UNIT 2: NATURAL RESOURCES

Earth's biosphere is endowed with extremely diverse kinds of environments which provide countless goods and services to human kind. Any component of the natural environment that can be utilized by man to promote his welfare is considered as a **natural resource**. The natural resource can be a substance, an energy unit or a natural process or phenomenon. Land, soil, water, forests, grasslands, etc. are examples of important natural resources. Some of the resources (e.g. soil, water) are important components of the life-supporting system. Besides being source of food, fodder and shelter, natural resources also provide recreational opportunities, solace and even inspiration to mankind. Natural resources have been exploited by humans since the beginning of civilization or even before. However, since the resources were abundant then relative to human population, no significant depletion occurred. During the last millennia human population has increased considerably causing serious damage or destruction of natural resources. In this chapter we will study major kinds of natural resources, causes of their degradation and their conservation.

CLASSIFICATION OF NATURAL RESOURCES

Natural resources vary greatly in their location, quantity and quality. For instance, a particular forest type may occur only in certain countries. Also the geographical area covered by forest and wood quality may differ widely in different countries. Some resources can be reused after being used once. A convenient classification of resources is based upon their exhaustibility and renewability (Fig. 2.1). Basically resources can be categorized as **Inexhaustible** and **Exhaustible**.

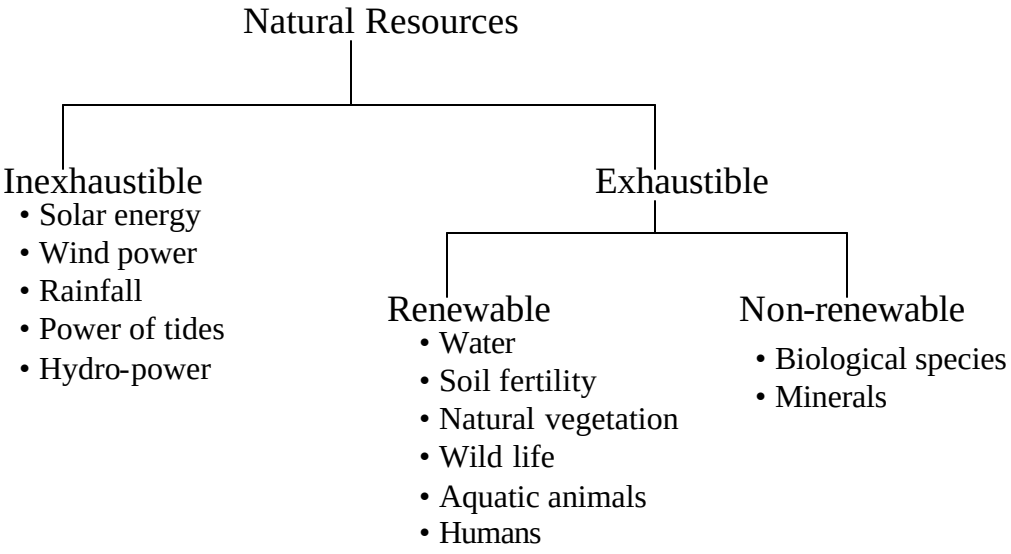

Fig. 2.1.Basic types of natural resources. Also shown are few examples of different kinds of resources.

Inexhaustible resources

Inexhaustible resources are available in unlimited quantities on the earth. While some inexhaustible resources remain virtually unaffected by human impact, many others may show some changes in their quality though their quantity may remain unchanged. Resources like solar energy, wind power, tide power, rainfall, and even atomic energy, cannot be exhausted significantly at global level due to human activities. Such resources may sometime be locally affected by human activities; for example, pollution may change the quality of air.

Exhaustible resources

A large number of natural resources are exhaustible, i.e. they have finite supply on the earth and can be exhausted if used indiscriminately. Broadly, the exhaustible resources can be either **renewable or non-renewable**

Renewable resources*:* Most of biotic resources are renewable. The growth and reproduction of such resources 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 get totally exhausted.

Selected examples of ecosystems and their important renewable products are: (1) Forests, which yield timber and other plant products, (2) Rangelands, which sustain grazing animals for milk, meat and wool production, (3) Wildlife, which maintain food chain, (4) Agricultural systems, which yield food and fibre, and (5) Marine and fresh water systems, which yield various foods from plants and animals. Soil and water are other renewable resources.

Non-renewable resources*:* Some biotic resources are non-renewable, i.e. they cannot be regained or reconstructed once they are used up. Biological species, which have evolved in nature during the course millions of years, are considered non-renewable. Once a biological species becomes extinct from the earth, it cannot be recreated by man.

