has experienced more and more desertification, thus increasing the vulnerability of larger parts of the country to droughts.

The problem of drought can be mitigated by afforestation programmes, which increase the content of air moisture, the amount of precipitation and the rate of rain water infiltration. Dry farming techniques and water conservation schemes also prove quite effective to fight the problem of drought.

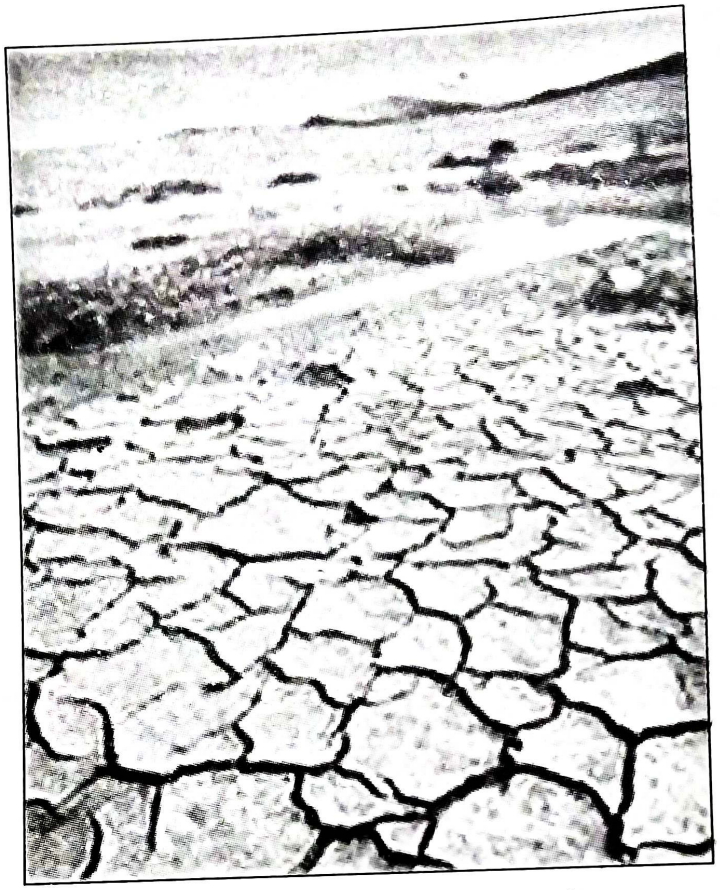


Fig. 2.8. An area affected by drought.

Water Crisis and Conflicts over Water

Water is an essential natural resource for sustaining life and environment. The availab water resources are under tremendous pressure due to the increased demands. Time is not f when water, which we have always thought to be available in abundance and free gift nature, will become a scarce commodity. The world is heading towards a water crises. Betwee 1940 and 1990, the world's population doubled and so did the per capita consumption of wate The global use of water has quadrupled in the recent years. Africa and west Asia are likely be worst affected by water scarcity, but with increasing population, water may fall short other parts of the world. According to a report of UN some 80 nations including India and 4 per cent of the world's population are already in the throes of a "water stress". In India, mar states like Rajasthan, Gujarat, Madhya Pradesh, Orissa and Andhra Pradesh are in the gr of a severe water shortage (*Fig. 2.9*).

Conflicts over sharing of river water between neighbouring countries or different stat of a country have now become quite common because of shortage of water. Out of India's 1 major rivers, 17 are shared between different states. In all those cases, there are intens conflicts over the sharing of water resources, which hardly seems to resolve.

Some major water conflicts are discussed below :

1. **Water Conflict in the Middle East.** In the Middle East countries, three river basin namely the Jordan, the Tigris-Euphrates and the Nile have the shared water resources. Ther is a fierce battle for water among Jordan, Syria and Israel for the share of Jordan river wate Turkey has abundant water and plans to build a chain of dams on Tigris-Euphrates fo hydrolectric power generation and plans to transport and sell water to other Middle Eas countries, which may create war like situation in these countries.

Fig. 2.9. Women queue up for drinking water.

2. **The Cauvery Water Dispute.** The Cauvery river water is a matter of conflict between Tamil Nadu and Karnataka and the fighting is almost hundred years old. Tamil Nadu, occupying the downstream region of the river wants water-use regulated in the upstream, whereas, the upstream state Karnataka refuses to do so and claims its over the river as upstream user. The river water is almost fully utilized and both the states have increasing demands due to complex cropping pattern and some cash crops demanding intensive water, thus aggravating the water crisis.

3. **The Satluj Yamuna Link (SYL) Canal Dispute.** The issue of sharing the Ravi-Beas waters and SYL issue between Pujab and Haryana is a case of dipute between two states. The Supreme Court on January 15, 2002 directed Punjab to complete the work of SYL within a year. But till date neither the SYL has been completed nor the conflict over sharing of Ravi-Beas water is resolved.

Conservation and Management of Water

The main approaches for *conservation of water* are as follows :

1. Increase in irrigation efficiency in agricultural fields by reducing water wastage. Through traditional method of irrigation plants absorb less than 50 per cent of the water applied to the soil, the rest is lost. This loss can be minimised by adopting efficient systems of irrigation like sprinkle irrigation, drip irrigation etc.

2. Recycling of used water in industries so as to reduce water wastage.

3. Reduction in domestic water wastage by constructing waste water treatment plants and recycling the treated water.

4. Harvesting of rain water by adopting practices like storing of rain water and recharging groundwater.

5. Protection of water sheds and afforestation to improve water economy.

Sustainable supply of high quality water can be achieved by adopting following *water management* approaches :

1. Construction of dams and water reservoirs to control floods, ensure year round supply of water and generation of electricity.

2. Desalinization of sea water and saline ground water to make it fit for human consumption and other purposes.

3. Diversion of water bodies through canals to increase water supply in drier areas.
4. Regular dredging and desiltation of rivers, streams and other water bodies.

Case Study

Israel's Drip Irrigated Farming. The small and arid state of Israel began using drip irrigation systems, as it is short of water. With this technique, Israeli farmers have been able to improve the efficiency of irrigation by 95%. Over a 20 year period, Israel's food production has doubled without an increase in the use of water for agriculture. Today, Israel is one of the major suppliers of fruit and vegetables in the world.

DAMS—Benefits and Problems

Benefits. The dams like Bhakra-Nangal, Heerakund, Nagarjuna Sagar and Damodar have played a significant role in India's social and economic progress during the past five decades. Without them India would have been a thirsty, hungry and dark land ravaged with floods and droughts every year. Our late Prime Minister Pt. Jawahar Lal Nehru called these dams, 'the temple of modern India', which store precious rain water to irrigate farmlands, generate electricity, supply drinking water and save land from floods and droughts.

The various benefits of dams are :

1. Hydroelectricity generation.
2. Ensuring the year-round water supply.
3. Transfer of water from areas of excess to areas of deficit using canals.
4. Flood control and soil protection.
5. Irrigation during dry periods.
6. Multi-purpose river valley projects also provide for inland water navigation, and can be used to develop fish hatcheries and nurseries.

Problems. As argued by environmentalists, big dams submerge forest, displace local people, cause water logging and siltation and may result in earthquakes. It is reported that River valley Projects in countries like India and China displace large number of people because of high population densities of these countries. The relief and rehabilitation programmes offered by the governments have always seemed inadequate. Thousands of people displaced by such projects are yet to be resettled amicably.

Some of the disadvantages/problems of dams are as under:

1. Submergence of large areas of land that might include fertile fields and human settlements.
2. Resettlement and rehabilitation of displaced people.
3. A number of water related diseases casually caused with the creation of reservoirs.
4. The enormous weight of water behind the dam could trigger seismic activity that might crack the dam and unleash a flood of biblical proportions.
5. Some dams lose enormous water through evaporation and seepage into porous rock beds that they waste more water than, what becomes available.

