ENVIRONMENTAL STUDIES

TH-5

3rd SEM

MECHANICAL ENGG.

Under SCTE&VT,Odisha

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CHAPTER -I

The Multidisciplinary approach of Environmental Studies:

Introduction:

All living and non- living organisms have continuous interaction with each other in respective environments. Without environment nothing can exist. Especially human beings cannot survive without an environment. There is a reciprocal relation between environment and mankind. Human activities have a lot of impact on the status of environment, which in turn has an impact on the overall development of our society.

Environment has both natural and man-made dimensions in terms of physical, chemical and biological. Natural changes occur over a period of time while man-made changes are mainly due to the scientific and technological development based on human activities.

Environmental studies is a multidisciplinary approach deals with every issue that affects a living organism.

Definitions

- The word environment is derived from an old French word 'ENVIRON' means encircle. Environment connotes the sum total of the things or circumstances surrounding an organism including humans (Cunnigham et al., 1993).

- Environment means the natural environment, which encompasses all the biotic and abiotic elements that form our surroundings, that is, air, land, water, forests, seas, animals , all other living and non-living elements on Planet Earth (Singh K., & Shishodia A., 2007).
- Environmental science is the study of how various species interact with one another and with the non-living environment. It is a study of how all the components of nature and human societies adapt and interact. It is the study of interaction of the biotic component (plants, animals and microorganisms) among themselves and together with the abiotic component (temperature, rainfall, soil, air, fire, atmosphere and topography) (Anjaneyulu Y., 2004).

Scope

Human beings live in villages, cities or towns which were originally forests, mountains or deserts. City dwellers have to get food from villages which grow various crops that are dependent on forests, grasslands, rivers, sea shores for resources such as water and nutrients. Our life depends on environment. We inhale oxygen, drink water, eat food produced in the nature, and exhale carbon dioxide, dispose wastes and by-products in it. We cannot continue to live without protecting the environment. Each action of us has an adverse effect on environment. For e.g. – Use of fertilizers and pesticides leads to soil infertility, Construction of mega – dams' leads to displacement of people etc.

Importance

Environment is our "mother nature" and respecting nature is vital to protect our own livelihoods. Environmental protection is very important from three perspectives i.e. productive value, aesthetic value and option value.

- Productive value of nature: World's species like plants and insects contain incredible and uncountable number of complex chemicals. These are the raw materials used for developing new medicines and industrial products. If we degrade and destroy their habitat, these species will become extinct. Thus, it is our responsibility to protect all living species, for sustainable living.

- Aesthetic / recreational value of nature:National parks, wild life sanctuaries and rivers in

undisturbed areas have recreational value. It brings about an understanding of the oneness of nature & intricate functioning of ecosystems. The recreational facilities like nature walk, trekking, rock climbing, river rafting, para sailing etc. not only provide a pleasurable experience, but are also intended to create a deep respect & love for nature. In an urban setting, green spaces & gardens are vital to the psychological and physical health of city dwellers; and create nature awareness.

- Option value of nature:Every consumption activity of ours has an adverse impact on nature's integrity. Nature provides us with various options on how we utilize its goods and services. We have the 'option' to use goods and services greedily to destroy its integrity or we can use its resources sustainably to reduce the degradation of environment. "The earth provides enough to satisfy every persons need but not every person's greed" is the vision of Mahatma Gandhiji.

Need for public awareness

Since our environment is getting degraded due to human activities, we need to do something about it to sustain the quality. We often feel that government should take proper measuring steps. But all of us are equally responsible to protect our environment. Hence public awareness needs to be created. Both print media and electronic media can strongly influence public opinion. Politicians should respond positively to a strong publicly supported activity. NGOs can take active role in creating awareness from grass root levels to the top-most policy decision makers.

Environment is an integration of both living and non-living organisms. Water, air, soil, minerals, wild life, grass lands, forests, oceans, agriculture are all life supporting systems. Since these natural resources are limited, and human activities are the causative factors for environmental degradation, each one of us need to feel responsible to protect the environment.

The activities help in creating awareness among public are

- Join a group to study nature such as WWF-I or BNHS or any other organization
- Read newspaper articles and periodicals like Down to earth, WWF-I newsletter, BNHS, Hornbill, Sanctuary magazine.
- Discuss environmental issues with friends and relatives.
- Join local movements that support activities like saving trees in your locality, reducing use of plastics, going for nature treks, practicing 3 Rs i.e. reduce, reuse, & recycle.
- Practice and promote good civic sense and hygiene such as enforcing no spitting or tobacco chewing, no throwing garbage on the road and no urinating in public places.
- Take part in events organized on World Environment Day, Wildlife week etc.
- Visit a National park or sanctuary or spend time in whatever natural habitat you have near your home.

World Environment Day : June 5th

CHAPTER – II

2.1 Introduction to Natural Resources

Any material which can be transformed in a way that it becomes more valuable and useful can be termed as resource. In other words, it is possible to obtain valuable items from any resources. Resource, therefore, are the means to attain given ends. The aspect of satisfaction is so important that we consider a thing or substance a resource, as so long it meets our needs. Life on this planet depends upon a large number of things and services provided by the nature, which are known as Natural Resources. Thus water, air, soil, minerals, coal, forests, crops and wild life are all examples of natural resources.

Classification of natural resources

Depending upon availability of natural resources can be divided into two categories such as (1) renewable and (2) Non renewable resources.

1.Renewable resources

Renewable resources are in a way inexhaustible resources. They have the ability to replenish themselves by means such as recycling, reproduction and replacement.Examples of renewable resources are sunlight, animals and plants,soil,water,etc.

2. Non-Renewable Resources

Non renewable resources are the resources that cannot be replenished once used or perished. Examples of non renewable resources are minerals, fossil fuels, etc.

Resources can also be classified as biotic or abiotic.

a)Biotic resources

These are living resources (e.g. forest, agriculture, fish and wild life) that are able to reproduce or replace them and to increase.

b)Abiotic resources

These are non-living resources (e.g. petrol, land, minerals etc.) that are not able to replace themselves or do so at such a slow rate that they are not useful to consider them in terms of the human life times.

* Problems associated with natural resources

1. The unequal consumption of natural resources

A major part of natural resources today are consumed in the technologically advanced or ‘developed’ world, usually termed ‘the west’. The ‘developing nations’ of ‘the east’, including India and China, also over use many resources because of their greater human population. However, the consumption of resources per capita (per individual) of the developed countries is up to 50 times greater than in most developing countries. Advanced countries produce over 75% of global industrial waste and greenhouse gases.