Many abiotic resources are also non-renewable. For instance, fossil fuels (coal, petroleum and gas) and metals once extracted cannot be regenerated at the place of extraction. After unlimited extraction and use, the fossil fuels will certainly get exhausted.

PRINCIPAL NATURAL RESOURCES

Amongst the earth`s resources the following contribute significantly to human welfare: (i) Forests (ii) Water (iii) Minerals (iv) Food (v) Energy and (vi) Land..

FORESTS

Approximately one-third of the earth's total land area is covered by tree species dominated communities called forests. The forests are storehouse of biodiversity and provide important environmental services to mankind. These services originate from the following key functions of forests.

(i) Productive functions, include production of wood, fruits and a wide variety of compounds, such as resins, alkaloids, essential oils, latex, pharmaceuticals, etc.

(ii) Protective functions, include conservation of soil and water; preventing drought, sheltering against wind, cold, radiation, noise, sights and smells, etc.

(iii) Regulative functions, involve absorption, storage and release of gases (CO_2, O_2), water, mineral elements and radiant energy. Such regulative functions improve atmospheric and temperature conditions, and enhance the economic and environmental value of the landscape. Forests effectively regulate floods and drought, and the global biogeochemical cycles, particularly of carbon**.**

Forest area in India

At the beginning of the 20^{th} century about 30% of land in India was covered with forests. But by the end of the 20^{th} century the forest cover was reduced to 19.4% (Table 2.1). This is considerably less than the optimum 33% forest area recommended by the National Forest Policy (1988) for the plains and at least 67% for the hills. Of the existing forests, less than two-third are dense forests, and the rest are open degraded forest. Today, per capita forest area available in India is 0.06 ha, which is much below the average for the world (0.64 ha per person).

Table 2.1. Forest Cover in India (1999 Estimate)

Class	Area (sq. km)	% Geographic area
Dense forest[1]	3,77,358	11.5
Open forest[2]	2,55,064	7.8
Mangove[3]	4,871	0.1
Sub-total	6,37,293	19.4
Scrub[3]	5,896	1.6
Non-forest (other land use)	25,98,074	79.0
Total	32,87,263	100.0

[1]Canopy cover > 40% of land.

[2]Canopy cover 10-40% of land.

[3]Canopy < 10% of land.

Deforestation

World's forest cover has been shrinking rapidly, especially in the developing countries located in tropics. While the temperate forests have lost only 1% or less of its area, the tropics have lost more than 40% of the forest cover due to deforestation. The main causes of deforestation are expansion of agriculture, urbanization, industrialization, excessive commercial use of timber, fuel wood, other forest products and cattle grazing. More than half of the trees cut down in the world today are used for cooking and heating; in fact, fuel wood accounts for about 90% of all wood used in India. Cattle grazing has expanded open forest areas, and excessive grazing has caused land deterioration due to erosion and suppression of regeneration of useful tree species. The current deforestation rate in tropics is estimated to be more than 10 million ha per year. If this rate of deforestation continues it is feared that remaining tropical forests may disappear within a century.

Forests, particularly on mountains, provide considerable protection from floods by trapping and absorbing precipitation, and slowly releasing it later. When

the forest is removed, the amount of runoff water flowing into rivers and streams increases several fold. Deforestation results in increased soil erosion and decreased soil fertility. In drier areas, deforestation can lead to the formation of deserts.

Deforestation causes the extinction of plant, animal and microbial species. It also threatens native people whose culture and physical survival depends upon the forests. Deforestation also induces regional and global climate change. Generally, rainfall declines in deforested areas and droughts become common. Deforestation contributes to global warming by releasing stored carbon into the atmosphere as carbon dioxide, which is a greenhouse gas.

Tribals/forest dwellers

Unfortunately tribals and forest dwellers are being maligned for causing deforestation due to shifting cultivation and consequent loss of top soil. This is due to our ignorance about tribals and their socio-economic compulsions to take recourse to shifting cultivation. It must, however, be understood that the tribals depend totally on forests and their long term interest lies in protection and not in destroying forests. Their whole life, economy and cultural heritage is intertwined with forests. Tribals are repository of several of our land races and primitive cultivars of economic plants as also partly domesticated or even wild animals. They are great store of our valuable traditional knowledge on medicinal and other uses of plants and animals. These species and varities, and also the traditional ethnobotanical knowledge, are in constant demand from the developed countries for formulating and patenting new products including drugs. There is an urgent need to evaluate and provide for the basic needs of the tribals, and to educate them about any unintentional damages of an international damage to forest wealth. The forest management programmes should actively involve the tribals.