6. Salt left behind by evaporation increases the salinity of the river and make its unusable when it reaches the downstream cities.

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

Conclusion. Anti-dam activists suggest that several small dams in place of one big dam will cause less damage to the environment. But, such argument is not convincing that how these small dams can fulfil the requirement of hydropower, irrigation and drinking water supply. Before coming to some conclusion about the adverse environmental effects of big dams, it is important to understand the need for dams. We need water throughout the year to irrigate our fields and quinch our thirst. But the rain, the main source of water, falls only during a period of 3–4 months in a year and that 80–85 per cent of this water is lost as runaway water. Thus, to meet country's requirements throughout the year, much of the rainwater is to be stored and this is only possible through dam building at appropriate sites.

When **Aswan Dam** across the Nile in Egypt was completed in 1970, the environmentists castigated it as an ecological disaster. Apprehensions were expressed about the loss of soil fertility down stream and rise in cases of snail borne diseases. Some of these fears have turned out to be real, but the benefits from the dam appear to far out weigh its negative impacts. The Aswan Dam is today a boon to the Egyptian economy. The same would perhaps, hold true for our Tehri and Narmada dams.

Case Study

Narmada Project. The **Narmada Bachao Andolan** in India is an example of a movement against large dams. The gigantic Narmada River Project has affected the livelihood of hundreds of extremely poor forest dwellers. The rich land holders downstream from the Sardar Sarovar Dam will derive the maximum economic benefit, whereas the poor tribal people have lost their homes and traditional way of life. The dam will also destroy the livelihood of fishermen at the eustry. The disastrous impact that this project has on the lives of poor, and the way in which they are being exploited, needs to be clearly understood.

Mineral Resources

Minerals are exhaustible, non-renewable resources found in the earth's crust. They are essential to our industrialized society and daily life. Due to rapid expansion of industries, the consumption of minerals has increased tremendously all over the world. A number of minerals such as silver, copper, mercury, tungsten, etc. are now in short supply, and likely to be exhausted within next 20 to 100 years. Even the minerals which are relatively plentiful (*e.g.* iron and aluminium), will become extremely expensive because of the depletion of deposits of these minerals.

Minerals can be **metallic** *e.g.* iron, copper, gold, etc. or **non-metallic** *e.g.* sand, stone, salt, phosphates, etc. Man uses a number of minerals in industries, production of consumer's goods, agriculture inputs, hospitals and defence and research equipments. Some important minerals and other uses are given in *Table 2.3*.

Table 2.3. Some Important Mineral Elements and Their Uses

Minerals	Selected Uses
I. Metal elements	
1. Aluminium	Aircraft, rockets, building materials, electrical wiring, utensils, packaging.
2. Chromium	Chrom plating, steel alloys
3. Copper	Alloy material, gold jewellery, silverware, brass and bronze, electric wiring, pipes, cooking vessels.
4. Gold	Jewellery, dentistry, alloys
5. Iron	Primary component of steel, lead pipes, battery electrodes, pigments.
6. Manganese	Alloy steels, disinfectants.
7. Nickel	Coin, alloys, metal plating.
8. Platinum	Jewellery, equipments, industrial catalyst.
9. Potassium	Fertilizers, glass, photography.
10. Silver	Jewellery, vessels, photography, alloy.
11. Uranium	Nuclear bomb, electricity, tincting glass.
12. Tin	Cans/containers, alloys, solders.
13. Zinc	Brass, electrodes, medicine.
II. Liquid metal element	
1. Mercury	Thermometer, dental inlays, electric switches.
III. Non-metal elements	
1. Phosphorus	Fertilizers, medicines, detergent.
2. Sulphur	Insecticides, rubber tyres, medicines.

Mining

The term 'mining' refers to the process of taking out minerals or their ores from the earth. Some minerals can be mined more easily as they are found at the earth's surface, while others lie far beneath the surface and can be obtained by digging deep underground.

There are two methods of mining : surface mining and sub-surface mining.

1. **Surface Mining.** This method of mining is utilized when mineral deposits occur at or near the surface of earth. It can be done by following ways :

(*i*) *Open Pit Mining.* The minerals are extracted out by making pits by removing the over burden (*i.e.*, the materials that cover the deposits). The minerals like copper, iron, gravel, limestone, sand-stone, marble granite etc. are obtained by this method.

(*ii*) *Dredging.* In this method chained buckets and drag lines are used to scrap out the minerals from under water mineral deposits.

(*iii*) *Strip Mining.* In this method the ores are stripped off by using bulldozers, power shovels and stripping wheels. Phosphate rocks are removed by this method.

2. **Sub-Surface Mining.** This method is used when the mineral deposit lies deep beneath the earth's surface. Big holes are dug in the earth surface to extract out ores from the horizontal ore bodies.

Mining Sites of Some Major Minerals in India

1. **Energy Generating Minerals.** The mining sites of **coal** and **lignite** are located in West Bengal, Jharkhand, Orissa, Madhya Pradesh and Andhra Pradesh. **Uranium** (Pitchblende or uranite ore) is extracted out in Jharkhand, Andhra Pradesh (Nellore, Nalgonda), Meghalaya and Rajasthan (Ajmer).

2. **Other Commercially Used Minerals.** The mining sites of **aluminium** (Bauxite ore) are situated in Jharkhand, West Bengal, Maharashtra, Madhya Pradesh and Tamil Nadu. **Iron** (Haematite and Magnetite ore) is extracted out in Jharkhand, Orissa, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and Goa. The extraction sites of **Copper** (Copper pyrites) are located in Rajasthan (Khetri), Bihar, Jharkhand, Karnataka, Madhya Pradesh, West Bengal, Andhra Pradesh and Uttaranchal.

Effects of Mining

The mining, processing and disposal of minerals have negative effects on environment. The main harms caused by mining are as follows :

1. The top soil is removed from the mining area to get access to the deposit. It disturbs and damages the land and results in defacing the landscape. Such a land is called **derelict land** or **mine spoil.**

2. Mining often causes **ground subsidence**, which results in tilting of buildings cracks in houses, bucklings of roads, bending of rail tracks and leaking of gas from cracked pipelines leading to serious disasters.

3. Mining disturbs the natural hydrological processes and also pollute groundwater as well as surface water. Sometimes radioactive substances like uranium also contaminate the water bodies through mine wastes.

4. Extraction and processing of ores emits enormous quantities of air pollutants such as suspended particulate matter (SPM, soot, metal particles etc.) leading to serious environmental hazards.

5. Miners often suffer from serious respiratory and skin diseases like asbestosis, silicosis, black lung disease etc. due to constant exposure to the suspended particulate matter and toxic substances.

Remedial Measures. The derelict lands can be reclaimed or restored to a semi-natural condition by revegetation, gradual restoration of flora, prevention of drainage discharge and conforming to the standards of air emissions. The adverse impact of mining can be minimised by adopting eco-friendly mining technology (like **microbial leaching technique** for extraction of gold with the help of bacterium *Thiobacillus ferrioxidans.*)

Case Study

1. **Mining and Quarrying in Udaipur.** The large scale mining in Udaipur (Rajasthan) for soap stone, building stone rock phosphate and dolomite have caused many adverse impacts on environment. The hills around the mines are suffering from acute soil erosion due to loss of vegetation. Many animals have disappeared from the mining area due to blasting activities. The discharge of mine water have polluted the surface water of that area.

2. **Mining in Sariska.** Mining operations in Sariska (Sariska Tiger Reserve) has put precious wildlife under serious threat. The hill region of the reserve is very rich in biodiversity and mineral reserves like quartzite marble and granite. Although, the Supreme Court has banned the mining activities, but still some illegal mining is still in progress.