2. Planning land use

Land is a major resource, needed for not only for food production and animal husbandry, but also for industry and growing human settlements. These forms of intensive land use are frequently extended at the cost of ‘wild lands’, our remaining forests, grasslands, wetlands and deserts. This demands for a pragmatic policy that analyses the land allocation for different uses.

3. The need for sustainable lifestyles

Human standard of living and the health of the ecosystem are indicators of sustainable use of resources in any country or region. Ironically, both are not in concurrence with each other. Increasing the level of one, usually leads to degradation of other. Development policies should be formulated to strike a balance between the two.

2.1.1 Forest Resources

Forest is important renewable resources. Forest vary in composition and diversity and can contribute substantially to the economic development of any country .Plants along with trees cover large areas, produce variety of products and provide food for living organisms, and also important to save the environment.
It is estimated that about 30% of world area is covered by forest whereas 26% by pastures. Among all continents, Africa has largest forested area (33%) followed by Latin America (25%), whereas in North America forest cover is only 11%. Asia and former USSR has 14% area under forest. European countries have only 3% area under forest cover. India's Forest Cover accounts for 20.6% of the total geographical area of the country as of 2005.

Significance of forests

Forest can provide prosperity of human being and to the nations. Important uses of forest can be classified as under

- Commercial values
- Ecological significance
- Aesthetic values
- Life and economy of tribal

Commercial values

- Forests are main source of many commercial products such as wood, timber, pulpwood etc. About 1.5 billion people depend upon fuel wood as an energy source. Timber obtained from the forest can used to make plywood, board, doors and windows, furniture, and agriculture implements and sports goods. Timber is also a raw material for preparation of paper, rayon and film.
- Forest can provide food , fibre, edible oils and drugs.
- Forest lands are also used for agriculture and grazing.
- Forest is important source of development of dams, recreation and mining.

Life and economy of tribal

Forest provide food, medicine and other products needed for tribal people and play a vital role in the life and economy of tribes living in the forest.

Ecological uses

Forests are habitat to all wild animals, plants and support millions of species. They help in reducing global warming caused by green house gases and produces oxygen upon photosynthesis.
Forest can act as pollution purifier by absorbing toxic gases. Forest not only helps in soil conservation but also helps to regulate the hydrological cycle.

Aesthetic values

All over the world people appreciate the beauty and tranquillity of the forest because forests have a greatest aesthetic value. Forest provides opportunity for recreation and ecosystem research.

Over exploitation of forests

Forests contribute substantially to the national economy. With increasing population increased demand of fuel wood, expansion of area under urban development and industries has lead to over exploitation of forest .At present international level we are losing forest at the rate of 1.7 crore hectares annually. Overexploitation also occurs due to overgrazing and conversion of forest to pastures for domestic use.

Deforestation

1. Forest are burned or cut for clearing of land for agriculture ,harvesting for wood and timber , development and expansion of cities .These economic gains are short term where as long term effects of deforestation are irreversible

2. Deforestation rate is relatively low in temperate countries than in tropics If present rate of deforestation continues we may losses 90% tropical forest in coming six decades
3. For ecological balance 33% area should be under forest cover but our nation has only 20.6% forest cover.

Causes of deforestation

Forest area in some developed area has expanded. However in developing countries area under forest is showing declining trend particularly in tropical region. Main causes of deforestation are

a) Shifting cultivation or jhum cultivation

This practise is prevalent in tribal areas where forest lands are cleared to grow subsistence crops. It is estimated that principle cause of deforestation in tropics in Africa, Asia and tropical America is estimated to be 70, 50, and 35% respectively. Shifting cultivation which is a practice of slash and burn agriculture are posses to clear more than 5 lakh hectares of land annually. In India, shifting cultivation is prevalent in northeast and to limited extent in M.P, Bihar and Andhra Pradesh and is contributing significantly to deforestation.

b) Commercial logging

It is a important deforestation agent. It may not be the primary cause but definitely it acts as secondary cause, because new logging lots permits shifting cultivation and fuel wood gatherers access to new logged areas.

c) Need for fuel wood

Increased population has lead to increasing demand for fuel wood which is also acting as an important deforestation agent, particularly in dry forest.

d) Expansion for agribusiness

With the addition of cash crops such as oil palm, rubber, fruits and ornamental plants, there is stress to expand the area for agribusiness products which results in deforestation.

e) Development projects and growing need for food

The growing demand for electricity, irrigation, construction, mining, etc. has lead to destruction of forest. Increased population needs more food which has compelled for increasing area under agriculture crops compelling for deforestation.

f) Raw materials for industrial use

Forest provides raw material for industry and it has exerted tremendous pressure on forest. Increasing demand for plywood for backing has exerted pressure on cutting of other species such as fir to be used as backing material for apple in J&K and tea in northeast states.

Major effects of deforestation

Deforestation adversely and directly affects and damages the environment and living beings .Major causes of deforestation are

- Soil erosion and loss of soil fertility
- Decrease of rain fall due to affect of hydrological cycle

Expansion of deserts

- Climate change and depletion of water table
- Loss of biodiversity ,flora and fauna
- Environmental changes and disturbance in forest ecosystems

*** Case studies**

1. Jhum cultivation

Jhum Agriculture or shifting agriculture has destroyed large number of hectare of forest tracts in North-Eastern states and Orissa. Jhum agriculture is subsidence agriculture in which tract of forest land is cleared by cutting trees and it is used for cultivation. After few years, when productivity of the land decreases, cultivators abandon the land and clear next tract. As a result of this practise, combined with increasing population there is rapid deforestation as more and more cultivators clear forest to cultivate land. Also, with increase in population there is cultivators are forced to return to previous tracts of land in relatively shorter durations, not allowing the land to regain its productivity.

2. Chipko movement

The Chipko movement or Chipko Andolan is a social-ecological movement that practised the Gandhian methods of satyagraha and non-violent resistance, through the act of hugging trees to protect them from being felled. The modern Chipko movement started in the early 1970s in the Garhwal Himalayas of Uttarakhand,with growing awareness towards rapid deforestation. The landmark event in this struggle took place on March 26, 1974, when a group of peasant women in Reni village, Hemwalghati, in Chamoli district, Uttarakhand, India, acted to prevent the cutting of trees and reclaim their traditional forest rights that were threatened by the contractor system of the state Forest Department. Their actions inspired hundreds of such actions at the grassroots level throughout the region. By the 1980s the movement had spread throughout India and led to formulation of people-sensitive forest policies, which put a stop to the open felling of trees in regions as far reaching as Vindhyas and the Western Ghats.