Forest conservation and management

Forest conservation and management programmes should ensure: (i) sustainable supply of tree products and services to people and industry, and (ii) maintenance of long term ecological balance through protection, restoration and conservation of forest cover. Extensive planting of trees through **afforestation** programmes is needed to save the diminishing forest cover. To achieve these goals the following forestry practices should be carefully integrated: (i) protection or conservation forestry, and (ii) production or commercial forestry.

Protection or **conservation** forestry involves protection of degraded forests to allow recoupment of their flora and fauna. Well-stocked forests are managed scientifically for producing timber and other forest products without causing any negative environmental impact on the forest. Forest areas designated as national parks and sanctuaries are protected from human interference.

On the other hand, **production** or **commercial forestry** aims to fulfill the commercial demand, without causing denudation of natural forests, through intensive plantation in available land. Production plantations of fast growing trees (e.g. *Eucalyptus*) are raised using modern forestry techniques. Social forestry, and agro-forestry programmes are also included in this category.

Social forestry aims to plant trees and shrubs on all unused and fallow land to provide fuelwood, fodder etc. thereby reducing pressure on existing forests. For example, unused farmland, community land, road and rail sides, etc are planted with suitable indigenous and/or exotic tree species.

Agro-forestry includes a variety of land uses where woody species are grown in combination with herbaceous crops, either at the same time or in time sequence. For instance, **taungya system** involves growing agricultural crops between rows of planted trees. The well known shifting cultivation or **jhum**, an agroforestry system widely practiced in the north-eastern region of our country, involves felling and burning of forests, followed by cultivation of crops for few years, and abandoning cultivation to allow forest regrowth

Forest and wildlife laws

Several legal provisions exist in our country to safeguard the national interests related to forests and wildlife. Notable amongst them are listed below.

***Forest Act 1927*:** This act aims to consolidate the law relating to forests, and its basic objectives are:

(i) Setting up and managing reserved forests, protected forests and village forests;

(ii) Protection of non-government forests and forest land;

(iii) Control of movement of forest produce;

(iv) Control of cattle grazing.

Wildlife (Protection) Act 1972, (Amended 1991): This act provides for protection of wild animals, birds and plants, and includes the following objectives:

(i) Restriction and prohibition on hunting of animals;

(ii) Protection of specified plants;

(iii) Setting up and managing sanctuaries and national parks;

(iv) Empowering zoo authority with control of zoos and captive breeding;

(v) Control of trade and commerce in wildlife, wildlife products and trophies.

National Forest Policy (1988): The principal aim of our Forest Policy is, formulated to regulate use of forest land, to ensure environmental stability and maintenance of ecological balance including atmospheric equilibrium which are vital for all life forms, human, animal and plant. The derivation of direct economic benefit (e.g. production of wood and other materials) is considered subordinate to the principal aim.

WATER RESOURCE

About three-fourth of the earth's surface is occupied by oceans which contain about 97.5 % of the earth's water in strongly saline condition. The rest 2.5% is

fresh water, and all of this is not available for direct human use. Most of the fresh water is frozen as polar or glacial ice (1.97%). Remaining fresh water occurs as ground water (0.5%) and water in lakes and rivers (0.02%), soil (0.01%) and atmosphere (0.0001%). Thus, only a small fraction of fresh water is available for human consumption. More so the distribution of fresh water is geographically uneven varying greatly from country to country and even within a country from one region to another.

About 84% of the total global evaporation occurs from ocean surface and 16% from land surface. 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. About 77% of the total rainfall on earth is received on the sea surface (as against 84% evaporation from this segment) and 23% on land (16% share of total evaporation to the atmosphere). There is a net gain of 7% rainfall water on land and this excess is returned to the oceans by surface runoff through rivers and sub-surface water flows. On global basis, the hydrological cycle is perfectly balanced as the total annual evaporation matches with annual precipitation.

Water use

On global basis, the water use has increased 4-8% per year since 1950, and the consumption rate varies among countries. World wide, approximately 70% of total water use is accounted by agriculture, only about 10% is used for domestic and municipal supplies, and the rest is consumed by various industries such as cement, mining, pharmaceutical, detergent and leather industry, etc.

In India since independence availability of water has declined by two thirds. The water requirement of major water consuming industries such as agriculture, refineries, petrochemical, fertilizers and chemicals has grown 40 times. It is estimated that water demand in agriculture sector will increase 2 fold in 2025 compared to demand in 1990. In domestic and industrial sectors

also 3-fold and 2-fold increase, respectively, by 2025is expected. Thus, over exploitation of our water resources without commensurate recharge has resulted in fall in groundwater table. Further, leaching of pollutants from pesticides and fertilizers into the aquifer has resulted in quality deterioration of groundwater. A 1994 survey of groundwater quality at 138 sampling locations in 22 industrialized zones revealed that water in all 22 zones was not fit for drinking.