Conservation of Minerals

The limited stock of minerals once exhausted cannot be replenished, therefore, consumption of minerals needs immediate attention. Following measures can be adopted to conserve the mineral resources.

1. **Recycling.** In recycling used and discarded items are collected, remelted and reprocessed into new products *e.g.* iron scraps, aluminium cans, etc. Some minerals present in products can be recycled *e.g.* gold, silver, lead, nickel, steel, copper, aluminium, zinc, etc. However, minerals in other products are lost through normal use, *e.g.* paints containing lead, zinc or chromium.

2. **Reuse.** Certain items can be collected and can be used over and over again. *e.g.* reuse of glass bottles. The reuse of items is more beneficial than their recycling. However, all products may not be reused.

Recycling and reuse not only renew the mineral resources but also help in (*a*) saving unspoiled land from the disruption of mining, (*b*) reducing the amount of solid waste that must be disposed and reducing energy consumption and pollution.

3. **Substitution.** The use of scarce minerals can be substituted with more abundant minerals keeping in mind the environmental implications. For instance, in recent years, plastics, ceramics, high strength glass fibres and alloys have been substituted for scarer materials like steel, tin and copper in many industries.

4. **Decreased Consumption.** To maintain the extended supply of minerals for a longer time, consumers must decrease their mineral consumption by becoming a low waste society. Products that are durable and repairable should be used again instead of discarding them as waste.

5. **Use of Waste.** The manufacturing industries may use the waste products of one manufacturing process as the raw materials for another industry.

Food Resources

The main sources of human food are plants and animals. We consume almost all parts of one or the other plant in the form of cereals, pulses, vegetables, fruits and spices. A number of animal products such as milk, butter, egg and meat also supplement our food requirements.

World Food Problems

World's population is growing every year and so the demand of food is also increasing constantly. Although world's food production has increased almost three times during the last 50 years, but at the same time rapid population growth especially in LDCs (less developed countries) has outstripped the food production. About 40 million people die every year due to undernourishment and malnutrition. Fifty per cent of which are growing children between the age of 1 to 15 years. According to an estimate about 300 million people are undernourished in India. People who receive less than 90 per cent of their minimum dietary intake on a long term basis are considered undernourished. Insufficient calories in food leads into a less productive life, and deficiency of nutrients make a person more susceptible to infectious diseases. Poor diet and poverty impairs the health and effect man's ability to work.

The persons who receive less than 80 per cent of their minimum daily calorie intake requirements are considered seriously malnourished. Seriously malnourished children are mentally retarded, show stunted growth and social and developmental disorders. Undernutrition often leads to malnutrition resulting in several nutritional deficiency diseases. The important nuritional deficiency diseases are given in *Table 2.4.*

Table 2.4. Important Nutritional Deficiency and their Effects on Health

Deficiency	*Effect on Health*	*Deaths Per Year (in millions)*
1. Proteins and calories	Stinted growth, kwashiorkar, Marasmus	15–20
2. Iron	Anaemia	0.71–1
3. Iodine	Goitre, cretinism	—
4. Vitamin A	Night blindness	—

Changes Caused by Overgrazing and Agriculture in Crop Production

The major source of our food are crops. The cropping pattern and crop yield are determined mainly by natural factors like rainfall, climate and soil conditions. Beside these, overgrazing, traditional agriculture and modern agriculture have also affected the crop production.

(*i*) ***Impacts of Overgrazing.*** Overgrazing refers to the condition when the livestock grazing surpasses the carrying capacity of a land. The carrying capacity of any system is the maximum population that can be supported by it on a sustainable basis. Often the grazing pressure crosses the carrying capacity, leading to failure of sustainability of the land. Following are the main impacts of overgrazing on crop production.

(*a*) Overgrazing removes the vegetal cover of the soil and makes it compact. It reduces the humus content due to decline in organic cycling and infiltration capacity of the soil. As a result more water is lost from the ecosystem along with surface run off and the soil loses its fertility.

(*b*) Due to the loss of vegetal cover the soil becomes susceptible to the action of wind and water and gets eroded.

(*c*) Overgrazing adversely affects the composition of plant population and their generation capacity. Several juicy fodder giving species like *Cenchrus*, *Dichanthium*, *Panicum*, *Heteropogon* etc. are replaced by unpalatable and sometimes thorny plants like *Parthenium*, *Lantana*, *Xanthium*, *Argemone* etc. Because of overgrazing vast areas of North-East states of our country are getting invaded by weeds and thorny bushes of low fodder value.

(*ii*) ***Impacts of Traditional Agriculture.*** About half of the global population practice traditional agriculture. It involves small fields simple implements, naturally available water, organic fertilizers and a mix crops, and results in low production. The main impacts of this type of agriculture on crop production are as follows:

(*a*) Shifting cultivation (slash and burn cultivation) practised in many tribal areas results in deforestation.

(*b*) Loss of forest cover exposes the soil to wind, rain and storms, thereby resulting in soil erosion.

(*c*) Slash and burn cultivation destroys the organic matter and makes the soil nutrient poor within a short period.

(*iii*) ***Impacts of Modern Agriculture.*** Modern agriculture is largely based upon technological factors like the use of improved seeds, chemical fertilizers, synthetic pesticides and extensive irrigation.

Though technological factors have proved a boon to our modern agriculture and have increased the crop yield manifold, they have created a number of problems. Some major problems related with modern agriculture are given below:

1. Intensive farming have reduced the fertility and productivity of the soil, and one can't think of crop yield without the use of chemical fertilisers.

2. Irrational use of chemical fertilisers to boost up the crop yield, have contaminated ground water with nitrate. The presence of excess nitrate in drinking water is dangerous for human health and may be fatal for infants. Nitrate reacts with haemoglobin and impairs the oxygen transport by the blood. This condition is called **methaemoglobinemia** or **blue baby syndrome.**

3. The excessive use of NPK fertilizers to boost up crop causes micro nutrient imbalance. Soils of many parts of Northern states of our country have become deficient of nucronutrients like zinc which is affecting the productivity of crops.

4. Excessive NPK fertilizers used in agriculture fields are often washed off with run off water to water bodies and lakes causing overnourishment of the lakes called **eutrophication**. Eutrophication often leads to algal blooms, which make water unfit for consumption and kill the aquatic life.

5. The excessive use of pesticides and herbicides have depleted the populations of ecologically important soil microorganisms. Many of these chemical pesticides are non-degradable and enter the food chain, and become hazardous to human life.

6. Some individuals of the pest species survive even after pesticide spray, and give rise to highly resistant **super pests**, which are immune to all types of pesticides.

7. Many pesticides are broad spectrum which not only kill the target species but also several non-target species that are useful to us.

8. Cultivation of high yielding varieties (HYVs) encourage mono-culture (*i.e.* cultivation of the same genotype over vast areas). In case of an attack by some pathogen, the crop of the entire area is devasted by the disease due to almost uniform conditions.

9. Intensive irrigation (*e.g.* paddy crop), is bringing the underground soluble salts to the soil surface and increasing the salinity of the soil. A large area of our fertile land have become saline and water logged in the recent years due to excessive irrigation (*Fig. 2.10*).