3. Western himalayan region.

Over the last decade, there has been widespread destruction and degradation of forest resources in Himalayas, especially western Himalayas. This has resulted in various problems such as erosion of top soil, irregular rainfall, changing weather patterns and floods. Construction of roads on hilly slopes, have not only undermined their stability, but also damaged protective vegetation and forest cover. Tribes in these areas are increasingly facing shortage of firewood and timber, due large scale tree cutting. Increased traffic volumes on these roads leads to increased pollution in the area.

*** Timber extraction**

There has been unlimited exploitation of timber for commercial use. Due to increased industrial demand; timber extraction has significant effect on forest and tribal people.

**** Logging***

- Poor logging results in degraded forest and may lead to soil erosion especially on slopes.
- New logging roads permit shifting cultivators and fuel wood gatherers to gain access to the logging area.
- Loss of long term forest productivity
- Species of plants and animals may be eliminated
- Exploitation of tribal people by contractor.

*** Mining**

Major effects of mining operations on forest and tribal people are:

- Mining from shallow deposits is done by surface mining while that from deep deposits is done by sub-surface mining. It leads to degradation of lands and loss of top soil. It is estimated that about eighty thousands hectare land is under stress of mining activities in India
- Mining leads to drying up perennial sources of water sources like spring and streams in mountainous area.
- Mining and other associated activities remove vegetation along with underlying soil mantle, which results in destruction of topography and landscape in the area. Large scale deforestation has been reported in Mussorie and Dehradun valley due to indiscriminating mining.
- The forested area has declined at an average rate of 33% and the increase in non-forest area due to mining activities has resulted in relatively unstable zones leading to landslides.
- Indiscriminate mining in forests of Goa since 1961 has destroyed more than 50000 ha of forest land. Coal mining in Jharia, Raniganj and Singrauli areas has caused extensive deforestation in Jharkhand.

- Mining of magnetite and soapstone have destroyed 14 ha of forest in hilly slopes of Khirakot, Kosi valley and Almora.
- Mining of radioactive minerals in Kerala, Tamilnadu and Karnataka are posing similar threats of deforestation.
- The rich forests of Western Ghats are also facing the same threat due to mining projects for excavation of copper, chromites, bauxite and magnetite.

*** Effects of dams on forests and tribal people**

Pandit Jawaharlal Nehru referred dam and valley projects as "Temples of modern India". These big dams and rivers valley projects have multi-purpose uses. However, these dams are also responsible for the destruction of forests. They are responsible for degradation of catchment areas, loss of flora and fauna, increase of water borne diseases, disturbance in forest ecosystems, rehabilitation and resettlement of tribal peoples.

- India has more than 1550 large dams, the maximum being in the state of Maharashtra (more than 600), followed by Gujarat (more than 250) and Madhya Pradesh (130).
- The highest one is Tehri dam, on river Bhagirathi in Uttaranchal and the largest in terms of capacity is Bhakra dam on river Satluj in Himachal Pradesh. Big dams have been in sharp focus of various environmental groups all over the world, which is mainly because of several ecological problems including deforestation and socio-economic problems related to tribal or native people associated with them.
- The Silent valley hydroelectric project was one of the first such projects situated in the tropical rain forest area of Western Ghats which attracted much concern of the people.
- The crusade against the ecological damage and deforestation caused due to Tehri dam was led by Shri. Sunder Lal Bahaguna, the leader of Chipko Movement.
- The cause of Sardar Sarovar Dam related issues have been taken up by the environmental activitist Medha Patkar, joined by Arundhati Ray and Baba Amte. For building big dams, large scale devastation of forests takes place which breaks the natural ecological balance of the region.
- Floods, droughts and landslides become more prevalent in such areas. Forests are the repositories of invaluable gifts of nature in the form of biodiversity and by destroying them (particularly, the tropical rain forests), we are going to lose these species even before knowing them. These species could be having marvellous economic or medicinal value and deforestation results in loss of this storehouse of species which have evolved over millions of years in a single stroke.

*** Forest conservation and management**

Forest is one of the most valuable resources and thus needs to be conserved. To conserve forest, following steps should be taken.

1. Conservation of forest is a national problem, thus it should be tackled with perfect coordination between concerned government departments.
2. People should be made aware of importance of forest and involved in forest conservation activities.
3. The cutting of trees in the forests for timber should be stopped.
4. A forestation programmes should be launched
5. Grasslands should be regenerated.
6. Forest conservation Act should be strictly implemented to check deforestation.
7. Awards should be instituted for the deserving.

2.1.2 WATER RESOURCES

'Water is the driver of Nature' - **Leonardo daVinci**

*** Introduction**

Water is an indispensable resource for life on earth. Approximately 70.8 % surface of earth is covered with water in the form of oceans. Out of this, about 97% is not fit for human consumption, about 2% is locked as a glacier and only less than 1% available as fresh water that can be used for human consumption and other uses.

Water is a very important source and essential for life because it has very unique characteristic such as

1. Water exists as liquid over a wide range of temperature 0-100^{0}C with highest specific heat and latent heat of vaporization.

2. Water is excellent solvent and act as carrier of nutrient and helps to distribute them to the cells in the body, regulates the body temperature and support structure and can dissolve various pollutant and can act as carrier of large number of microorganisms

3. It is responsible for hydrological cycle which acts as resource of water to the earth. It is estimated that about 1.4 inch thick layer of water evaporates and majority of water returns to earth through hydrological cycle.

*** Water Use**

More than 99% of earth water is unavailable for use; only 1% water is available for people, animal, plants and earth. There is an uneven distribution of water resources, tropical rain forest are receiving maximum rainfall where as desert receive only little rainfall.

Due to its unique properties water is of multiple uses for all living organisms. Water is absolutely essential for all the living organisms. One can survive for weeks without food but cannot survive more than a few days without water. Since the earliest days of mankind water availability was the major factor to decide the place of human settlements. Water dissolves nutrients and distributes them in different parts of plants and regulates the temperature and removes the waste.