Problems related with water resources

About 40% of the world's population lives in arid or semi-arid regions. These people spend substantial amounts of time, energy and effort in obtaining water for their domestic and agricultural use. To meet the needs of the huge population, surface waters (ponds, lakes, rivers etc.) are overdrawn. Due to over use of surface water the nearby wetlands may dry up. When more groundwater is removed for human use than can be recharged by rainfall or snow-melt, the ground water may also dry out.

Excessive irrigation in semi-arid and arid regions can cause salt accumulation in the soil due to which crop productivity may decline. The continuous depletion of ground water along the coastal regions, often leads to the movement of saline sea water into freshwater wells spoiling their water quality. Estuaries become more saline and consequently less productive when surface waters are overdrawn. .

Heavy rainfall results in rapid runoff from areas having the exposed soil particularly on mountain slopes. This not only causes soil erosion but puts lowland areas at extreme risk of destruction due to flooding. Uncontrolled soil erosion results in sedimentation of waterways that can harm fisheries.

Conservation and management of water

Main approaches for conservation of water are:

(1) Reducing agricultural water wastage by increasing efficiency of irrigation. By the traditional method of irrigation plants absorb less than 50% of the water applied to the soil, the rest is lost.

(2) Reducing water wastage in industry by recycling the used water.

(3) Reducing domestic water wastage by constructing waste water treatment plants and recycling the treated water.

(4) Rain water harvesting by employing practices to store rain water and recharge ground water.

(5) Afforestation and protection of watersheds to improve water economy.

Some important water management approaches to provide a sustainable supply of high quality water are:

(1) Construction of dams and reservoirs to ensure year round supply of water and, in addition, controlling flood and generating electricity.

(2) Desalinization of seawater and saline ground water, making it fit for drinking and other purposes. Diversion of water bodies (e.g. through canal) to increase the natural supply of water to a particular area.

Regular dredging and desiltation of water bodies.

MINERAL RESOURCES

Minerals essential to our industrialized society and daily life are non-renewable resources. Due to the increase in industrialization, the consumption of minerals has increased tremendously all over the world. The minerals now in short supply (e.g. silver, copper, mercury, tungsten, etc) will probably be exhausted within next 20 to 100 years. Even the minerals which are relatively plentiful, e.g. iron and aluminum, will become extremely expensive because of the depletion of large, rich and easily accessible deposits of these metals. Minerals can be metallic, e.g. iron, copper, gold, etc. or non-metallic, e.g. sand,

stone, salt, phosphates, etc. Some important minerals and their uses are given in Table 2.2. The minerals occur naturally in the earth's crust, however, their distribution is not even.

Table 2.2. Some Important Mineral Elements and Their Uses

Mineral	Selected uses
Metal elements	
Aluminium	Structural material, packaging
Chromium	Chrome plate, steel alloys
Copper	Alloys material in gold jewellery, silverware, brass and bronze,; electric wiring, pipes, cooking vessels
Gold	Jewellery, dentistry, alloys
Iron	Primary component of steel
Lead	Pipes, battery electrodes, pigments
Manganese	Alloy steels, disinfectants
Nickel	Coins, alloys, metal plating
Platinum	Jewellery, equipments, industrial catalyst
Potassium	Fertilizer, glass, photography
Silver	Jewellery, vessels, photography, alloy
Uranium	Nuclear bomb, electricity, tinting glass
Tin	Cans/containers, alloys
Zinc	Brass, electrodes, medicine
Non-metal elements	
Phosphorus	Medicine, fertilizers, detergent
Sulphur	Insecticide, rubber types, medicine
Liquid metal element	
Mercury	Thermometer, dental inlays, electric switches

Extraction (i.e. mining), processing and disposal of minerals have negative effects on environment. Mining not only disturbs and damages the land but also pollutes the soil, water and air. The land that has been destroyed due to mining is known as derelict land or **mine spoil.** Such derelict lands can be reclaimed or restored to a semi natural condition by re-vegetation to prevent further degradation and also to make the land productive for other purposes.

Conservation of minerals

Mineral conservation measures involve their recycling and reuse. 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, lead, nickel, steel, copper, aluminum, silver, zinc, etc., however, minerals in other products are lost through normal use such as paints containing lead, zinc or chromium. During reuse, used products are collected and used over and over again, e.g. reuse of glass bottles. The benefits of reuse are greater than those of recycling. All products, however, may not be reused. Recycling and reusing not only renew the mineral resources but also help in: (i) saving unspoiled land from the disruption of mining, (ii) reducing the amount of solid waste that must be disposed, and (iii) reducing energy consumption and pollution.