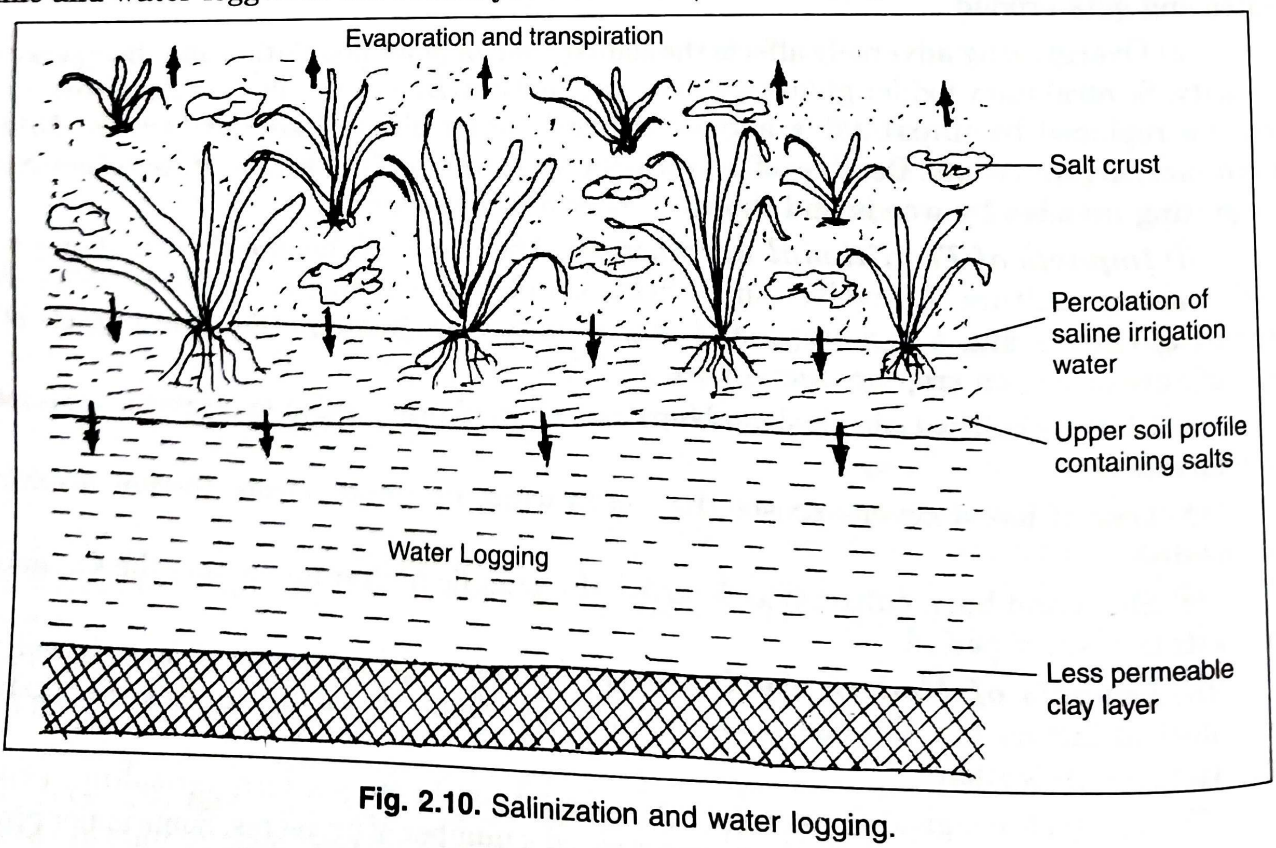


Fig. 2.10. Salinization and water logging.

Case Studies

(*i*) ***Salinity in Haryana and Punjab.*** In arid and semi-arid regions, when crop lands are irrigated with water containing dissolved salts, the water evaporates leaving behind salts in the upper soil profile and make the soil saline. Thousands of hectares of land area in Haryana and Punjab are affected by soil salinity and alkalinity.

(*ii*) ***Water Logging in Punjab, Haryana and Rajasthan.*** Many parts of Punjab, Haryana and Rajasthan are facing the problems of water logging. Frequent floods in some parts of Punjab have aggravated water logging problem. About 1.2 million hactres of land in Haryana has resulted in rise in water-table followed by water-logging and salinity due to introduction of canal irrigation. 'Indira Gandhi Canal Project' of Rajasthan has changed a large area in Western Rajasthan into water logged wasteland.

(*iii*) ***Control of Salinity.*** The excess salts present in the soil can be removed by using good quality of water to irrigate the soil. It gradually flushes out the salts. In another method a network of perforated drainage pipes are laid underground (sub-surface drainage system) to remove the salts. The soil water containing salts seeps into the pipes slowly, and is drained out of the fields. This method has been successfully used by the Central Soil Salinity Research Institute (CSSRI) in district Karnal (Haryana), and has converted barren lands into productive lands.

Energy Resources

Energy is an important input for development. It aims at human welfare covering household, agriculture, transport and industrial complexes. The rapidly expanding human population, human energy needs are increasing rapidly. It will demand the exploitation of most energy sources. Like other natural resources, energy resources are also non-renewable as well as renewable.

I. Non-Renewable Energy Resources

These include various fossil fuels and nuclear energy. The fossil fuels include coal, petroleum products and natural gas. The nuclear energy is mainly obtained from the nuclear fission of the uranium. The world's reserve of fossil fuels and uranium are limited and eventually be exhausted.

(*i*) ***Fossil Fuels.*** Fossil fuels are found inside earth's crust where they have been formed through heat and compression on forests and other organic matter burried underneed due to earthquake, landslides, lava etc. Fossil fuels are three types : (*a*) *Solid* (*e.g.* coal, peat) (*b*) *Liquid* (*e.g.* petroleum) and (*c*) *Gaseous* (*e.g.* natural gas). Coal is the most abundant fossil fuel in the world. It contains carbon, water, sulphur and nitrogen. Coal is mainly of three types : (*a*) *Anthracite* or hard coal (carbon 90 per cent and calorific value (8700 k.cal/kg) (*b*) *Bituminous* or soft coal (carbon 80 per cent) and (*c*) *Lignite* or brown coal (carbon 70 per cent).

Coal meet 70 per cent of total energy needs of the world and 87.4 per cent of all commercial energy. In India about 58 per cent of commercial energy is obtained from coal and 38 per cent from petroleum along with natural gas. Coal is used for cooking, heating, in industries and thermal power plants. Petroleum is employed for transport, agriculture and some industries. Natural gas is used both in cooking and in industries.

(*ii*) ***Nuclear Energy.*** It is obtained through fission or fusion reaction of selected radioactive materials, which yields large amount of heat energy.

(*a*) *In nuclear fission*, the nucleus of certain isotopes (*e.g.* Uranium-235) with large mass numbers are spilt into lighter nuclei on bombardment by neutrons. It releases a large

amount of energy through chain reaction. One a.m.u. (atomic mass unit) of uranium-235 yield energy equal to burning of 15 metric tonnes of coal or about 14 barrels of crude oil.

(*b*) *In nuclear fusion*, two isotopes of a light elements are forced, together at extremely high temperatures, until they fuse to form a heavier nucleus releasing enormous amout of energy.

With vast expansion of industry and agriculture sectors, the available fossil fuels and uranium, began to fall in their supply, Besides, the burning of fossil fuels is causing a number of negative environmental consequences such as global warming, acid rain, air pollution and oil spills during transportation. It has, therefore, become necessary to minimise the use of fossil fuels and replace them with ecofriendly renewable resources.