*** Fresh water crisis**

On global scale water availability is not a problem itself, but it's availability in right form, right time and right place is a problem. Irregularities in duration and intensity of rainfall cause floods and droughts. Out of the total water reserves of the world, about 97% is salty water (marine) and only 3% is fresh water.

Due to increased demands overuse of groundwater for drinking, irrigation and domestic purposes has lead to rapid depletion of groundwater in various regions leading to lowering of water table.

Pollution of many of the groundwater aquifers has made them unfit for consumption. Rivers and streams have long been used for discharging the wastes. due to industrialization river water are being polluted because industrial residues are pushed into the river .Civilizations have grown and flourished on the banks of rivers, but being over populated due to fast growth are polluting the natural resources of water.

*** Problems associated with water resources**

These are some problems associated with use of water

- **Water Scarcity** (precipitation/evapotranspiration balance, temporal availability, per capita availability)
- **Floods and droughts** (spatio-temporal distribution; regular floods related to heavy winter or spring rains, increasing damage level due to shifting land use (settlements in flood zones) recurrent summer droughts coinciding with peak demand periods for agriculture and tourism)
- **Groundwater availability and quality** (aquifer size and access, yield, saltwater intrusion, pollution of shallow aquifers)
- **Watershed degradation** (deforestation, land use, increasing impervious (sealed) areas due to urbanization the main concern here is land use change (primarily deforestation and urbanization) and its effects on runoff patterns (flooding) and water quality including erosion/sediments with subsequent problems such as reservoir siltation/capacity loss)
- **Coastal interaction** (salinity intrusion in groundwater and estuaries, coastal pollution due to pollution runoff)

*** Over-Exploitation of Water**

1. Groundwater

About 9.86% of the total fresh water resources are in the form of groundwater and it is about 35-50 times that of surface water supplies.

Effects of extensive and reckless groundwater usage:

1. Subsidence
2. Lowering of water table
3. Water logging

2. Surface water

Surface water mainly comes directly from rain or snow covers. The various surface sources are natural lakes and ponds, rivers and streams, artificial reservoirs. Availability of surface water decides the economy of the country. On one side surface water availability affects the productivity, but on the other side water sources may cause floods and drought. Due to unequal distribution, water may lead to national (interstate) or international disputes. Sharing of surface water due to these disputes is affecting productivity of different agro eco-zone and creating problems for government.

Recently many water conflicts at national and international levels relating to sharing of surface water are catching the headlines of newspaper.

*** Major Water Conflicts**

Some of the major water conflicts that have become thorn in relations between states and countries are

1. Water conflict in the middle east

Countries involved are Sudan, Egypt and Turkey. It also affects countries which are water starved viz. Saudi Arabia, Kuwait, Syria, Israel and Jordan.

2. The Indus water treaty

This Indus water treaty dispute between India and Pakistan is lingering since long.

3. The Cauvery water dispute

It involves two major states of India viz. Tamilnadu and Karnataka.

4. The Satluj-Yamuna link canal dispute

The dispute is between two Northern states viz. Punjab and Haryana and UP, Rajasthan as well as Delhi has also interest in it .

In traditional water management, innovative arrangements ensure equitable distribution of water, which are democratically implemented. These disputes can be solved amicably through 'Gram Panchayats", if transparency is maintained. But disputes between countries or states sometimes attain war like situation and are difficult to solve.

*** Dams - Benefits and Problems**

Water is a precious resource and its scarcity is increasing at global level. There is a pressure to utilise surface water resources efficiently for different purposes. According to World Commission on Dam Report -2001 there are 45000 large dams spread over 140 countries

- **Major benefits of dams**

The major benefits of dams are

1. Hydroelectricity generation
2. Year round water supply to ensure higher productivity
3. Equal water distribution by transferring water from area of excess to area of deficit
4. Helps flood control and protects soil
5. Assure irrigation during dry periods
6. River valley projects provide inland water navigation ,employment opportunities and can be used to develop fish hatcheries and nurseries

7. River valley projects have tremendous potential for economic upliftment and will help to raise the standard of living and can help to improve the quality of life

- **Disadvantages/problems**

Although dams have proved very useful over the centuries but recent past big dams has created lot of human as well as environmental issues

1. Submergence of large areas may lead to loss of fertile soil and displacement of tribal people
2. Salt left behind due to evaporation increase the salinity of river water and makes it unusable when reaches down stream
3. Siltation and sedimentation of reservoirs not only makes dams use less but also is responsible for loss of valuable nutrients
4. Loss of non-forest land leads to loss of flora and fauna
5. Changes in fisheries and the spawning grounds
6. Stagnation and water logging near reservoir leads to breeding of vectors and spread of vector-borne diseases
7. Growth of aquatic weeds may lead to microclimatic changes.

2.1.3 Mineral Resources:

A mineral is a naturally occurring substance of definite chemical composition and identifiable physical properties. An ore is a mineral or combination of minerals from which a useful substance, such as a metal, can be extracted and used to manufacture various useful goods. Minerals are formed over a period of millions of years in the earth's crust. These are nonrenewable resources important for modern civilization. The minerals of India are unevenly distributed and are localized in few areas. More than 90% of our mineral wealth is concentrated in Chotta Nagpur Plateau region. Minerals are obtained from the earth through the process of mining. Mining operations progress through four stage.

*** Process of mining**

Mining operations progress through four stages:

Prospecting: Searching for minerals

Exploration: assessing the size, shape, location, and economic value of the deposit.

Development: the work of preparing access to the deposit so that the minerals can be extracted from it.

Exploitation: Extracting the minerals from the mines.

*** Uses of minerals**

1. Iron, aluminum, zinc, manganese and copper are important raw materials for industrial use.
2. Important non-metallic resources include coal, salt, clay, cement and silica.
3. Stone used for building material, such as granite, marble, limestone, constitute another category of minerals.
4. Minerals with special properties such as diamonds, emeralds and rubies are used for aesthetic and ornamental purpose.
5. Minerals in the form of oil, gas, coal were formed when ancient plants and animals were converted into underground fossil fuels.

*** Exploitation of Mineral Resources**

Exploitation of mineral refers to the use of mineral resources for economic growth. Exploitation of mineral resources at a mindless speed to meet the growing needs of modern civilization has resulted in many environmental problems.

