UNIT 16 APPROACHES FOR NATURAL RESOURCE CONSERVATION

Structure

16.18 Some useful books and suggested readings

16.0 OBJECTIVES

After studying this unit, you should be able to

- understand how resource use pattern is related to sustainability
- differentiate between over-exploitation and sustainable use of a resource
- comprehend the various links between resource use, depletion, environmental degradation, and pollution
- comprehend the sustainability issue related to mining, drilling, and other harvesting practices
- provide alternative strategies for sustainable energy and material future

16.1 INTRODUCTION

16.1.1 Background to Natural Resources

In this unit, we take an overview of the nature of natural resources and their management. Many of the natural resources suffer from depletion. Depletion occurs when a resource is utilized faster than it is replaced by natural processes. A material resource deposit (mineral or fuel) that took millions of years to form, for example, may be extracted and consumed in just a few years, or a species that took many thousand years to evolve may be driven to extinction in a few years. Conservation in the broadest sense has always been one of the important applications of ecology. The term 'conservation' is derived from two Latin words - con (= together) and servare (= to keep or guard), thus meaning is to keep together. World Conservation Strategy defines conservation as the management of human use of the biosphere so that it may yield the greatest sustainable benefits to the present generation while maintaining its potential to meet the needs and aspirations of future generations. Thus, conservation is a practice embracing preservation, maintenance, sustainable utilization, restoration, and enhancement of the natural environment. Summarily, the true aim of conservation is two fold: (i) preservation of the quality environment and (ii) to ensure the yield of useful materials (living or nonliving) by establishing a balanced cycle of harvest and renewal.

The ideal goal of such resource management is sustainable resource use, which seeks to "conserve" or slow down the rate of resource consumption to the point where the resource can be replaced by nature. Harvest of trees or fishes or other biological organisms is examples. In other cases, if the resource is in immediate threat of disappearing, sustainable management must preserve the resources where the exploitation is stopped so that the resource gets time for regeneration or attain resilience, e.g. endangered species and endangered ecosystem. Sustainable management of resources can eventually lead to achieving the goals of sustainable development. Sustainable development encourages forms of growth that meet current basic human needs while preserving the resources for the needs of future generations. Economic development is linked to environmental conservation. Thus sustainable development implies a change

in all aspects of life. It depends upon the willingness of the people to change their perceptions of the socio-economic and environmental conditions around them, and the readiness of each individual to alter their present use of natural resources.

It is known that stopping or slowing down the rate of resource use not only slows down the depletion but usually has the added advantage of minimization of waste and reducing pollution. A sustainable society practices "throughput" reduced to the point where exploited resource (inputs) stocks get enough time for regeneration by natural processes and pollution (output) load remains under the assimilation capacity of the resource base. However, the conventional ways of resource management have not achieved this goal of sustainable use as they are more influenced by short-term social, economic, and political gains which emphasize rapid exploitation of resources. Sustainable use of natural resources must require skillful management and preservation of resources, as we cannot completely deny their use, there should be a switch of use from non-renewable sources to unconventional and renewable sources of energy, with appropriate technological support.

16.1.2 Need for Conservation of Natural Resources

As we know the human population is rapidly increasing and their dependency on natural resources has also been increased many folds, which leads to the depletion of non-renewable natural resources rapidly. Coal and fossil fuel have been the predominant source of energy since the dawn of the industrial revolution. However, in recent decades, there has been a preference towards renewable sources of energy, albeit low as compared with fossil fuels. The approaches for conservation and management of some of the non-renewable and renewable resources are described in the following sections.

16.1.3 Conservation and Management of Natural Resources

Conservation and management of natural resources refer to their preservation for future generations and their sustainable utilization. It majorly includes sustainable management of land resources, judicious utilization and rejuvenation of water assets, protecting and enhancing the marine environment, and conserving and recuperating biodiversity. Natural resources provide several kinds of ecosystem services contributing to human wellbeing. It provides fundamental life support to humans, in the form of both consumptive and public-good services. Most human lifestyle depends on these natural resources to meet their basic needs and these are depleting rapidly. The degradation and depletion process is irreversible, thus the unavailability of these resources meant deterioration in the quality of life. Hence to provide a better life to our future generations we must conserve and sustainably utilize the resources. There are several strategies for the conservation of these natural resources, which will be discussed separately in each section but it is essential that these resources are utilized judiciously and the dependency is shifted from non-renewable sources to renewable resources. But in underdeveloped and developed countries it is a bit difficult to achieve these goals due to the unavailability of funds and prerequisite technology. So it is time for developed countries to generously come forward and help these countries in providing the technology so that the entire human population gets

benefited.

16.2 MINERAL RESOURCES

Minerals are the most important natural resources found on the earth's crust in any form (solid or liquid), which are then extracted for use. It, being the vital raw material for many basic industries, plays an important role in the mining sector, industrialization, and overall development of the nation. A particular mineral is formed through a certain combination of elements that depends upon the physical and chemical conditions under which the material forms.

16.2.1 Mineral Resources Status in India

India is fortunate to have fairly rich, varied, and unevenly distributed mineral resources. About 11 metallic, 52 non-metallic, 4 fuels, 3 atomic & 22 minor minerals are found in India. Metals like iron, steel, silver, cobalt, gold, copper, lead, etc., and building materials like coal, iron ore, glass sand, gypsum, bauxite, dolomite, chromite, petroleum, natural gas, etc., are extracted and produced respectively from minerals in India. Most of the mineral resources are non-renewable and some are non-recyclable. Since the socio and economic prosperity of a nation depend upon the proper use of minerals, hence they should be conserved and should not be misused.