The substitution of more abundant minerals for scarce minerals may prove useful provided environmental implications are kept in mind. In recent years, plastics, ceramics, high strength glass fibres and alloys have been substituted for scarcer materials like steel, tin and copper in many industries. Although substitution can extend our mineral supplies, it is not a solution of the problem. 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 encouraged to be used again instead of discarding them as waste. Manufacturing industries may also use the waste products of one manufacturing process as the raw materials for another industry.

FOOD RESOURCES

It is estimated that one or more parts of about 30,000 plant species can be eaten by people; however, interestingly only 15 plant and 8 animal species supply as much as 90% of food eaten by us. In fact, only four crops (namely wheat, rice, corn and potato) together account for more of the world's total food production than all other crops combined. Two-third of the world human population survives on a diet of grains, mainly rice, wheat and corn. Perhaps this large fraction of population can not afford meat products. With rise in income due to development, the grain consumption generally increases because people consume more of meat, eggs and milk produced by grain-eating livestock.

Food production systems: Broadly, there are two major types of agricultural systems: industrialized and traditional. **Industrialized agriculture** (common in developed nations) uses large amounts of water, fertilizers, pesticides and fossil-fuel energy to produce huge quantities of crops. In several tropical less developed countries **Plantation agriculture** (also a form of industrialized agriculture) is used to grow cash crops like coffee and cacao. During the post-1960 period industrialized agriculture has spread into some developing countries also bringing in the era of **Green Revolution.** On the other hand, **traditional agriculture** is widely practiced in most of the developing countries. **Traditional subsistence agriculture** using human labour with minimal or no input (e.g. shifting cultivation in north-eastern part of India) produces just enough food for the farm or tribal families. **Traditional intensive agriculture** involves high input of human labour, fertilizer and water to substantially increase the crop yield.

Marine food resources: About three-fourth of earth's surface is occupied by oceans yielding valuable food resources. Since ancient times, marine algae have been widely used as human food. In many countries animals are still regularly fed on fresh or processed seaweeds (e.g. *Laminaria* and *Fucus*). From

the point of view of human use, fishes, molluscs (mussel, oyster, clam etc), crustaceans (prawn, lobster, crab) and mammals (whales, dolphins, porpoises) are important among the animals found in the ocean.

World food problem

Although during the five decades in the second half of the 20th century, the world food production has increased more than three times due to one or other form of green revolution. In spite of such an impressive increase in food production, the rapid increase in human population is outstripping food supply, especially in the developing countries. More than 100 countries still import food from the developed nations. Food scarcity has caused wide spread malnutrition and hunger in developing countries. Such hunger in developing countries mainly results from poverty, which prevents poor people from growing and/or buying enough food regardless of how much of it is available. Nevertheless, the record of India in food production has been impressive. Our food grain production has increased from about 50 million tons in 1950 to more than 200 million tons by the end of 20th century, a conversion from a food-importing to food-exporting nation. Such increase in food production has been mainly due to:

- Advances in agricultural research and education;
- Increased use of fertilizers and pesticides;
- Extensive use of irrigation;
- Increased availability of agricultural credit and expansion of cooperatives;
- Better agricultural extension and integrated rural development.

Presently about two-third of Indian population is engaged in agricultural practices (compare this with only about 2.4% people engaged in agriculture in USA), and about 47% of our land is under cultivation. The greatly increased food production in India is mainly obtained from the Green Revolution areas having facilities for irrigation, extending to about one-third of the total

cultivated area in the country. The remaining two-third cropped area in India is dryland, which is rain-fed only. While food production has nearly reached the peak in irrigated areas, there is immense potential for increasing the productivity of drylands by developing appropriate new ecologically viable management practices.

Environmental effects of food production

Both industrialized and traditional agriculture significantly affect our air, soil and water in various ways. These include loss in biodiversity due to habitat loss when natural systems like forests and grasslands are cleared, or wetlands are drained, for establishing agricultural fields. Replacement of thousands of wild varieties of crop plants with fewer high yielding varieties (as in green revolution) causes loss in genetic diversity. Inadequate safeguards in agriculture may lead to soil erosion and decreased soil fertility, and in extreme cases even waterlogging, salinization and desertification. Excessive employment of farm machinery causes increased air pollution and greenhouse gas emission from the fossil-fuel used. Heavy use of pesticides (often having long persistence in soil) in industrialized agriculture results in pollution of air, water as well as soil. Pesticides may kill fishes and contaminate drinking water. Similarly, substantial fraction of heavy fertilizer inputs may be leached causing water pollution (e.g. high nitrate contamination of drinking water). As such agricultural systems require huge amounts of surface water resource.