Although, the exploitation of minerals began at a slow pace during the industrial revolution in Western countries, during the 20th century, the exploitation of some minerals, especially the fossil fuels increased exponentially to meet the growing energy need. Today, about 80% of the world's energy consumption is sustained by the extraction of fossil fuels, which consists of oil, coal, and gas.

*** Consequences of Exploitation of Mineral Resources.**

Excessive exploitation of mineral resources has led to the following severe problems.

- Deforestation and desertification
- Extinction of species
- Rapid depletion of high grade minerals
- Forced migration
- Wastage of upper soil layer and vegetation
- Soil erosion and oil depletion
- Ozone depletion
- Greenhouse gas increase
- Environmental pollution
- Natural hazards, etc.

*** Environmental <u>effects</u>**

- The mining, processing, and use of resources require enormous amounts of energy and often cause land disturbance.
- Mineral industry is a major contributor to air and water

  <u>pollution</u> and to emissions of greenhouse gases.

- The grade of an ore – its percentage of metal content – has
  an impact on metal mining; it takes more money, energy and water to exploit lower grade ores.

- Exploring the minerals involve geophysical surveys, drilling and trenching lead to camp garbage, road erosion, habitat disruption, and noise pollution.

- Mining and milling operations lead to wildlife and fisheries habitat loss, changes in local water balance, sedimentation,
  and heavy metal leaching from acid mine drainage.

- Smelting and refining activities lead to sulphur dioxide emissions contribute to acid rain.

- Even mine closure activities would be causing revegetation failure, wind borne dust, seepage of toxic solutions into ground and surface water contamination from acid mine drainage.

- Roads and unlimited access to mines have a negative impact on wilderness areas in 4 ways:
  a. Habitat fragmentations as roads disrupt movement and migratory routes.
  b. Collisions between vehicles and wildlife occur. Roads allow uncontrolled hunting and increased wildlife mortality
  c. Degradation and sedimentation of streams and river beds.
  d. Pollutants in pristine areas.

Minerals are non-renewable resources. Minerals are obtained from the earth through the process of mining. Minerals are much localized in their occurrence. No country within its own boundaries has adequate production and reserves of all the minerals needed for its industrial development. India is largely self-sufficient in coal, bauxite, iron and manganese ore. The mining, processing, and use of resources require enormous amounts of energy and cause serious environmental effects like land disturbance, air and water pollution, habitat fragmentation, increased wildlife mortality and stream sedimentation.

2.1.4 FOOD RESOURCES

'A house is not a home unless it contains food and fire for the mind as well as the body'--

Benjamin Franklin

*** Introduction**

Food is essential for growth and development of living organisms. These essential materials are called nutrients and these nutrients are available from variety of animals and plants. There are thousands of edible plants and animals over the world, out of which only about three dozen types constitute major food of humans.

- **Food sources**

The majority of people obtain food from cultivated plants and domesticated animals. Although some food is obtained from oceans and fresh waters, but the great majority of food for human population is obtained from traditional land-based agriculture of crops and livestock.

- **Food crops**

It is estimated that out of about 2,50,000 species of plants, only about 3,000 have been tried as agricultural crops. Under different agro-climatic condition, 300 are grown for food and only 100 are used on a large scale.

Some species of crops provide food, whereas others provide commercial products like oils, fibres, etc. Raw crops are sometimes converted into valuable edible products by using different techniques for value addition .At global level, only 20 species of crops are used for food. These, in approximate order of importance are wheat, rice, corn, potatoes; barley, sweet potatoes, cassavas, soybeans, oats, sorghum, millet, sugarcane, sugar beets, rye, peanuts, field beans, chick-peas, pigeon- peas, bananas and coconuts. Many of them are used directly, whereas other can be used by changing them by using different techniques for enhancing calorific value.

- **Livestock**

Domesticated animals are an important food source. The major domesticated animals used as food source by human beings are 'ruminants' (e.g. cattle, sheep, goats, camel, reindeer, llama, etc.).

Ruminants convert indigestible woody tissue of plants (cellulose) which are earth's most abundant organic compound into digestible food products for human consumption. Milk, which is provided by milking animals, is considered to be the complete food. Other domestic animals like sheep, goat, poultry and ducker can be used as meat.

- **Aquaculture**

Fish and seafood contributes 17 million metric tonnes of high quality protein to provide balance diet to the world. Presently aquaculture provides only small amounts for world food but its significance is increasing day by day.

*** World Food Problems**

As per estimates of Food and Agriculture Organization (FAO), about 840 million people remain chronically hungry and out of this 800 million are living in the developing world. In last decade, it is decreasing at the rate of 2.5 million per year, but at the same time world's population is

increasing. Target of cutting half the number of world's chronically hungry and undernourished people by 2015 will difficult to meet, if the present trend continues. Due to inadequate purchasing power to buy food, it is difficult to fulfil minimum calorific requirement of human body per day. Large number of people are in India are poor which can be attribute to equitable distribution of income. Food insufficiency can be divided into two categories into under-nourishment and malnourishment. Both of these insufficiencies are global problems.

- **Under-nourishment**

The FAO estimates that the average minimum daily caloric intake over the whole world is about 2,500 calories per day. People who receive less than 90% of their minimum dietary intake on a long-term basis are considered undernourished. Those who receive less than 80% of their minimum daily caloric intake requirements are considered 'seriously' undernourished. Children in this category are likely to suffer from stunted growth, mental retardation, and other social and developmental disorders. Therefore, Under-nourishment means lack of sufficient calories in available food, resulting in little or no ability to move or work.

- **Malnourishment**

Person may have excess food but still diet suffers from due to nutritional imbalance or inability to absorb or may have problem to utilize essential nutrients. If we compare diet of the developed countries with developing countries people in developed countries have processed food which may be deficient in fibre, vitamins and other components where as in the diet of developing countries, may be lack of specific nutrients because they consume less meat ,fruits and vegetables due to poor purchasing power .

Malnourishment can be defined as lack of specific components of food such as proteins, vitamins, or essential chemical elements.

The major problems of malnutrition are:

- **Marasmus**: a progressive emaciation caused by lack of protein and calories.
- **Kwashiarkor**: a lack of sufficient protein in the diet which leads to a failure of neural development and therefore learning disabilities.
- **Anemia:** it is caused by lack of iron in the diet or due to an inability to absorb iron from food.
- **Pellagra**: it occurs due to the deficiency of tryptophan and lysine, vitamins in the diet.