16.2.2 Conservation of Mineral Resources

The mineral resources are limited in quantity and are being depleted very fast. The following steps need to be taken for the conservation of these resources:

- minimizing waste and developing technologies to recover the resources from waste
- developing technologies to recycle metals (cycling and reuse of metals)
- research to substitute some metals like gold, silver, mercury, and platinum, etc with synthetic (man-made) products
- development of alloys which will reduce the demand for some pure metals, e.g. alloys of magnesium are replacing steel and reducing the demand for copper, lead, and tin
- alternatives to fossil fuels to be found such as nuclear and solar energy
- mining areas to be reclaimed
- a data bank on the availability and expenditure of mineral resources should be maintained so that their use is regulated
- new reserves on the ocean floor and unexplored areas need to be searched for
- regulation of human population
- enforcement of conservation and antipollution laws
- enforcement of the land-use rule
- long-term planning

- peace (war is a great waste of materials)

16.3 RANGELAND

16.3.1 Background

Land that supplies food for grazing or browsing animals is called rangeland. Rangelands are essentially grasslands but may contain occasional trees and shrubs. Grasslands occur where rainfall is too low to support the forest community but is higher than that which results in a desert community. Generally, in grassland annual precipitation ranges between 250 and 750 mm. Over 6,000 species of grasses, adapted to a wide variety of climatic regimes are found on the earth's surface. Rangelands cover one-third of the earth's continental surface. With 0.5% of the world's grazing land, India supports 18% of the world's cattle population. This has resulted in pressures on the land resource often beyond its resilience capacity. Our lack of understanding and awareness on conserving natural resources has led to their exploitation beyond the carrying capacity. Thus, rangeland ecosystems require attention for the want of services it provides.

16.3.2 Conservation and Management of Rangeland

The conservation and management of rangeland require a clear understanding of the causative factors for their degradation and depletion, some of the important ones are i) change in land-use pattern, ii) phenomenal growth of livestock population, and iii) infestation by invasive and alien species. Thus, the focus of rangeland management should be to maximize livestock production consistent with the conservation of range resources. Some of the important methods in range management are briefed as under:

i) **Regulation of Grazing Pressure:** overgrazing in rangelands is known to induce problems of secondary succession eventually leading to desertification. Grazing reduces more palatable and nutrient-rich species facilitating the growth of less palatable ones. Overgrazing is detrimental to rangeland structure and productivity. Thus, grazing should be prevented in areas where regeneration is sought. The period for which grazing should be closed varies from species to species, and in the case of slow-growing species the period may extend up to 15 to 20 years. Grazing should be prohibited in areas that are highly prone to erosion. The catchment areas of river valley projects should be completely prohibited for grazing thereby reducing the runoff issues and siltation problems in dams, and also help in the conservation of grazing lands. On the whole, grazing intensity should be brought to the carrying capacity level of rangelands.

ii) **Stock Level Policy:** Every rangeland has an ideal carrying capacity, i.e. the average number of grazing animals, such as buffaloes, cows, goats, or sheep that can be properly maintained over a given area. But in nature, all years are not equally productive due to fluctuations in the climate (e.g. annual rainfall, summer, and winter temperature). In some years, there are droughts and plant productivity falls considerably and several animals die of starvation. Therefore, appropriate methods have to be developed by

manipulating the number of cattle in different ways so that the problems of overgrazing and starvation deaths are reduced to a minimum level. This can be achieved either by maintaining a high level of stock in good years and selling away a portion in drought years or permanently keeping a lower population at 60 to 70% of the carrying capacity.

iii) **Deferred Grazing:** The range may be divided into several compartments. Grazing in successive periods is regulated in such a way that in each compartment, a grazing year alternates with a non-grazing year so that there is always a mature and full-grown stand available.

iv) **Fire:** sometimes rangelands are burnt at regular intervals of annual or longer cycles to destroy less palatable and hardy species, which otherwise overtake rangelands on account of grazing in due course of time. Fire is a good method of range management provided there is little possibility of rain immediately after the fire as that causes erosional losses of much fertile ash of the burnt-up vegetation.

v) **Reseeding:** Rangelands also sometimes need grasses and legumes for their successful growth against naturally involving less desirable species. Some suitable fodder-grown species are Cenchrus ciliaris and C. setigerus, and leguminous fodders are Berseem sp. and Lucerna sp. Broadcasting seeds on a larger scale is necessary.

vi) **Selection of Cattle Breeds:** Cross-breed, improved varieties of cattle are preferable to increase milk yield. Further, it is necessary to cull the scrub cattle, and owing to the sentiments of people, such cattle should be kept in Go-sadans and have to be processed with great caution.

vii) **Introduction of Stall Feeding:** management of cattle from open grazing to stall feeding is highly essential because roaming bovine gain nothing to be converted to milk on account of their energy largely being dissipated in traveling.

viii) **Control of Weeds and Pests:** this includes the use of herbicides and pesticides to get rid of unwanted weeds and pests.

16.4 LAND RESOURCE MANAGEMENT

The land is one of the most crucial exhaustible resources, which is being degraded by both natural and anthropogenic factors, viz., rain, wind, deforestation, erosion landslides, land-use changes, urbanization, industrialization, and so on. This precious resource must be managed properly and should be used according to its suitability and capability. Some of the essential components of land management are described as under:

- A land classification and land capability map using spatial tools (GIS & RS technology) is a prerequisite.
- The land must be classified keeping in mind the nature of the soil, physical features, availability of water and its storage, run-off, and so on.
- Fertile agricultural land should not be sacrificed for non-agricultural purposes, such as road building, development of industries, or

construction of water reservoirs. Urban areas should not be developed on agricultural lands. Since forests shelter wildlife, prevent soil erosion and impact the climate, they should be developed in hilly areas and deforestation should be checked.

- Changes resulting from land-use should be monitored and the intensity and frequency of natural hazards like cyclones, floods, and so on should be anticipated/predicted.
- The landscape and pollution load also need to be considered.

16.5 SOIL CONSERVATION

Soil resources are the crucial factor for ensuring farm productivity and ultimately our food security. It has been realized that productivity can be maintained if soil resource is available in desired quality. Rapid industrialization and urbanization along with the conversion of forests to crop fields for an increase of food grains to cater to the needs of the growing population have led to the destruction of forests and rangelands, eventually leading to soil erosion and land degradation. Hence, one of the immediate concerns in soil management has been the prevention of physical loss of soil due to erosion. Some of the measures to check soil erosion are listed as under:

i) Large-scale plantations and the development of grasslands can prevent soil erosion. As a result, the roots of the trees and grasses will stabilize the soil and prevent soil erosion. Further, trees will act as breakers and will prevent the loss of topsoil due to wind erosion.

ii) The development of a good drainage system in slopes will reduce soil erosion.

iii) In hill slopes, alternation of crop fields with patches of grasses, maize, tobacco, sugarcane, and other soil erosion-resistant plants help in the stabilization of soil.

iv) In hilly areas, landslides are checked by the construction of drainage ditches and walls along the slopes.

v) Soil erosion from the banks of the rivers, streams, and even the seashores is prevented by the construction of thick concrete walls.

vi) The bare soil may be covered with dry leaves and straw. This mulch when soaked with water will prevent erosion of soil due to the action of wind and water.

vii) In desert areas and other areas prone to cyclonic effects, patches of shrubs and trees are planted to act as barriers to check wind action and thereby soil erosion due to wind action.