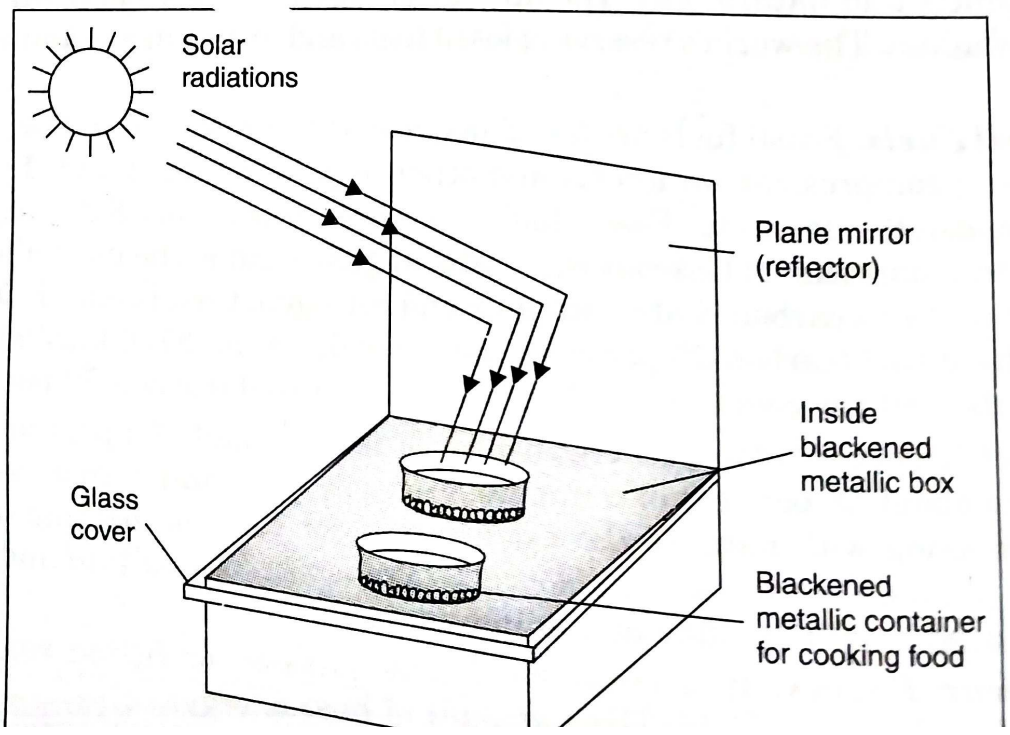
II. Renewable Energy Resources

These resources are regenerated by natural processes so that, they can be used indefinitely. These include solar energy, hydropower, wind energy, geothermal energy, ocean waves and tidal energy. The renewable energy resources generally cause much less environmental impact than fossil fuels or nuclear energy. Presently the generation of renewable energy is often expensive than the energy produced by fossil fuels or nuclear energy. However with the advancement of technology, the cost of renewable energy production is expected to decrease.

The important renewable energy resources are described below :

(*i*) ***Solar Energy.*** Sun is an inexhaustible and pollution free source of energy. Solar energy can be used for human welfare in two ways : directly or indirectly.

(*a*) *Direct Solar Energy*. The direct solar energy is the radiant energy. It can be used for direct heating or sun's heat is converted into electricity. Photovoltaic cells convert direct solar energy into electricity. It is called **thermal** or **photovoltaic conversion** of solar energy. For an uninterupted power supply, when solar power is not operative at night or during cloudy days, a backup system is required to store and generate electricity. A number of solar equipments have been developed to harness sun rays to heat water, cook meals (*Fig. 2.11*), lit our houses pump out water (*Fig. 2.12*) and to run certain machines.



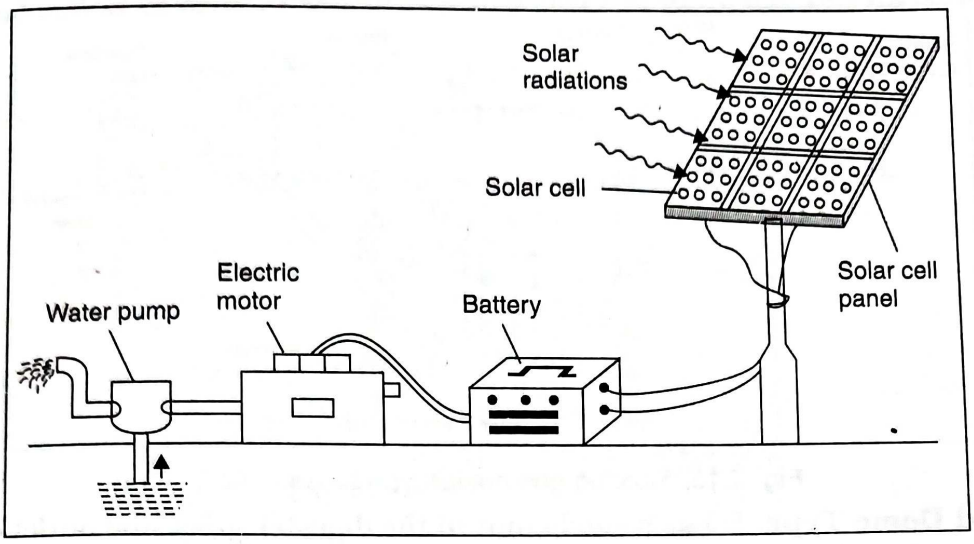


Fig. 2.12. A solar pump run by electricity produced by solar cells.

(*b*) *Indirect Solar Energy*. It is the energy obtained from materials that have previously incorporated the sun's radiant energy. Among indirect solar energy, **biomass energy** is the most important one. Biomass is the term used for all materials originating from photosynthesis. It includes live plant material and dried residues, fresh water and marine algae, agricultural and forest residues (*e.g.* straw, husks, corn cobs, bark, sawdust, roots, animal's wastes) and biodegradable organic wastes from industries like sugar mills and breweries etc. At least half of the world's population uses biomass as their main source of energy for domestic purposes. In rural areas of our country fuel wood is still a major source of energy for domestic purposes.

Biomass fuel, which is burned to release energy is of three types : **solid**, **liquid** and **gas**. The solid biomass include wood charcoal, animal dung and peat. The biomass can also be used to obtain liquid fuels like **methanol** and **ethanol.** The liquid biomass fuels can be used in internal combustion engines of automobiles. Gasoline mixed with 10-20 per cent ethanol can be used in conventional gasoline engines. The biomass, particularly animal dung can be converted into gaseous fuel called **biogas.** The animal dung is decomposed anaerobically by bacteria (methanogens) in biogas digesters to obtain biogas. Biogas is a mixture of two gases *i.e.* about 60 per cent methane and about 40 per cent carbon dioxide. It is a clean anaerobic fuel which can be stored and transported easily. Its combustion produces fewer pollutants than other combustible energy resources.

The biogas plants used in our country are basically of two types :

1. **Floating Gas Holder Type.** It has a well-shaped digester tank under the ground. The digester tank has a partition wall, an inlet pipe to receive the dung-water mixture and an outlet pipe to discharge the spent slurry. An inverted steel drum floats to hold the biogas produced (*Fig. 2.13*).

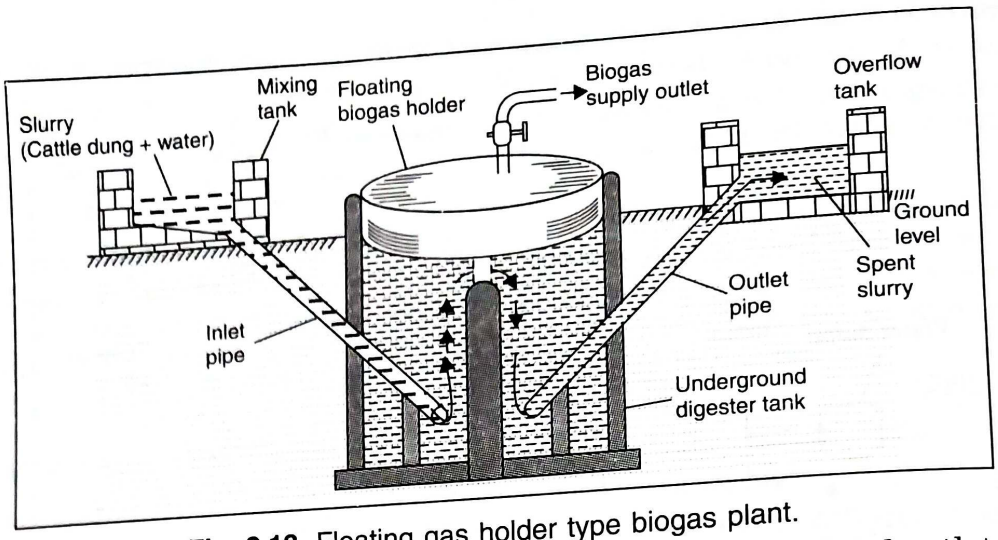


Fig. 2.13. Floating gas holder type biogas plant.