Every year, food problem kill as many people as were killed by the atomic bomb dropped on Hiroshima during World War II. This shows that there is drastic need to increase food production, equitably distribute it and also to control population growth. Although India is the third largest producer of staple crops, it is estimated that about 300 million Indians are still undernourished. India has only half as much land as USA, but it has nearly three times population to feed. Our food problems are directly related to population.

- **Balanced diet**

Supply of adequate amount of different nutrient can help to improve malnutrition and its ill effects. Cereals like wheat and rice can supply only carbohydrate which are rich in energy supply, are only fraction of nutrition requirement. Cereal diet has to be supplemented with other food that can supply fat, protein and minor quantity of minerals and vitamins. Balanced diet will help to improve growth and health.

*** Changes Caused by Agriculture and Overgrazing**

From centuries, agriculture is providing inputs to large number of industries involved in production, processing and distribution of food. Accordingly, agriculture has significant effect on environment. The effects of agriculture on environment can be classified as local, regional, and global level. The agriculture also makes impact on the usage of land generally as follows:

1. Deforestation
2. Soil Erosion
3. Depletion of nutrients
4. Impact related to high yielding varieties (HYV)
5. Fertilizers related problems include micronutrient imbalance, nitrite pollution and eutrophication.
6. Pesticide related problems include creating resistance in pests and producing new pests, death of non-target organisms, biological magnification.
7. Some other problems include water logging, salinity problems and such others.

The carrying capacity of land for cattle depends upon micro climate and soil fertility. If carrying capacity is exceeded than land is overgrazed. Because of overgrazing the agricultural land gets affected as follows,

- Reduction in growth and diversity of plant species
- Reduce plant cover leads to increased soil erosion
- Cattle trampling leads to land degradation

*** Effects of Modern Agriculture**

For sustainable production modern techniques are used to enhance productivity of different cropping systems under different agro-eco-zones. Adoption of modern agricultural practises has both positive and negative effects on environment. Effects of modern agriculture are briefly discussed under different heads as under:

- **Soil erosion**

Raindrops bombarding bare soil result in the oldest and still most serious problem of agriculture. The long history of soil erosion and its impact on civilization is one of devastation. Eroded fields record our failure as land stewards.

- **Irrigation**

Adequate rainfall is never guaranteed for the dry land farmer in arid and semiarid regions, and thus irrigation is essential for reliable production. Irrigation ensures sufficient water when needed and also allows farmers to expand their acreage of suitable cropland. In fact, we rely heavily on crops from irrigated lands, with fully one-third of the world's harvest coming from that 17% of cropland that is under irrigation. Unfortunately, current irrigation practices severely damage the cropland and the aquatic systems from which the water is withdrawn.

- **Agriculture and the loss of genetic diversity**

As modern agriculture converts an ever-increasing portion of the earth's land surface to monoculture, the genetic and ecological diversity of the planet erodes. Both the conversion of diverse natural ecosystems to new agricultural lands and the narrowing of the genetic diversity of crops contribute to this erosion.

*** Fertilizer-pesticide problems**

For photosynthesis apart from water, sunshine and CO_2, plants need micro and macro nutrients for growth. These nutrients are supplied in the shape of fertilizers. There is lot of potential to increase food productivity by increasing fertilizer use. On one hand application of artificial chemical fertilizers increases the productivity at faster rate as compare to organic fertilizers, on the other hand application of fertilizers can be a serious problem of pollution and can create number of problems. Excessive level of nitrates in ground water has created problems in developed countries. These are:

a. Accumulated phosphorous as a consequence of use of phosphoric fertilizer are posing serious threat as residues in domestic water supply and for ecology of river and other water bodies. Increased level of phosphates in different water results in eutropication.

b. Effect of chemical fertilizer is long term, therefore leads to net loss of soil organic matter.

To control insects, pests, diseases and weeds which are responsible for reduction in productivity different chemicals are used as insecticides, pesticides and herbicides. Successful control of insects, pests and weeds increases productivity and reduces losses and provide security for harvest and storage. Applications of these synthetic chemicals have great economic values and at the same time cause number of serious problems such as:

a. Affects human health which includes acute poisoning and illness caused by higher doses and accidental exposes

b. As long term effect, cause cancer, birth defects, Parkinson's disease and other regenerative diseases.

c. Long term application of pesticides can affect soil fertility.

d. Danger of killing beneficial predators.

e. Pesticides resistance and pest resurgence

*** Water Logging**

High water table or surface flooding can cause water logging problems .Water logging may lead to poor crop productivity due to anaerobic condition created in the soil. In India, deltas of Ganga, Andaman and Nicobar Islands and some areas of Kerala are prone to frequent water logging.

*** Salinity**

Due to adoption of intensive agriculture practices and increased concentration of soluble salts leads to salinity. Due to poor drainage, dissolved salts accumulate on soil surface and affects soil fertility. Excess concentration of these salts may form a crust on the surface which may injurious to the plants. The water absorption process is affected and uptake of nutrient is disturbed. According to an estimate, in India, 7 million hectare of land is saline and area is showing in increasing trends due to adoption of intensive agriculture practises**.**

*** Case Studies**

1. A study on birth defects in water birds, in Kesterson wildlife refuge in California, indicated that these defects where due to high concentration of selenium.
2. Recent reports from cotton growing belt of Punjab which covers Abohar, Fazalka and part of Bathinda indicates that over use of pesticides for control of insect pest in cotton to enhance productivity has not only affected soil health, but also caused cancer in human being.
3. Diclofenac is the drug for veterinary use to treat the livestocks which have strong residual nature, which leads to high persistence throughout the foodchain .Due to biomagnification it becomes more dangerous to the vultures as they are consumers of diclofenac treated cattle. Diclofenac is responsible for bringing three South Asian species of *Gyps* vultures to the brink of extinction. It has been banned in India since 2006.

2.1.5 Energy Resources:

Energy is the capacity to do work and is required for life processes. An energy resource is something that can produce heat, power life, move objects, or produce electricity.
Matter that stores energy is called a fuel.

*** Growing energy demands**

- Modern agriculture uses chemical fertilizers, which require large amounts of energy during their manufacture
- Various gadgets in household sector require to use both renewable and non-renewable

energy.

- Industry uses energy to manufacturing processes.

- Energy demanding roads and railway lines are built to transport products from place to place and to reach raw materials in mines and forests.