In addition to soil erosion, restoration of soil fertility is another important aspect of soil management. Soil loses its fertility due to over-use while waterlogging leads to an increase in the salinity and alkalinity of the soil. In coastal areas, over-extraction of groundwater also leads to salinity ingression into inland, thereby degrading the fertile land. Further, the use of synthetic chemical fertilizers also reduces the natural fertility of the soil. For the restoration of soil fertility some

of the measures are listed as below:

i) Since, different crops of varied nutrient requirements, crop rotation helps in the proper use of nutrients available in the soil.

ii) Growing legume plants periodically in the crop fields increases the nitrogen level of the soil.

iii) The roots and stems of crop plants, if retained in the crop fields after harvesting, will decompose and enrich the soil with organic matter.

iv) The alkalinity and salinity of soil are reduced by the addition of gypsum, phosphogypsum, pyrites, and organic manures.

v) Salt-resistant plants may be grown in saline soil to reduce the soil salinity.

vi) The agrochemicals used in the crop fields should be highly degraded so that they decompose easily.

16.6 WATER RESOURCE

Water is an essential resource for the sustenance of the biosphere. It is mainly used for drinking, agriculture, transportation, cleaning, industry, recreation, producing electricity, and other commercial use. India accounts for about 4% of the water resources of the world. It has an average annual rainfall of about 1170 mm and 1,869 cubic km of surface water and replenishable groundwater, of which only 60% can be put to beneficial uses. India has traditionally been an agrarian economy, and about two-thirds of its population has been dependent on agriculture. Hence, the development of irrigation to increase agricultural production has been assigned a very high priority in the Five Year Plans, and multipurpose river valleys projects like the Bhakra-Nangal, Hirakud, Damodar Valley, Nagarjuna Sagar, Indira Gandhi Canal Project, etc. have been taken up. India's water demand at present is dominated by irrigational needs. While the share of the industrial sector is limited to 2% of the surface water utilization and 5% of the groundwater, the share of the domestic sector is higher (9%) in surface water utilization as compared to groundwater. The over-use of groundwater resources has led to a decline in the groundwater table in several states. The per capita availability of water is dwindling day by day due to the increase in population. The available water resources are also getting polluted with industrial, agricultural, and domestic effluents, and this, in turn, is further limiting the availability of usable water resources. Hence, a comprehensive water management plan is required for making its sustainable use and equal and equitable distribution to every part of India.

16.6.1 Water Resource Conservation and Management

Water resources are one of the unique categories of resources, where management solutions are crucial. The management of water resources must aim at maintaining wastage by preventing misuse of water, storage of water and its scientific distribution, and availability of pure water for human consumption. Some of the strategies for the management of water resources are listed as under:

i) Avoiding loss through leakage during the distribution of water

ii) Water for human consumptive use, viz., bathing, drinking, and cooking should be different from that used for irrigation, and accordingly, the distribution system must be in place.

iii) After an appropriate level of treatment and purification, municipal and domestic water can be made fit for use in industry and agriculture.

iv) Rainwater harvesting must be implemented in full spirit, which will ensure proper storage of rainwater during monsoon season (in pits, trenches, and so on) for later use.

v) Provisions must be made to recharge groundwater during the rainy season, which will be a stop-gap arrangement during the time of scarcity.

vi) The water quality of surface water bodies must be maintained by preventing the discharge of domestic and industrial effluents and arresting runoff from catchment areas.

vii) Water used in the industrial sector must be subjected to multiple recycling through treatments and reuse.

viii) Multi-purpose dams must be constructed for the storage of water for flood control, power generation, and irrigation.

ix) Public awareness must be created

   a) on the impacts of pollution of aquatic bodies on ecosystem health including humans and wildlife, and

   b) in favor of meaningful utilization of water.

16.7 FOREST AND WILDLIFE MANAGEMENT

16.7.1 Forest Conservation and Management

Forests constitute one of the principal natural resources and are considered as lungs of nature. According to Gautam Buddha, "the forests possess unlimited kindness and benevolence that makes no demands for its sustenance and extends generously the products of its life activity, it affords protection to all beings, offering shade to even the ax-man who destroys its". Forests are well-known for the ecosystem goods and services they provide for human wellbeing. However, in the past several decades, forests have been degraded and depleted due to various reasons. The natural factors include frost, fire, cyclone, drought, wind, lightning, snow, disease, pest outbreak, etc. The anthropogenic factors include deforestation, agricultural extension, and intensification, cattle grazing, shifting cultivation, over-extraction of fuelwood and industrial wood, exploitation for developmental activities/projects, etc. Thus, forests need to be conserved and managed properly for the sustenance of the biosphere.

The forests are to be managed to obtain a sustained yield, which is possible through sustained growth on following considerations:

- A forest should possess the correct proportion of trees of different age groups
- Tree felling should be banned

Thus, to undertake forest management proper knowledge of climatic trends, the composition of the biotic community, successional trend, the life cycle of important species, high yield species and organismal interactions such as parasitism, pests, diseases are necessary. Some of the measures involved in forest management are described as under:

i) Restrained felling: the concept of sustained yield in forestry denotes the management of forests in such a way that the modest timber crop may be harvested indefinitely year after year, without being depleted. This can be achieved through (i) enhancing the annual growth through different silviculture practices or (ii) limiting the annual fellings.

ii) Block and Selective Cuttings: Block cutting method can be effectively applied in a forest having almost even-aged trees of a few species. In this method, trees are harvested not at random but in a block. For example, from 10 acres of such forest land, one acre may be harvested year after year, after the 10th year another block develops and is ready for harvesting. The major drawback of this method is, altogether timber sources may be exploited effectively, all other uses such as aesthetic, recreational, and ecology are disturbed in the patch removed. The selective cutting of trees annually is better than block cutting to have multiple uses of forests.