2. **Fixed Dome Type.** It has a single unit in the digester, inlet and outlet chambers. A dome shaped roof made of cement and bricks holds the gas produced in the digester (*Fig. 2.14*).

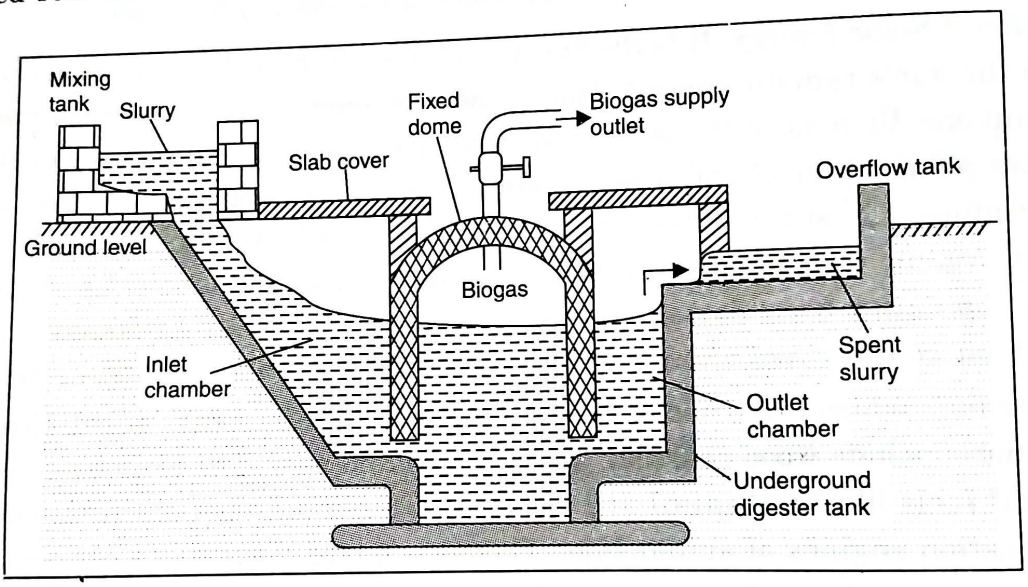


Fig. 2.14. Fixed dome type biogas plant.

For the production of biomass sufficient area of land and water is required. Growing plant species to produce biomass for energy is called **energy plantation.** The plant species having high calorific value and growth rate are raised in selected areas for this purpose.

(*i*) ***Hydropower (Hydro-Electric Energy).*** Hydro-electric energy is produced from the kinetic energy of water falling from a height. Hilly and high land areas are suitable for this purpose, where there is continuous flow of water in large amounts falling from high slopes. Water falling from a height turns turbines at the bottom of dams to generate electricity. Approximately one fourth of the world's electricity is produced by hydropower. It is cheaper than the electricity produced by thermal power plants. However, building a dam to hold the water leads to several environmental problems like destruction of animal habitats, submergence of vegetation, displacement of people and earthquake.

(*ii*) ***Geo-Thermal Energy.*** In some places, the heated water comes to the earth's surface as hot springs. It can be used for heating water and buildings and for generating electricity.

(*iii*) ***Wind Power.*** It has been used for centuries to run the wind-mills for grinding grains and pump water in certain areas (*Fig. 2.15*). But the wind does not blow with required intensity

all the year round and in all areas. Therefore, wind power can be used in certain areas and on certain days.

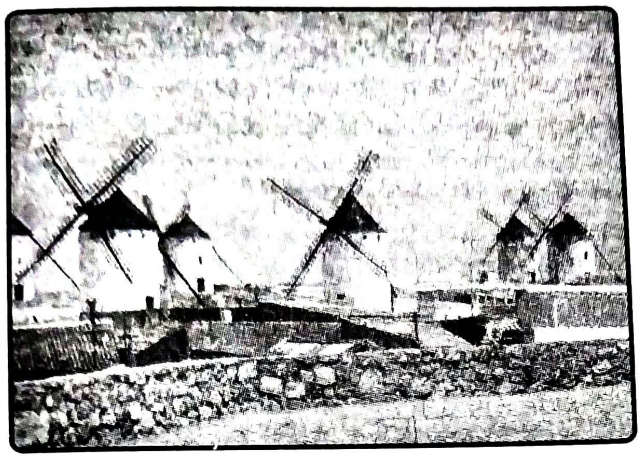


Fig. 2.15. Wind mills.

(*iv*) ***Tidal Energy.*** Tidal waves of the sea can be used to turn turbine and generate electricity. The tidal energy can be harnessed by constructing a tidal barrage. During the high tide, the sea water flows into the reservoir of the barrage, which turns the turbine to produce electricity. Under the low tide water from the reservoir flows back into the sea and turns the turbine to generate electricity (*Fig. 2.16*).

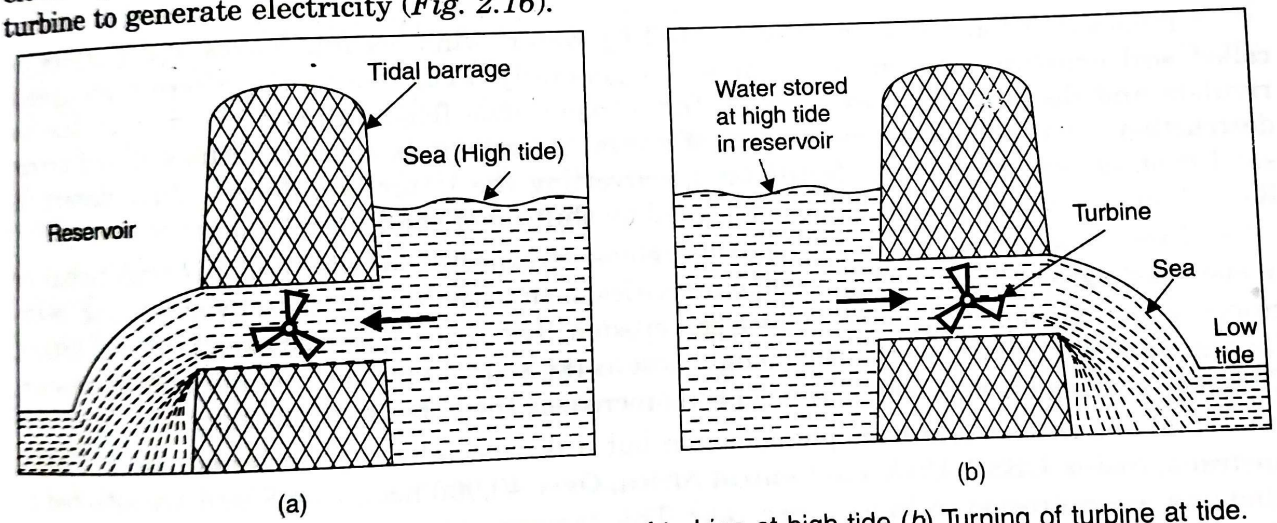


Fig. 2.16. Harnessing of tidal energy (*a*) Turning of turbine at high tide (*b*) Turning of turbine at tide.

Land Resources

Land is a major constituent of one of the life supporting system—the lithosphere. It forms about one fifth of the earth surface, which is largely covered with natural forests, grasslands, wetlands (low lying area covered with shallow water or transitional places between terrestrial and aquatic areas), agricultural land and urban and rural settlements. These land areas are important source of many materials essential to man and other organisms.