- Almost 2 billion people will require electrical energy and those who have access will continue to increase their individual requirements.
- Between 1900-2000 world energy consumption has increased by a factor of 14 times while the population has increased only by 3 times.

- Fossil fuels (eg: coal, oil and gas) were used in 19th and 20th century. Today's energy options include fossil fuels, nuclear energy, solar energy and renewable fuels.
- India's oil demand has raised more than twice domestic output.

*** Classification of Energy**

Energy resources can be described as renewable and non renewable. Renewable energy sources include

- Wind power
- Wave power
- Ocean Thermal Exchange Capacity (OTEC) - based on temperature differences in ocean layers.
- Solar Power
- Hydro power
- Fuel cells
- Bio- fuels- also known as biomass fuels-such as alcohol form, sugar, methane from organic waste or charcoal from trees and biodiesel.

The key characteristics of renewable energies is that the energy sources are continually available, still some cases such as with hydro power and biomass, continuing availability requires good management – for example tree planting or river management. Other renewable like solar and wind power are available for the foreseeable future without any human intervention.

Non- renewable types of energy include all the fossil fuels – coal, oil, gas and their derivatives such as petrol and diesel. The non- renewable are finite in supply because their rate of formation is so low that they are, in reality, finite sources.

*** Non-renewable energy sources**

These resources exist on earth in fairly fixed amounts and have the potential of being used faster than they are replaced by nature. These consist of mineral based hydro carbon fuels – coal, oil and natural gas – were formed after the plant life is fossilized. When they are burnt, produce waste products like carbon dioxide, oxides of sulphur, nitrogen etc. cause air pollution. They cause respiratory tract problems in number of people, and affected historic monuments like Tajmahal, killed many forests and lakes due to acid rain. These are also causing global warming, a raise in global temperature, increased drought in some areas, floods in other regions, melting of ice caps, a rise in sea levels and sub merging coastal belts all over the world.

Oil powered vehicles emit carbon dioxide, sulphur dioxide, carbon monoxide, nitrous oxide and particulate matter that are a major cause of air pollution, especially in cities with heavy traffic density. During gulf war, fires wasted 5 million barrels of oil and produced over a million tons of airborne pollutants including sulphur dioxide.

Natural resources such as coal, petroleum, oil and natural gas take millions of years to form naturally and cannot be replaced as fast as they are being consumed. Eventually natural resources will become too costly to harvest and humanity will need to find other sources of energy. At present, the main energy sources used by humans are non-renewable as they are cheap to produce.
Some natural resources, called renewable resources, are replaced by natural processes given a reasonable amount of time. Soil, water, forests, plants, and animals are all renewable resources as long as they are properly conserved. Solar, wind, wave, and geothermal energies are based on renewable resources. Renewable resources such as the movement of water (hydropower, including tidal power; ocean surface waves used for wave power), wind (used for wind power), geothermal heat (used for geothermal power); and radiant energy (used for solar power) are practically infinite and cannot be depleted, unlike their non-renewable counterparts, which are likely to run out if not used wisely. Still, these technologies are not fully utilized.

*** Renewable energy resources**

The majority of renewable energy technologies are powered by the sun. The Earth-Atmosphere system is in equilibrium such that heat radiation into space is equal to incoming solar radiation, the resulting level of energy within the Earth-Atmosphere system can roughly be described as the Earth's "climate." The hydrosphere (water) absorbs a major fraction of the incoming radiation. Most radiation is absorbed at low latitudes around the equator, but this energy is dissipated around the globe in the form of winds and ocean currents. Wave motion may play a role in the process of transferring mechanical energy between the atmosphere and the ocean through wind stress. Solar energy is also responsible for the distribution of precipitation which is tapped by hydroelectric projects, and for the growth of plants used to create biofuels.

Renewable energy is derived from natural processes that are replenished constantly. In its various forms, it derives directly from the sun, or from heat generated deep within the earth. Included in the definition is electricity and heat generated from solar, wind, ocean, hydropower, biomass, geothermal resources, and biofuels and hydrogen derived from renewable resources. Each of these sources has unique characteristics which influence how and where they are used.
These resources can be replenished through relatively rapid natural cycles and have the potential to last indefinitely. These include

- SUN – SOLAR ENERGY
- WIND – WIND ENERGY
- WATER – HYDEL ENERGY
- HOT DRY ROCKS, MAGMA, HOT WATER SPRINGS, NATURAL GEYSERS – GEOTHERMAL ENERGY
- WAVES/ TIDAL WAVES – OCEAN/ TIDAL ENERGY

*** Alternative energy sources:**

Alternative Energy refers to energy sources other than fossil fuels. This includes all renewable sources and nuclear.

- **Solar energy**

Sun provides a continuous supply of energy i.e. 600 times more than the amount of energy produced/day by all other energy sources combined. Solar energy is utilized in three ways.

1. Passive heating system: Sun’s energy is converted directly into heat for use at the site where it is collected. E.g.: solar cookers

2. Active heating system: Sun’s energy is converted into heat, but heat must be transferred from the collection area to the place of use. E.g.: solar water heaters and lanterns.

3. Sun’s energy can be used to generate electricity, which may be used to operate solar batteries. E.g.: Photovoltaic cells

Solar photovoltaic cells can be used for a number of applications such as: Domestic lighting, street lighting, water pumping, railway signal lighting, desalination of salty water, village electrification, powering of remote telecommunication repeater stations.
In this context, "solar energy" refers to energy that is collected from sunlight. Solar energy can be applied in many ways, including to:

- Generate electricity using photovoltaic solar cells.
- Generate electricity using concentrated solar power.
- Generate electricity by heating trapped air which rotates turbines in a Solar updraft tower.
- Generate hydrogen using photo-electro-chemical cells.
- Heat and cool air through use of solar chimneys.
- Heat buildings, directly, through passive solar building design.
- Heat foodstuffs, through solar ovens.
- Heat water or air for domestic hot water and space heating needs using solar-thermal panels.
- Solar air conditioning

- **Wind Energy**

Kinetic energy i.e. movement of atmospheric air is converted into more useful form of power by wind energy systems. Wind energy was used for sailing, irrigation and grinding grain for the past 100s of years. Wind mills are used for water pumping and electricity generation. Wind turbines transform the energy in the wind to mechanical power and to electric power. Wind turbines used in clusters called wind farms.