iii) Reforestation: in the places where forests are harvested on block cutting or selective tree cutting, the reforestation of denuded areas is essential to maintain continuous yield. There are two schools of thought in forestry. One school says forests should be managed as free forms in the same ways as food crops are cultivated. This is achieved by, (i) artificial selection of high timber yielding trees (e.g. Acacia sp.), (ii) monoculture and harvest, and (iii) high input of fertilizers. The other school proposes it as a natural ecosystem having multispecies and multi-aged trees having all other purposes besides producing timber but low yields. These have low-cost maintenance but no environmental hazards.

iv) Control of Diseases: disease, pests, and fire are the chief agents of forest destruction. Forest diseases resulting from viruses, parasites, fungi, rusts, and nematodes cause nearly half of the destruction of timber. Young seedlings are more vulnerable to nematode infections. The use of antibiotics, chemicals and the development of resistant varieties of trees are the means to get rid of timber destruction. Weevil moths, aphids, budworms, sawflies, beetles, borers, termites are the chief insect pests in a forest. All parts of plants are infested by one or other pests. Efficient quarantine use of pesticides, biological and integrated pest control methods are suggested.

v) Social Forestry: A social forestry is a participatory approach aiming at growing forest trees in various barren places such as schools, compounds, road and railway line sides, office verandas, etc. It is often said that social forestry initiatives are the activity of raising of forest for the people and by the people. Such afforested places provide various ecological goods and services, viz., providing shade, fruits, habitat to birds and reduce the pressure of fuelwood and noise pollution. The social forestry program was started in 1976 to use private lands for raising forests. It has two main objectives: (i) to use public and common land to produce firewood, fodder

for local poor and also manage soil and water conservation, and (ii) to relieve pressure from conventional forestry. Another modified version of social forestry is agro-forestry. The perennial wood plants are raised similar to crops, to obtain sustained outputs. The activities of agroforestry, social forestry, and community forestry will reduce the pressure on forests for firewood.

vi) Recycling of Forest Goods: recycling paper and other forest produce plus stringent conservation and management plans could reduce the per capita pressure on annual growth. It is estimated that a ton of waste paper recycled to produce paper again serves 4 m3 of timber and 900 m3 of water and reduces the consumption of electricity by almost 50% besides reducing the pollution. Thus, to summarize, to meet sustained yield and enjoy other benefits of forests too, joint forest management programs should be implemented in letter and spirit and should focus on multiple uses of forests.

vii) Government Policies and Legal Framework: The Government of India has announced the National Forest Policy in 1952, owing to the importance of forests and protecting them. Due to changing scenarios in the country, the said policy is revised from time to time to accommodate the best interests of various stakeholders such as natural resource base and wildlife, and to facilitate sustainable development. The basic aims of the forest policy are: (i) conservation of existing resources for safeguarding the environment, (ii) development and enlargement of the tree-cover and resource-base to meet the basic needs (e.g. energy, small timber, and fodder) of the people and the country, and (iii) to develop minor forest produce for providing sustenance for certain communities living near forests. Further, to strengthen the ongoing efforts and to provide legal standing, the Government of India promulgated the Forest (Conservation) Act of 1980, which ensures that illegal diversion of forest land for non-forestry purposes is stopped, and the defaulters are taken to task and punished appropriately. This act also facilitates the management of natural habitats for wildlife, and thus, the Forest (Conservation) Act of 1980 complements the Indian Wildlife (Protection) Act 1972 for wholesome conservation and management of forest resources and biological wealth of forests.

16.7.2 Wildlife Conservation and Management

A brief on the reasons for the depletion of wildlife is a prerequisite before elaborating on the ways and means to conserve wildlife and manage their habitat and population. The major factors responsible for the depletion of flora include (i) natural events such as earthquakes, floods, landslides, and competition (inter-species competition) and (ii) anthropogenic events/activities like habitat destruction by mining activities, deforestation, shifting cultivation, grazing and so on. The factors responsible for the depletion of wild animals are (i) habitat destruction (ii) poaching for meat, skin, fur, tusk horn, sport, etc. (iii) competition from domestic livestock and transmission of disease from them, and (iv) industrial activities causing contamination of the environment, thereby endangering their life.

Wildlife management can be defined as the application of ecological knowledge

to populations of animals and plants in such a manner that brings a balance between these populations to meet the needs of the people. Broadly speaking, wildlife management is the creation and maintenance of suitable wildlife and its habitats for the production of wildlife goods and services on a sustainable basis. Therefore, the management should be done to imply both the principles of conservation and control. The following measures should be taken for the conservation of wildlife in India.

- Protecting the natural habitat of wild animals and controlled killing concerning the carrying capacity of the natural habitat.
- Water resources such as streams and waterfalls in natural habitats should be properly managed and guarded carefully for the benefit of wildlife. In summer, these water sources become particularly important.
- Poaching should be completely banned in protected areas (PAs, e.g. wildlife sanctuaries, national parks, game reserves), and the ban on poaching must be dealt with sternly both inside and outside PA.
- The polyculture of trees must replace the monoculture practice in social forestry programmes, as that would help to support diversified wildlife.
- Trees in forests should not be cut frequently and heavily. Light cuts at regular intervals are desirable.
- Controlled burning increases forage and preserve organic matter in the soil. Areas may be burnt by rotation and burning may be done in blocks with unburnt areas in between.
- Artificial salt licks are necessary for animals for their health and growth and should be provided in natural habitats and sanctuaries.
- Grazing by domestic animals near forest zones or inside forests should be regulated so that wild animals are not adversely affected.
- Wild animals should not be allowed to come in contact with domestic animals frequently as there is a danger of the spread of diseases from the domestic animals and vice versa.
- Veterinary units should be made proactive to take care of wildlife in case of epidemics.
- Regular or periodic estimation of the population of wild animals should be made through effective census operations.
- Cultivation near wildlife-protected areas should be banned to minimize the effects of agrochemicals and human interference.
- An appropriate level of encouragement should be made to promote research on the biology and ethology of wild animals.
- The establishment of breeding firms, especially for the threatened species be made so that these can be reared in semi-natural conditions and then released in PAs.
- Conservation of endangered animals through the captive breeding

programme should be taken up aggressively, and already existing success stories (case studies), though very few, should be discussed widely for building the confidence of conservationists.

- Implementation of existing legal framework and instruments for the conservation of wildlife must be made in letter and spirit.
- Extensive outreach and awareness programmes should be conducted to increase awareness regarding the importance of wildlife conservation.