ENERGY RESOURCES

Future energy needs of rapidly expanding human population will demand the exploitation of most energy sources. Broadly, energy resources can be recognised as non-renewable or renewable. **Non-renewable energy** sources include various fossil fuels and nuclear energy. Fossil fuels include petroleum products, natural gas and coal. Nuclear energy is mainly obtained from the nuclear fission of the uranium. The world reserves of fossil fuels and uranium are limited and will eventually be depleted. Burning fossil fuels for energy has

negative environmental consequences such as global warming, air pollution, acid rain and oil spills. It has become necessary to minimize use of non-renewable energy resources, and to replace them with renewable resources.

Renewable energy resources are regenerated by natural processes so that they can be used indefinitely. Renewable energy generally causes much less negative environmental impact than fossil fuels or nuclear energy. With the current state of technology the generation of renewable energy is often more expensive than energy produced by fossil fuels or nuclear energy, however, with technological advances the costs of renewable energy is expected to decrease. Among the renewable energy sources, the most important one is solar energy. The other renewable energy resources are hydropower, wind, geothermal energy, ocean waves and tidal energy.

Solar Energy

Solar energy can be used directly or indirectly for human welfare. **Direct solar energy** is the radiant energy, whereas **indirect solar energy** is energy obtained from materials that have previously incorporated the sun's radiant energy. Solar energy can be used for direct heating, and alternatively the heat converted into electricity (thermal electric generation). Photovoltaic cells convert direct solar energy into electricity. A backup system is required to store and generate electricity when solar power is not operative at night or during cloudy days.

Among various energy resources where solar energy is utilized indirectly, **biomass energy** is the most important one. Biomass energy is obtained from those materials whose origin can be traced to photosynthesis such as 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 wastes) etc. Biomass also includes biodegradable organic wastes from industries like sugar mills, breweries, etc. At least half of the world's population relies upon biomass as their main source of energy. In India, fuel wood is still a major source of energy for domestic purposes in rural areas.

Biomass fuel, which can be a solid, liquid or gas, is burned to release its energy. Solid biomass includes wood, charcoal, animal dung and peat. Biomass can be converted to liquid fuels especially methanol and ethanol which can be used in internal combustion. Biomass, particularly animal waste, can also be converted into **biogas** in biogas digesters by using the process of microbial decomposition. Biogas is a clean fuel whose combustion produces fewer pollutants than other combustible energy resources. It is composed of a mixture of gases and can be stored and transported easily.

Production of biomass for energy requires sufficient area of land and water. **Energy plantations** of plant species, showing high calorific value and growth rate, are raised in selected areas to produce biomass.

Other renewable energy resources

Among other renewable energy resources the following are important, but their availability differs in different regions.

Hydropower: Water falling from a height turns turbines at the bottom of dams to generate electricity. Hydropower produces approximately one-fourth of the world's electricity and is usually cheaper than electricity produced by thermal power plants. However, building a dam to hold the water leads to several environmental problems; e.g. submergence of plant and animal habitats and displacement of people.

Wind energy: When fans are rotated by the action of wind its energy can be used for generation of electricity. However, harvesting wind energy is possible only in the areas that receive fairly continual winds such as islands, coastal areas, and mountain passes.

Tidal energy: The difference in the level of water between high tide and low tide can be used to generate electricity.

Geothermal energy: Heated groundwater flowing upward as hot water or steam, or as hot springs, can be used to turn turbines and generate electricity in geothermal power plants.

Ocean waves energy: Ocean waves, produced by winds have the potential to turn a turbine and generate electricity.

LAND RESOURCES

Earth's one-fourth area is formed by land which is largely covered with natural forests, grasslands, wetlands, and man-made urban and rural settlements along with agriculture. Low lying areas covered with shallow water are called wetlands. The wetlands are transitional between terrestrial and aquatic areas. Soil is the upper weathered crust of earth which supports plant growth. In all land resources soil is of critical importance. Estimates indicate that over 50% of land area in India suffers from soil degradation.

Soil resource

The yield of all biotic products in terrestrial ecosystems depends on soil fertility. Soil is composed of inorganic particles, organic matter, air, water and a variety of organisms. It takes decades or even centuries for the development of soil horizons having different physico-chemical properties. Human activities often create worldwide problems like soil erosion and depletion of fertility.