The fertile surface layer of earth capable of supporting plant life is called soil. Terrestrial plants obtain their water and mineral nutrients from the soil. Plants and animal materials decay are released into the nutrient bank in the soil. Many micro-organisms and animals involved in detritus pathway inhabit the soil. Soil covers about four fifth of the land area. The

study of soil is called **pedology** (Gk. *pedion* = ground, *logos* = discourse). It deals with the origin, formation and geographic distribution of the soil.

Soil is a most important resource and it takes decades or even centuries for the development of soil horizons having different physio-chemical properties. Soil is formed by two processes (*i*) *weathering*—breaking down of rock into small particles and (*ii*) *pedogenesis*—maturation of soil through development of humus. Weathering of rocks involves physical and chemical breakdown. Physical breakdown is caused by temperature variations, alternate drying and wetting, microbial activity, action of plant roots and burrowing animals. Chemical breakdown occurs by oxidation, reduction, hydration and other related reactions.

The yield of all biotic products in terrestrial ecosystems depend on soil fertility. Soil is composed of inorganic particles (mineral matter) organic matter, air, water and a variety of organisms. Human activities often create worldwide problems like soil erosion and depletion of fertility.

Land Degradation

A number of factors are responsible for the degradation of land. These include soil erosion water logging, salination, shifting cultivation, desertification and various developmental activities. Soil degradation is a real cause of alarm, because soil formation is a very slow process and the annual degradation rate is many times more than its renewal.

Soil Erosion

Removal of top fertile layer of the soil by water, wind oceanic waves and glaciers is called **soil erosion**. Erosion of soil by water generally occur near hills, where high speed rivulets and flooding removes top soil. India experience floods almost every year due to destruction of forests in catchment areas of rivers. Strong winds also erode the soil and bring sand from deserts to adjacent fertile land, converting the latter into desert. Thar desert in Rajasthan once a fertile land has been formed by shifting of sand from Gujarat coast.

Erosion occurs in both wet and arid regions, irrespective of whether it is traditional or modernised agriculture. Various human activities such as felling of trees, over-grazing, over-cropping and improper tilling accelerate soil erosion. The roots of grasses keep the soil intact. Disruption of the grass cover by the plough loosens the soil and makes it vulnerable to erosion. Tilling or grazing on slopes or semi-arid soils increases the rate of soil erosion.

Soil erosion is world-wide phenomenon but it is especially high in Nepal, India, China, Australia, Spain, USSR, USA and Central Africa. Over 40,000 hectares of land are affected by wind and water erosion in India every year. The damage of top soil in India is 18.5 per cent which is the maximum of the global loss. It is due to overgrazing by livestocks whose population is largest in India.

Depletion of soil fertility

The growing population and advancing civilisation have forced human beings to clear large tracts of natural vegetation to develop agricultural lands, residential areas and industrial establishments. When natural vegetation is removed, not only the nutrients stored in vegetation are removed, the organic matter and nutrients accumulated in the soil are also lost. From agricultural systems nutrients are lost through crop harvest. As a result, the agricultural soil inevitably loses its fertility over a period of time. Water logging and application of non-degradable chemicals also leads to the loss of soil fertility.

Soil Conservation

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Soil Conservation

Soil conservation (L. *Con*—together, *servare*—guard) refers to the measures and practices, which protect the soil against loss and help in maintaining its fertility with a view to establish sustainable agriculture. The art of soil conservation is based on following basic principles.

(*i*) Protection of soil from impact of rain drops.

(*ii*) To slow down the water from concentrating and moving down the slope in a narrow path.

(*iii*) To slow down the water movement, when it flows along the slope.

(*iv*) To encourage more water to enter the soil.

(*v*) To increase the size of soil particle.

(*vi*) Reduction in the wind velocity near the ground by growing vegetation cover and ridging the land, and

(*vii*) To grow the strips of stubble or other vegetation cover, which might catch and hold the moving particles of soil.

Keeping in view the above said principles, ecologists have devised several methods, to prevent the loss of soil due to its erosion. These methods include the following practices :

1. **Conservational Tillage.** The incorporation of residues from previous crops into the soil by ploughing is called conservational tillage. It improves soil permeability and increases the organic matter, which in turn improve soil moisture and nutrients.

2. **Organic Farming.** Organic farming involves practices which provide increased organic input to the soil. Application of biofertilizers is an important practice of organic farming. The organic farming has long term beneficial effects on soil fertility.

3. **Crop Rotation.** It is a practice of growing different crops (generally legumes after cereal crops) in successive years on the same piece of land. It decreases soil loss and prevents depletion of nutrients from the soil.

4. **Contour Ploughing.** It is an old method useful in areas with low rainfall in the preparation of the field with alternate furrows and ridges. Water is caught and held in furrows and stored, which reduces runoff and erosion.

5. **Mulching.** Soil is allowed to remain untilled and is covered with crop residue and other form of plant litter. It retain soil moisture, decreases runoff and increases organic matter in the soil.

6. **Strip Cropping.** It involves planting of crop in rows or strips to check flow of water. It may be contour strip cropping (strip planted along contour at 90° to the direction of slope), field strip cropping (strip planted parallel to each other), or wind strip cropping (strip planted in straight parallel rows at 90° to the direction of prevailing wind).

7. **Terrace Farming.** A slope is divided into a number of small flat fields called **terraces.** The terraces slow down the velocity of the run-off and allow the water to move to the sides of the fields, where it flows away without eroding the soil.

8. **Agrostological Methods.** In agrostological methods grasses are grown to check soil erosion. The grasses form sod and act as soil binders or stabilizers. The grasses are grown either in rotation or alongwith agricultural crops (**lay farming**) or they are grown on such lands, where major portion of the top soil has been eroded (**retiring lands to grasses**). The grasses prevent erosion and also improve soil permeability.

9. **Afforestation.** Trees or windbreaks are planted in deserts which check the velocity of wind. Windbreaks are planted across the area at 90° to the prevailing wind.

Conservation of Erosion-Affected Soils

The conservation of erosion affected soils involve following two steps.

(*i*) *Soil Stabilization.* Soil stabilization is achieved by seeding the bare ground with plants that can survive harsh conditions, *e.g.* growing drought resistant grasses (lay farming). The growing grasses eventually establish vegetation cover on the soil, preventing further erosion.

(*ii*) *Restoration of Soil Fertility.* The soil fertility can be restored by increasing the amount of detritus to the soil. It increases nutrients and organic matter in the soil and also improves moisture level of the soil. The restoration of soil fertility to its original level is a slow process.

Shifting Cultivation

It is peculiar practice of slash and burn agriculture prevalent in many tribal communities inhabiting in tropical and sub-tropical regions of Asia, Africa and Oceania (islands of Pacific ocean and nearby sea). It consists of cutting down trees and setting them on fire and raising crops on the resulting ash. This practice is called **Jhuming** in north-eastern India and is spread in 3×10^7 km^2 of tropical or Jhum forests. It is not harmful, if the jhuming cycles are longer. However, when jhuming is done in 5 or 10 years of cycle, it destroys forests and destabilises the soil.

Desertification

Transformation of fertile land into a desert by natural or man's activities is called desertification. It can result from various causes such as erosion of top soil, shifting of sand dunes by wind and overgrazing in lands sparsely covered by grass. Many deserts of the world have developed by the aforesaid human activities.

Developmental Activities

Various developmental activities such as rapid urbanisation, construction of dams, roads railways, airports, industries and mining have caused excessive loss of large areas of fertile and productive croplands, woodlands and grasslands.

Control of Land Degradation

The following measures can be adopted to check the land degradation :

1. Land degradation by soil erosion, floods and water logging can be checked by restoring forests and grasscovers.

2. Degradation of soil by shifting cultivation can be prevented by crop rotation, mixed cropping and plantation cropping. These practices would improve soil fertility.