The following measures need to be taken for forest and wildlife management:

i) Unauthorized tree felling should be prohibited.

ii) Slash and burn practices for shifting cultivation should be discouraged.

iii) Adoption of scientific methods for harvesting forest produce.

iv) Adopting short rotation and long rotation tree plantation.

v) Destruction of forests due to fire and overgrazing must be tackled.

vi) Creating awareness among people about the ecosystem services that forests are providing and their usefulness for human beings and wildlife.

vii) Ban on poaching must be dealt with sternly.

viii) Law enforcement needs to be implemented strictly.

ix) Protected area networks should be strengthened by creating and/or declaring more national parks and wildlife sanctuaries.

x) Corridor connectivity must be ensured among the protected areas.

16.8 ENERGY CONSERVATION

With the growth of population and economy, the energy demand has been rapidly increasing. Moreover, several sectors that require a high level of energy intensity are a matter of concern. In such cases, efficient use of energy resources and their conservation assumes tremendous significance. We cannot afford the wastage of energy, so we have to curtail the wasteful consumption and divert them towards useful developments. Recognizing the fact that efficient use of energy and its conservation is the least-cost option to meet the increasing energy demand, the Government of India has enacted the Energy Conservation Act, 2001, and established the Bureau of Energy Efficiency in March 2002. This provides for institutionalizing and strengthening the delivery mechanism for energy efficiency services in the country and provides the much-needed coordination between the various entities. Energy-saving must be a national cause and all of us will have to join hands and make all-out efforts in making India an energy-efficient economy and society so that not only we remain competitive within our market but also can compete in the international market. In recent years India has been making efforts towards economic self-reliance in the case of the energy sector. If it has to achieve the targeted growth in GDP, it would need equal input of energy, mainly commercial energy in the form of coal, oil, gas, and electricity. However, India's fossil fuel reserves are limited. Energy is an important element of the infrastructure sector that has to be ensured its availability on a sustainable basis. On the other hand, the energy

demand is growing multiple times and the energy sources are becoming scarce and costlier. Hence an efficient energy conservation plan is required for a better and safe future.

Energy conservation planning can be divided into four steps:

- Specifying targets and preparing detailed plans.
- Identifying energy inefficient facilities and equipment which must have an efficient index EEI (energy quantity index) and energy effectiveness index (energy quality index EQI).
- Implementation of energy conservation measures: which includes a method of installation (i.e., recycling, retrofitting) and method of heat use (e.g. installation of equipment for waste heat recovery and utilization).
- Evaluation of benefits.

Energy management:

- The primary objective of energy management is to maximize profits and minimize costs. The main objectives of energy management programs include:
- Increasing the energy efficiency while decreasing energy use, in turn, reduces costs.
- Environmentally less harmful and Sustainable technology.
- Developing and maintaining efficient monitoring and management strategies for wise usage.
- Researching better ways to increase returns from energy investments.
- Decreasing the impacts of an interruption in energy supplies.

Some strategies regarding energy conservation and management:

- Compulsory energy audit for every consumer.
- High-end research facilities for sustainable energy utilization technologies.
- Laying down of energy efficiency standards for energy consumption.
- Marking of energy efficiency labels on every piece of equipment.
- Discarding the inefficient pieces of equipment and barring the production and sale of such types of equipment.
- Preparing energy efficiency norms for every institution.
- Incentivizing energy conservation.
- Formulation of energy conservation and sustainable energy production plans for large industries especially which require a high amount of energy.
- Creating awareness among different categories of consumers regarding

sustainable energy usage and conservation.

16.9 CONSERVATION AND MANAGEMENT OF AGRICULTURE

Conservation agriculture is a management system that maintains a soil cover through surface retention of crop residues with no-till or reduced tillage. It is described by FAO as "a concept for resource-saving agricultural crop production which is based on enhancing the natural and biological processes above and below the ground". Conservation agriculture is mainly based on maximizing yields while maintaining the soil and agricultural ecosystem resources. It also promotes the combined social and economic benefits received from the combination of agricultural production and environment protection, while reducing input and labor costs. By using this process, farmers become providers of a healthy living environment by reducing the use of pesticides, fossil fuels, and other pollutants and maintaining environmental integrity. It is being practiced in many countries on the principle of making more sustainable use of land. By adopting these practices we can enhance the efficiency of resources used and the yield hence making it a tool for natural resources management and to achieve sustainability in agriculture. It depends on three principles:

- Minimum mechanical soil disturbance: also known as "biological tillage" and it is not compatible with mechanical tillage. With mechanical soil disturbance, soil structuring processes will disappear. Minimum soil disturbance provides/maintains optimum proportions of respiration gases, moderate organic matter oxidation, porosity for water movement, and limits the re-exposure of weed seeds and their germination.
- Permanent organic soil cover: it is important to protect the soil against the harmful effects of exposure to rain and sun; to provide the microorganisms with a constant supply of food; and alter the microclimate in the soil for optimal growth and development of soil organisms, including plant roots.
- Diversified crop rotations: This is essential for maintaining soil health as it provides diverse food to the soil microbes and helps in recycling nutrients in the soil layers. Crop rotations involving legumes help in biological nitrogen fixation and increases biodiversity.

Conservation agriculture in India has been adopted more than a decade ago and it has been slowly adopted by farmers. Several State Agricultural Universities, ICAR institutes are planning to make progress in it. In Indo-Gangetic plains where the rice-wheat cropping system dominates these technologies are taking place. It mainly focuses on zero-till seed-cum fertilizer drill for sowing of wheat. In addition, raised-bed planting and laser land leveling are also being increasingly adopted by the farmers of the north-western region.

The following prospects are seen for the promotion of Conservation Agriculture:

- Reduction in cost of production and increase in yields.
- Reduced incidence of weeds and resource improvement.

- Saving in water and other environmental benefits like reduction in the burning of crop residues, maintaining the soil health, etc.
- Crop diversification opportunities through crop rotation, agroforestry helps in keeps stable nutrition in the soil.