Soil Erosion*:* Movement of water and air removes top soil from the land by the process of **erosion.** Abundant plant cover significantly reduces soil erosion. Human activities accelerate soil erosion by removing natural plant cover. From

croplands in India, millions of tons of topsoil are eroded into sea each year. Erosion causes a significant loss of soil fertility by transporting organic matter and nutrients that are essential part of the soil. The eroded soil, which gets into streams, rivers and lakes in the form of sediments, affects water quality and habitats of aquatic organisms.

Depletion of soil fertility: When natural vegetation is removed to develop agricultural systems, as has happened in most parts of India and indeed in the world, 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 exported through crop harvest. Thus, over a period of time the agricultural soil inevitably loses its fertility.

Landslide damage

Landslide, the catastrophic event and one of the physical agents of natural disturbance is defined as downward and outward movement of slope forming materials composed of natural rocks, soils, artificial fills, or combination of these materials. The term landslide is used to refer to all kinds of rapid mass movements involving either rapid flow or slip. The earth mass may move during landslide by falling, sliding or flowing or by their combination. Landslides, the major cause of natural disturbance in tropical and temperate forests, occur in areas having high rainfall and weak lithological structure with steep slopes. Geomorphological conditions weathering, climate, lithology, hydrology and seismic factors are the natural causes of landslides. Besides, the natural factors, anthropogenic factor also cause, directly and indirectly, to the happening of landslides. These man-induced factors are: intensive cultivation, extensive exploitation of forest resources (deforestation), overgrazing, improper drainage system, and the substandard road construction.

As, landslide involves the movement of soil and vegetation mass, the self-sustaining, soil plant system is fragmented which often lead to disruption of community structure, nutrient cycling and losses of soil with nutrients from

the ecosystem. Generally the destruction of habitat results in loss of biodiversity, and decrease in forest biomass and soil fertility. The recovery after landslide disturbances depends upon intensity of disturbance. If disturbance is of low intensity the recovery in this case is faster. Recovery is delayed if the site is disturbed for long term duration.

Soil conservation: Several soil and crop management practices can minimize erosion and reduce nutrient depletion of agricultural soils. These include practices like conservation tillage, organic farming, crop rotation (especially cereal with legumes), contour ploughing and strip-cropping terraces, etc. In contrast to conventional tillage, conservational tillage incorporates residues from previous crops into the soil, thereby increasing the organic matter, which in turn improves soil moisture and nutrients. Reduced tillage and no-tillage are two kinds of conservation tillage.

Efforts to improve erosion-affected soils involve two steps: (1) stabilizing the soil to prevent further erosion, and (2) restoring the soil fertility. Soil stabilization will need seeding of bare ground with plants that can survive harsh conditions, e.g. drought-resistant grasses. Such plants eventually establish vegetation cover on the soil, preventing further erosion. With increasing addition of detritus, the soil organic matter, nutrient and moisture levels improve. The restoration of soil fertility to its original level is a slow process. Application of biofertilizers is useful in enhancing soil fertility. Various organic farming measures, which provide increased organic input to soil, have long-term beneficial effects on soil fertility.

Grasslands

Grasslands (also called rangeland) provide forage and habitat to domestic animals and wildlife. In rural areas, dried hay removed from grasslands, particularly from tall grasses, is also used as fuel or thatching material. Grass

cover is extremely effective in binding soil particles with the help of highly branched fibrous root system, thereby significantly reducing soil erosion. In India the area under various kinds of grass cover, including fallow and waste lands, is estimated to be about 18% of the total land area. If we include the forested area (about 19% of total land), most of which also supports grazing, about 37% of land can be said to be available for grazing. The average annual production of dry grass or hay in India is about 250 million tons.

Degradation of grassland: Degradation or destruction of grassland is mainly related to overpopulation. To enhance food production, grasslands possessing fertile soils are ploughed and converted to agricultural lands (e.g. American prairies). In developing countries, grassland areas are frequently overgrazed. For example, the number of animals grazing in the arid and semi arid regions of India has been found to be 2-10 times greater than the capacity of the grassland to feed the animals.

The lack of plant cover due to overgrazing causes soil erosion due to water and wind. When overgrazing occurs in combination with extended periods of drought, once fertile grassland can be converted to a desert. The conversion of grassland (or forest) to desert is called **desertification**.

Grassland management: Frequently employed measures of grassland management are outlined below.