3. Salinity of soil can be checked by improving drainage. Salinated lands can be reclaimed by leaching them with more water, if the ground water table is not high.

4. Advancement of deserts can be checked by mulching (use of artificial protective covering) or by growing appropriate plant species and by raising trees as wind breakes.

Landslides

Landslide is the moving down of coherent rock of soil mass due to gravitational pull. Various anthropogenic activities like hydroelectric projects, large dams, reservoirs, construction of roads and railwaylines, mining etc. make mountain slopes fragile leading to landslides. Huge portions of mountainous areas are cut during construction of roads, railway tracks and tunnels, mining activities etc. It makes mountain slopes weak and fragile resulting in landslides

ROLE OF INDIVIDUAL IN CONSERVATION OF NATURAL RESOURCES

Conservation of resources means the management of human use of the resources so that it may give maximum benefit to present generation, while maintaining its potential to meet the requirements of the future generations. Environment belongs to each one of us and all of us have a responsibility to contribute towards its conservation and protection. An individual can contribute in conservation of natural resources in the following way.

Conservation of Water

(*i*) Continuous running of water taps should be avoided while brushing, shaving, washing or bathing.

(*ii*) Wastage of water can be avoided by installing water saving toilets, which uses only 6 litres of water per flush.

(*iii*) While using washing machines, fill the machine with water only to the level required for your clothes.

(*iv*) Water leakage in pipes and toilets if any, should be repaired promptly.

(*v*) Watering of plants in kitchen garden and lawns should be done only in the evening when evaporation losses are minimum.

(*vi*) Drip irrigation and sprinkling may be practised to improve irrigation efficiency and reduce evaporation.

(*vii*) Water of washings from clothes may be used for washing off courtyards driveways etc.

(*viii*) Rain water harvesting system should be installed in the houses for future use.

Conservation of Energy

(*i*) Solar cooker may be used for cooking food on sunny days to cut down LPG consumption.

(*ii*) Make a habit of switching off lights, fans and other appliances when not in use.

(*iii*) One can save petrol or diesel by using public transportations and by sharing a car pool if you have to go the same place regularly.

(*iv*) Avoid using car or scooter for short distances and cover such distances by walking or riding bicycle.

(*v*) Build your house with provision for sunspace to keep the house well lit and to save electricity.

(*vi*) Instead of using the heat convector more often wear adequate woolens during winter.

(*vii*) Houses should be build with proper insulation to avoid heat loss during winters. It will also prevent heating of the house during summers and will cut of electricity charges on coolers.

(*viii*) Deciduous trees may be grown outside houses to cut off intense heat of summers and to get a cool breeze. The trees shed off their leaves in winter and provide adequate sunlight and heat. It will reduce the consumption of electricity on coolers during summer and heat convectors during winter.

Conservation of Soil

(*i*) Don't throw vegetable peelings and kitchen wastes and make compost from the same to use it in kitchen garden or flower pots.

(*ii*) Avoid strong flow of water to irrigate lawn and plants. Use sprinkling irrigation to prevent washing off the soil.

(*iii*) Avoid over irrigation of agricultural fields to prevent water logging and salination.

(*iv*) In agriculture fields crop rotation and mixed cropping may be practised to maintain soil fertility and to prevent the depletion of certain soil nutrients.

(*v*) Crop residues should be incorporated in the soil by ploughing instead of burning it in the field.

(*vi*) Green manure and mulch may be used in the fields to maintain soil fertility and protection of the soil against erosion.

Case Study

The Gandhian Way of Life. Mahatma Gandhi had deep insights into the need to conserve resources. 'Man need but not his greed' can be supported by our Earth' was an important concept that was initiated by him, when people had not fully realized how short the world would be of resources in future. At the time, natural resources seemed to be limitless to most people. This was, thus, a new concept and suggested the need for a uniquely different pattern of living.

Gandhiji believed in simplistic living to save our Earth's resources. He once said that if India were to become industrial nation on the lines of England, the world would be stripped bare of its resources by India's people alone.

EQUITABLE USE OF RESOURCES FOR SUSTAINABLE LIFE STYLES

There is a great variation in the utilisation of natural resources among different countries. The more developed countries (MDCs) represent only 22 per cent of world's population, but consume about 88 per cent of natural resources and about 80 per cent of the global energy. MDCs include USA, Canada, Japan, Australia, New Zealand and Western European countries. On the other hand less developed countries (LDCs) represents 78 per cent of the world's population and use only about 12 per cent of natural resources and 27 per cent of the global energy. Developed nations and affluent groups use natural resources and energy lavishly, while in less developed countries majority of people cannot even meet their minimum requirement of natural resources and energy needs.

The rich or more developed countries are contributing more to pollution and threatening the sustainability of life supporting systems of the earth. The poor or less developed countries, on the other hand, are still struggling hard with their large population and poverty problems. The rich have grown richer and poor have stayed poor or gone even poorer. This needs equal distribution of resources especially the basic requirements like drinking water, food, fuel etc. so that the people in less developed countries are at least able to sustain their life. The problems of LDCs like pollution, unhygienic conditions, diseases etc. can be brought under control only with the help of MDCs. The rich countries will have to reduce utilization of natural resources and much of the portions of resources will have to be diverted to the poor countries. This will narrow down the gap between MDCs and LDCs and will lead to sustainable development of the entire world.

IMPORTANT TERMS

1. **Aforestation.** Extensive plantation of trees to save the diminishing forest cover.
2. **Agro Forestry.** Practice of using the same land for farming and forestry.
3. **Agrostological.** Related to the cultivation of grasses.
4. **Aquifer.** A highly permeable layer of sediment or rock containing water.
5. **Bio gas.** A clean anaerobic fuel composed of a mixture of methane and CO_2.
6. **Biomass.** The materials originating from photosynthesis.
7. **Biomass Energy.** Energy obtained from the biomass.
8. **Compost.** A nutrient rich soil amendment produced by biological degradation of organic material under aerobic conditions.
9. **Deforestation.** Refers to destruction of forests.
10. **Desertification.** Conversion of grassland/forest into deserts.
11. **Energy Plantation.** Raising of plant species having high calorific value and growth rate.
12. **Forest.** A biotic community which is predominately composed of trees, shrubs or any woody vegetation and often with a closed canopy.
13. **Ground Water.** Water held in aquifers below the earth's surface.
14. **Jhum Cultivation.** Practice of felling and burning of forests, followed by cultivation of crops for few years.
15. **Landslides.** Mass movement of rock or soil down hill.
16. **Mine Spoil (Derelict Land).** The land that has been destroyed due to mining.
17. **Mulching.** Practice of covering soil with crop residue and other form of plant litter.
18. **Natural Resources.** The materials which living organisms can take from nature for the sustenance of their life.
19. **Organic Farming.** Practice of farming with increased organic input to the soil.
20. **Photovoltaic Cell (PV Cell).** Solar cell that converts solar energy into electricity.
21. **Salinity.** Refers to excess of soluble salts in water or soil.
22. **Social Forestry.** The practice of raising trees for firewood, fodder, agricultural implements and fruits on common lands.
23. **Taungya Cultivation.** Practice of growing agricultural crops between rows of planted trees.
24. **Urban Forestry.** The practice of growing ornamental and fruit trees on vacant lands in urban areas.
25. **Wetlands.** Low lying areas covered with shallow water having characteristic soils and water tolerant vegetation.

TEST QUESTIONS

Multiple Choice Type Questions

Select the correct option to the following questions

1. Common energy source in Indian villages is
   (*a*) Electricity (*b*) Coal
   (*c*) Sun (*d*) Wood and animal dung.
2. Fossil fuels and metallic minerals are
   (*a*) Renewable resources (*b*) Inexhaustible resources
   (*c*) Non-renewable resources (*d*) None of these.