16.10 MARINE RESOURCES

The marine ecosystem forms an integrated and essential component of the Earth's ecosystem. It covers nearly three-fourths of the earth's surface and contains a diversity of natural resources starting from fishes to other organisms which mainly provide food and other non-living resources like petroleum minerals, etc. Hence management of marine resources has a large potential for sustainable development. Biotic resources like fishes, crustaceans, corals, seaweeds, and mangroves are some of the major resources associated with the livelihood of the coastal community. Prospects in the sector of Seaweeds have high-income potential as it is spreading its wings into the alternative food source, cosmetics, fodder, fertilizer, pharmaceuticals, textile, and biomass. It has been estimated that the total annual yield of seaweeds is about 1 lakh tonnes. Mangroves ecosystem besides becoming a bioshield has a higher economic potential. Among abiotic resources, different sources of energy in the form of waves, tides, thermal ocean currents; petroleum, oil, gas, and mineral substances in various forms are available. Besides that, it has a great source of minerals resources also.

16.10.1 Conservation and Management of Marine Resources

The utilization of the ocean resources has increased, as it supplies alternative sources of food and energy to humankind while the land resources are receding. But the rapid increase in population and the expansion of industrialization have put forth great pressure on the resources and the environment of oceans. The offshore oil extraction, overfishing, the sewage disposed into the sea has created and havoc in the marine ecosystem. Rapidly changing marine environment and the bleaching of corals are the indicators of the declining marine ecosystem. It is necessary to have an action plan based on sustainable utilization to reduce overexploitation. Without proper management, the resources can be threatened. Therefore, considering the importance of marine resources, International law, as reflected in the United Nations Convention on the Law of the Sea (UNCLOS), has provided the legal framework for the conservation and sustainable use of the oceans and their resources. Besides that the following practices should be adopted for the conservation and management of marine resources:

- Increasing the number of marine and protected areas so that the source population of marine bioresources can be conserved and an ecological balance can be maintained in the marine ecosystem.
- Maintaining the health of the oceanic ecosystem so that the oceanic acidification, temperature rise, etc. can be curtailed.
- Reducing marine pollution and disposal of debris produced from land-based activities. An integrated effort for ensuring effective treatment

of the effluents before disposing them into the ocean.

- Promoting sustainable exploitation of marine resources and provide sufficient time for its regeneration.
- Eliminating harmful subsidies that promote fishing overcapacity and encouraging sustainable small-scale fisheries.
- It is necessary to initiate researches an inter-disciplinary action to encourage and support the collaboration among scientists from the different areas on the various energy and minerals resources and subsequently plan for monitoring the extraction on keeping in view the international laws.
- Strengthening the institutions and ensuring full implementation of regional and international regimes governing oceans and seas.
- Creating awareness among the people about the importance of the marine ecosystem and its resources for future perspectives.

16.11 CONSERVATION AND MANAGEMENT OF BIODIVERSITY

The earth holds a vast diversity of living organisms, which includes different species of plants, animals, and microorganisms. Besides that, there is intraspecific diversity where they are genetically different. The earth also holds an immense variety of habitats and ecosystems. The total diversity and variability of living things and of the system of which they are a part are generally defined as biological diversity. In other words, it also refers to the totality of genes, species, and ecosystems in a region. Biodiversity represents the very foundation of human existence. Although it has profound ethical and aesthetic importance, it is very clear that biodiversity loss has serious economic and social costs. It is part of our daily lives and livelihood and constitutes the resources upon communities, nations and future generations depend. Several factors and forces are responsible for the decline in the earth's biodiversity during the last century. The major cause of loss of biodiversity is due to anthropogenic pressure and this, in turn, resulted in the overexploitation of natural resources habitat loss and fragmentation, and pollution. Besides that, invasive species and climate change are also serious threats. Hence conservation is the need of the hour and for that, the most effective and efficient mechanism is to prevent further destruction or degradation of habitats. There are two basic strategies for conservation, i.e. in-situ (on-site) conservation, and ex-situ (off-site) conservation.

In-situ Conservation: The in-situ strategy emphasizes the protection of total habitat or ecosystems where they naturally occur. The in-situ approach includes protection of a group of typical ecosystems through a network of protected areas, facilitating gene flow through corridor development, the introduction of new genetic stock.

Protected areas: These are areas of land or sea of a country specially dedicated to the protection of biodiversity. The Ministry of Environment and Forests is carrying out the in-situ conservation of biodiversity through Biosphere Reserves, National Parks, Wildlife Sanctuaries, and other protected areas like community

reserves, conservation reserves, etc. These are managed through legal or other effective means. According to the National Wildlife Database (Wildlife Institute of India) as of September 2020, there is a total of 981 protected areas in India, which covers 5.03% (1,71,921 km2) of the total geographic area of India excluding 18 biosphere reserves.

Ex-situ Conservation: The ex-situ conservation strategies are generally done out of their natural habitats like zoos, botanical gardens, and gene banks. It is further divided into two types i.e., in vivo and in vitro ex situ conservation.

- In-vivo ex-situ conservation: This includes zoological parks, botanical gardens where the conservation of living organisms in enclosed and artificial habitats for the preservation of genetic resources under normal growing conditions. They are kept under observation and allowed to breed so that the population can grow and can be reintroduced to their natural habitat.
- In-vitro ex-situ conservation: This is especially carried out by cryopreservation in liquid nitrogen, is particularly useful for conserving stem cells, embryos, etc. of the organism. Cryopreservation is the storage of material at an ultra-low temperature either by very rapid cooling or by gradual cooling and simultaneous dehydration at low temperatures. The material can be stored for a long period in compact, low-maintenance refrigeration units. The preserved materials can be used for the regeneration of the organism through in-vitro techniques and prevent the species from extinction.

Legal Framework for biodiversity conservation in India: The Government of India has introduced various legislations in response to the increasing destruction of wildlife and forests. Some of them are stringent legal instruments ensuring that the conservation processes are not hampered and wildlife and its habitats are well protected. Some of them are as given below:

- Wildlife (Protection) Act, 1972: Prohibits hunting, Protects wildlife habitats through the establishment of protected areas, and controls of trade in parts and products derived from wildlife.
- Indian Forest Act (1927) and Forest Acts of State Governments: Provides state ownership on Forest and regulated its use, makes cutting forest or obtaining its products, grazing, quarrying, fishing, and hunting are punishable.
- Forest Conservation Act (1980): curtails indiscriminate logging and release of forestland for non-forestry purposes.
- Environment (Protection) Act (1986): Provides legal protection to non-forest habitats and mainly regulates pollution.
- Biological Diversity Act (2002): Conserves Biological Diversity, makes a plan for sustainable use of Bioresources, and ensures fair and equitable sharing of benefits.
- National Forest Policy (1998): Provides sustainable use and conservation of forests, prioritizes the maintenance of ecological

balance through the conservation of biodiversity, soil, and water management.