(1) Protection from grazing to allow recovery of severely damaged vegetation.
(2) Use of **rotational grazing**; while some areas are closed to grazing, allowing the plant cover to recover, grazing is permitted in other selected areas.
(3) Removal of woody bushes or shrubs and weeds, which usually adversely affect the productivity of grasses.
(4) Conservation of soil and water by reducing loss of soil and water from the grassland.
(5) Use of controlled burning to promote recycling of nutrients stored in dried mulch and to reduce woody species invasion.

Wetlands

Wetlands are low lying areas usually covered by shallow water and have characteristic soils and water-tolerant vegetation. Wetlands may be either freshwater or salt water (coastal). Freshwater wetlands include **marshes** (where grass-like plants dominate), **swamps** (where trees or shrubs dominate), and periodically flooded **riverine** forests found in lowlands along streams.

Wetlands occupy almost 6% of the world's land surface and provide crucial environmental services. Wetlands are often drained, dredged or filled up for housing and industrial purposes. They are increasingly threatened by agriculture, pollution, and engineering constructions (such as dams).

Freshwater wetlands: Wetland plants are highly productive and provide food and habitat to support a wide variety of organisms. Wetlands help control flooding by holding excess water, and the flood water stored in wetlands then drains slowly back into the rivers, providing a steady flow of water throughout the year. Wetlands also serve as ground water recharging areas. Another important role of wetlands is to help clean and purify water runoff, even water that is polluted. Fresh water wetlands also provide important commercial products including wild rice and various types of berries (e.g. black berries, blue berries, etc.). In addition, wetlands provide sites for fishing, boating, nature study, etc.

Salt water wetland*:* Coastal wetlands, also known as saltwater wetlands, include highly productive estuaries which provide food and habitat for a large number of marine organisms.

Mangrove swamps are coastal wetlands in tropics containing certain trees and shrubs growing best in the intertidal zone. Mangroves hold sediments and accumulate soil along the shoreline. As mangroves expand into the ocean, other plants colonize the soil left behind. Mangrove roots provide habitat for oysters, crabs and other marine organisms.. Like fresh water wetlands, coastal

wetlands are also being destroyed for space for coastal development and agricultural lands.

Wetland conservation: Programmes for the conservation of wetlands generally employ the management approaches listed below.

(1) Preparation of wetland inventories.

(2) Identification of wetlands of critical importance for their protection.

(3) Checking waste disposal in wetlands.

(4) Reduction of excessive inflow of nutrients and silt into wetlands from surrounding uplands by keeping them under plant cover.

Role of individuals in conservation of resources

The resource consumption pattern of people in economically developed and developing countries differs radically. In developed countries people have aspirations for better quality of life and their resource demand is far more than necessary for reasonable living. Consequently they exhaust resources and degrade the global environment seriously. On the other hand, people in developing countries have small resource need due to their simpler subsistence level existence. But their exploding population, coupled with lower environmental awareness and growing desire to rapidly upgrade living conditions, leads to reckless destruction of resources. The resource use pattern of western countries which is based on consumerism is spreading fast in developing countries.

India is a unique country with a great cultural diversity, associated with all kinds of climates and rich flora and fauna. The human societies in our country have evolved within magnificent environments and reverence to nature is inherent in our cultural ethos. The roots of ecological and environmental values are deep in our ancient Vedic literature and Upanishads. The *Atharva-Veda* solemnly recognises an enduring allegiance of human kind to Mother Earth. A stanza in *Isho-Upanishad* states: “The whole universe together with its

creatures belong to the Lord (Nature).... Let no one species encroach over the rights and privileges of other species. One can enjoy nature by giving up greed." Living in harmony with nature has always been emphasized with the philosophy to take from nature only what we actually need and not more. '*Khsiti*' (Soil), '*Jal*' (water), '*Pavan*' (energry), '*Gagan*' (space) and '*Samira*' (air) are recognised as the basic resources of the earth. All organisms including man are integral part of nature, returning all the nourishment borrowed from Mother Earth.

Our classical literature abounds with the message that resources should not be used wastefully but should be conserved. For example, Kautilaya's famous treatise *Arthshashtra* describes what may be considered as the world's first Forest Conservation and Wild Life Management programme. Contemporary Mauryan Kings maintained forests for different purposes like elephant domestication, hunting, and forests as reserve. Through the history, the Indian people have not been exploiters but utilizers of nature. Our country has been under the influence of humans and agriculture for about 10,000 years. Fortunately for us, the resource depletion has not been proportional to our very long history. This has been mainly due to the compassion for the living and non-living and the principle of *Ahimsa puromo dharma* that are ingrained in our culture. There is a need to incorporate these principles in regulating resource use. Based on our cultural heritage and tradition, our resource utilization should be optimized. We must recognize our responsibility to conserve earth's resources for future generation.