The participatory approach of Conservation: making the people the guardians of biodiversity is the best way to conserve it. Making them aware of the resources and the benefit of resources will always solve the problem. Sustainable harvest practices will help them in generating money vis-à-vis encouraging them in conservation also. The creation of more Community Conservation Areas could be an option that is entirely managed by the community representatives; therefore, they are the ones to decide on access and benefits from that area. Thus, this concept is more acceptable to the local communities. The Man and Biosphere Programme is also, opens a second venue to create a community co-management institution for the Forests. All these alternatives are hustle-free as they involve the local community in conservation but there must be proper incentivization for their work and also stringent punishment for degrading biodiversity so that the system can work properly.

16.12 MANAGEMENT OF COMMON INTERNATIONAL RESOURCES

Common International Resources are global resource domains in which common-pool resources are found and where no single country owns them. According to the World Conservation Strategy, a report on conservation published by IUCN in collaboration with UNESCO and UNEP, and WWF "A commons is a tract of land or water owned or used jointly by the members of a community. The global commons include those parts of the Earth's surface beyond national jurisdictions — notably the open ocean and the living resources found there — or held in common — notably the atmosphere. The only landmass that may be regarded as part of the global commons is Antarctica". These resources are shared by many individuals or nations; they are not legally alienated to individuals, firms, or nations, for several reasons. It includes the shared natural resources, which includes the high oceans, deep sea beds, the atmosphere, outer space, and the Antarctic in particular. The exploitation of these resources is almost universally regarded by governments in the light of potential contributions to their economies. But as there are no specific and strong guardians of these resources, the resource tends to be used too quickly and is often depleted. In light of more extraction inefficient and capital-intensive exploitation creates congestion among users of the resource.

The key challenge of the global commons is the design of governance structures and management systems capable of addressing the complexity of multiple public and private interests, subject to often unpredictable changes, ranging from the local to the global level. Several treaties define the utilization of these resources. The United Nations Environment Programme (UNEP) has identified several areas of need in managing the global ocean: strengthen national capacities for action, especially in developing countries; improve fisheries management; reinforce cooperation in semi-enclosed and regional seas; strengthen controls over ocean disposal of hazardous and nuclear wastes; and advance the Law of the Sea. In the polar regions, the Arctic Council and the Antarctic Treaty System manages the resources. The Arctic Council, operates on a consensus

basis of their member nation, mostly dealing with environmental treaties and not addressing boundary or resource disputes. The Antarctic Treaty and related agreements, collectively called the Antarctic Treaty System or ATS, regulate international relations for Antarctica. The treaty, entering into force in 1961 and currently having 50 signatory nations, sets aside Antarctica as a scientific preserve, establishes freedom of scientific investigation, and bans military activity on that continent. The Outer Space Treaty provides a basic framework for international space law. It covers the legal use of outer space by nation-states. The treaty states that outer space is free for all nation-states to explore and is not subject to claims of national sovereignty. It also prohibits the deployment of nuclear weapons in outer space. The treaty was passed by the United Nations General Assembly in 1963 and signed in 1967 by the USSR, the United States of America, and the United Kingdom. As of mid-year, 2013 the treaty has been ratified by 102 states and signed by an additional 27 states.

16.13 APPLICATION OF REMOTE SENSING AND GIS TECHNIQUES IN NATURAL RESOURCE MONITORING, MANAGEMENT AND PLANNING

In recent years, remotely sensed data has been widely used for its application in various natural resource management disciplines. The accessibility of remotely sensed data from different sensors of various platforms with a variety of radiometric, spatiotemporal, and spectral resolutions has made satellite data as, the best data source for large-scale applications and studies. The exhaustive data provided by remote sensing serves as an input for several environmental process modeling. The integrated use of remotely sensed data with GPS and GIS tools will enable the managers and researchers of natural resources to work on a variety of natural resource management applications and make appropriate plans for its management. It is a potential tool to study the change in land cover, forest density, coastal morphology, the status of the reef, and biodiversity of islands even if, located in a remote place.

Most of the natural resources are used for the production of food, fuel, and other materials for making improvements in the human lifestyle. The important issues that need immediate attention and where remote sensing can play a significant role are:

- Inventory and mapping of resources.
- Evaluation of present land-use practices and projections for the future.
- Assessment of land resources that are physically useable and economically relevant.
- Identification of strategies that offer sustained production and other benefits.
- Analysis of constraints related to resource development - physical, economic, or social.
- Identification of appropriate corrective and conservative measures

required for bringing about the desired product and minimizing the environmental damages.

- Evaluation of changes in the structure and function of land systems.

In natural resource management, remote sensing and GIS are mainly used in the mapping processes. These technologies can be used to develop a variety of maps. Examples include Land cover maps, Soil maps, Vegetation maps, Geology maps, etc. However, before these maps are developed, there are a variety of data need to be collected and analyzed. Data can be collected using either ground photographs, aerial photographs, or satellite photographs of the area of study. Satellite images can also be used to collect relevant data for the study. These types of photographs are however superior to aerial photographs in the sense that they have higher spectral, spatial, radiometric, and temporal resolutions. Thus, satellite images are more detailed hence a lot of data can be generated from them. However, for remote sensing data to be effective, it needs to be incorporated together with topographical maps that show the variation of climate, soils, and other factors.

The visual and digital data that has been collected is usually analyzed to generate a pre-field map. Various components and elements of the data are analyzed. Elements such as tone, texture, pattern, association, size, and shape are essential in the analysis process. These elements bring about a detailed view of the area of study. The pre-field map that has been generated together with the results from the analysis of the various elements is used to determine the characteristics of different elements and themes found on the ground.

Over the last century, the forest cover of the world has declined at an alarming rate. Being a renewable resource, forest cover can be regenerated through sustainable management. Hence, with the help of remote sensing and GIS data, a forest manager can generate information with regards to forest cover, types of forest present within the area of the study, human encroachment into forest land/protected areas, encroachment of desert-like conditions, and so on. This information is critical in the development of forest management plans and in the process of decision-making to ensure that effective policies have been put in place to control and govern how forest resources are utilized.

Water as a resource has been diminishing over the years, mostly in underdeveloped and developing nations. Water management has therefore been a challenge in developing nations. However, with the use of satellite data, water bodies such as rivers, lakes, dams, and reservoirs can be mapped in 3D with the help of GIS technology. This data can be used in the sustainable management of water bodies since respective authorities can decide which regions need effective protection and management. At the same time, decisions regarding the most effective means of the utilization of these regions can always be arrived at.

Geospatial data can be used to determine the soil types present in a given area and nutrient availability. Negative change can always be identified once this data is collected over a long period. GIS data can also be used to determine the land-use practices within a given area and vegetation constitution and the impact that they have on the environment. Consequently, slope information of a region can also be determined with the use of GIS data. With all this

information, an individual can easily determine whether desert-like conditions are encroaching in an area. If desert-like conditions have been identified, their impacts and intensity shall be analyzed to decide on whether artificial or natural methods shall be used to combat the situation.

Geospatial data can also be used in the management of flora and fauna within protected areas. Ground and aerial photographs are essential in this practice. Aerial and satellite photographs can be used to determine the presence and distribution of vegetation within a protected area. These photos can also be used to determine the presence and distribution of invasive species within an ecosystem. This information is essential as it determines the amount of cover and food that is present, particularly for herbivores during various seasons of the year.

Aerial photographs can be used to ease the process of counting during animal census activities. The stop capability of photographs eases this process. It is always essential for protected area managers to determine the population and distribution of various species within a protected area to ensure that they have enough food and water, to eliminate the chances of overstocking that might lead to soil erosion and to ensure that a balance within the ecosystem is arrived at.

Geospatial data can also be used to show human encroachment into protected areas as well as animal activities outside protected areas. These data are critical in the process of resolving human/wildlife conflicts. Finally, the use of GPS technology can be applied to monitor the movement of endangered species as well as newly introduced species to determine their progress as well as protecting them from poachers. Finally, geospatial data can be used to carry out an environmental impact assessment (EIA) of various projects carried out within protected areas, thereby contributing to sustainable development and planning of natural resource management. Projects such as the building of roads, buildings, pipe ways, dams, and so on might have various effects on the ecosystem.

16.14 ROLE OF NATIONAL AND INTERNATIONAL ORGANIZATIONS IN THE PROMOTION OF SUSTAINABLE NATURAL RESOURCE USE AND MANAGEMENT

Post World War II, there was a unique opportunity for securing peace, sustainable development, and participatory democracy. Countries started to unite and made action for global peace and development, which paved the way for the creation of the United Nations (UN) in 1945. Slowly the UN expanded its branches and prepared programs for every aspect that has a global significance. Subsequently, a great deal of attention and synergistic efforts were devoted to the preparation of the 1992 UN Conference on Environment and Development. Since the Stockholm Conference on the Human Environment in 1972, there have been several specialized UN Conferences to deal with issues that have a direct bearing on sustainable development. As the first global environmental union, IUCN established in 1948 brought together governments and civil society organizations with a collective target to protect nature. It aimed to

encourage international cooperation, make available the scientific knowledge and tools to guide conservation action. In 1980, the Assembly of the World Conservation Union under IUCN approved the World Conservation Strategy and, in 1990, Caring for the World- A Strategy emphasizing sustainable development and conservation. Further several international conventions were established with a specific goal and action plan for a different aspect of natural resource conservation. The Ramsar Convention (1971) has especially focused on wetlands and an intergovernmental treaty was made to create a framework for the conservation and wise use of wetlands and their resources. The World Heritage Convention (1972) focused on the conservation of sites with natural and cultural importance. The significant feature is that 'it links together in a single document the concepts of nature conservation and the preservation of cultural properties. The Convention identifies the means for creating a balance between the human and nature. The Convention on International Trade in Endangered Species, (1974) is an international agreement between governments that aims to ensure that international trade of wild plants and animals does not threaten the survival of the species. The Convention on Biological Diversity (1992) or the Rio Earth Summit is dedicated to promoting the conservation of biological diversity and sustainable development. It has been designed as a practical tool for fulfilling the goals of Agenda 21 (a non-binding action plan of the United Nations concerning sustainable development) into reality.

16.15 LET US SUM UP

Ever since the dawn of human civilization, there has been increasing pressure on the natural resources base of the planet earth. This has been increasing at an accelerating rate post-industrial revolution. Thus, natural resources conservation and management have been of paramount importance in the development policy of several countries including India. This chapter has been articulated to provide a brief on the need for sustainable natural resources management for the good sustenance of the biosphere and human wellbeing. Since population growth is impacting different components of earth systems and resource base such as land, water, energy, forest, biodiversity, this chapter provides an overview of approaches for conservation and management of such resources. Through this chapter, it is advocated that there needs to be a paradigm shift of preference from non-renewable to renewable resources.

16.16 KEYWORDS

Energy resources : Energy resources are all forms of fuels used in the modern world, either for heating, generation of electrical energy, or for other forms of energy conversion processes.

Forest resource : Forest resources means those natural assets which are obtained from forest, like timber, fruits, and other products.

Land resource : Land is a naturally occurring finite resource. It provides the base for

survival of living beings. It holds everything that constitutes terrestrial ecosystems.

Natural resources : Natural resources are naturally occurring materials that are useful to man or could be useful under conceivable technological, economic or social circumstances or supplies drawn from the earth, supplies such as food, building and clothing materials, fertilizers, metals, water and geothermal power.

Sustainable development : The development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Water resource : Water resources are natural resources of water that are potentially useful as a source of water supply.

Wildlife resource : Wildlife resources means all wild animals, wild birds, and aquatic animal life.

16.17 TERMINAL QUESTIONS

- What do you understand by conservation and management of natural resources and why it is needed?
- What do you mean by sustainable development?
- What are the different methods of forest and wildlife conservation?
- Describe the main principles of Conservation agriculture?
- Explain strategies regarding energy conservation and management.
- What are the essential components of land resource management?
- What is the role of national and international organizations in the promotion of sustainable natural resource use and management?
- Describe the application of remote sensing and GIS techniques in Natural Resource Management.

16.18 SOME USEFUL BOOKS AND SUGGESTED READINGS

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