A wind farm, when installed on agricultural land, has one of the lowest environmental impacts of all energy sources:

- Wind power occupies less land area per kilowatt-hour (kWh) of electricity generated than any other energy conversion system, apart from rooftop solar energy, and is compatible with grazing and crops.
- It generates the energy used in its construction in just 3 months of operation, yet its operational lifetime is 20–25 years.
- Greenhouse gas emissions and air pollution produced by its construction are low and declining. There are no emissions or pollution produced by its operation.
- In substituting for base-load coal power, wind power produces a net decrease in greenhouse gas emissions and air pollution, and a net increase in biodiversity.
- Modern wind turbines are almost silent and rotate so slowly (in terms of revolutions per minute) that they are rarely a hazard to birds.

- **Ocean**

Oceans collect and store huge quantities of solar radiation in the form of heat. Most of the heat is stored on the surface of sea water while the temperature of deep water is very low. Using this temperature difference, heat is converted into electricity.

- **Geothermal energy**

The core of the earth is very hot; as high as 60,000 C, which can be used effectively. In some regions the molten mass from earth’s core breaks through the earth and produces volcanoes. In other regions, the hot material is close enough to the surface to heat underground water and form steam i.e. geysers and hot springs.
Geothermal energy is energy obtained by tapping the heat of the earth itself, both from kilometers deep into the Earth's crust in some places of the globe or from some meters in geothermal heat pump in all the

places of the planet. It is expensive to build a power station but operating costs are low resulting in low energy costs for suitable sites. Ultimately, this energy derives from heat in the Earth's core.

- **Hydel**

The energy in the flowing water can be used to produce electricity. When water flows down a natural gradient turns turbines to generate electricity by constructing dams across rivers. Energy can be extracted from tides by creating a reservoir or basin behind a barrage and then passing tidal waters through turbines in the barrage to generate electricity. The first hydro electric dam was built in late 1800s by Tatas in the Western Ghats of Maharashtra. They use the high rainfall areas in the hills as storage areas

- **Hydrogen energy**

When hydrogen is combusted, it combines with oxygen to form water and release a large amount of energy, which is used in rocket engines.

- **Tidal power**

The gravitational pull of sun and moon, along with the earth's rotation causes tides. The tidal movement of water represents a great deal of energy. As water flows from higher level to a lower one, it can be used to generate electricity. Tidal power is trapped by placing a barrage across an estuary and forcing the tidal flow to pass through turbines. Water power converts the motion of waves into electrical or mechanical energy.
Energy in water (in the form of kinetic energy, temperature differences or salinity gradients) can be harnessed and used. Since water is about 800 times denser than air, even a slow flowing stream of water, or moderate sea swell, can yield considerable amounts of energy.

- **Biomass**

Biomass is organic material which has stored sun light in the form of chemical energy. Eg: wood, wood waste, straw, manure, sugar cane etc. By photosynthesis, solar energy can be converted into biomass which in turn can be stored and used as fuel in various forms. There are three ways to use biomass; a) can be burnt to produce heat and electricity eg: pyrolysis b) changed to a gas like fuel such as methane eg: bio-gasification c) changed to a liquid fuel i.e. bio fuels eg: Hydrogenation

- **Nuclear energy**
  It is the energy trapped inside each atom. It can be used as an important supplementary source to coal and hydel power that was realized nearly 3 decades ago and can generate electricity and has potential applications in industry, medicines, agriculture and research.

Energy is found on our planet in a variety of forms, some of which are immediately useful, while others require a process of transformation. Sun is the primary energy source in our lives. We use energy for household use, agriculture, production of industrial goods and for running transport. There are two types of energy i.e. renewable and non-renewable. Non- renewable energy sources are coal, oil and natural gas. Renewable energy sources are hydropower, solar, wind, biomass, hydro, geothermal and nuclear. We use energy wastefully, and are contributing to the environmental deterioration of our planet.

2.1.6 Land as a resource

Land is a finite natural resource. Land forms like hills, valleys, plains, river basins and wetlands include different resource-generating areas that the people living in them depend on. Soil is an

organized mixture of minerals, organic material, living organisms, air and water. The roots of trees and grasses bind the soil. If forests are depleted, or grasslands overgrazed, the land becomes unproductive and wasteland is formed.

Land is an important resource as it provides essential medium for development of agriculture, vegetation, forestry etc. In India nearly 54 per cent of land is used for agriculture. Man needs land for building homes cultivating food, maintaining pastures for domestic animals, developing industries to provide goods and supporting industries by creating towns and cities.

*** Land degradation**

It can be defined as any change in the land that reduces its condition or quality and hence its productivity or productive potential. It occurs whenever the natural balances in the landscape are changed by human activity, through misuse or overuse. The major land degradation problems are:

- Wind erosion
- Water erosion including mass movement of hill slopes
- Dry land salinity
- Irrigation-induced salinity
- Soil surface scalding
- Water logging
- Soil acidity
- Soil structure decline
- Soil fertility decline or nutrient loss
- Vegetation decline and degradation, such as weed infestation and lack of it
- Tree regeneration
- Loss of flora and fauna and hence of biodiversity

Causes for land degradation

- Deforestation: Forest soils contain much organic matter. When a forest is cleared, the trees are burnt, which leads to an immediate loss in organic matter. Cutting forest for fuel wood is another form of deforestation.

- Over grazing: When insufficient amounts of grass litter are left for the soil, the soil organisms die and the soil loses fertility.

- Agriculture: Over irrigating farmland leads to salinization, as the evaporation of water brings the salts to the surface of the soil on which crops cannot grow. Over irrigation also creates water logging of the top soil, so that crop roots are affected and the crop deteriorates. The use of more and more chemical fertilizers poisons the soil and eventually the land becomes unproductive.

- Industrialization: Industries and mining operations can pollute soils.

*** Landslide**

A landslide (or landslip) is a geological phenomenon which includes a wide range of ground movement, such as rock falls, deep failure of slopes and shallow debris flows, which can occur in offshore, coastal and onshore environments. Although the action of gravity is the primary driving force for a landslide to occur, there are other contributing factors affecting the original slope stability. Typically, pre-conditional factors build up specific sub-surface conditions that make the area/slope prone to failure, whereas the actual landslide often requires a trigger before being released.

Human causes include:

A. Vibrations from machinery or traffic

B. Blasting
C. Earthwork which alters the shape of a slope, or which imposes new loads on an existing slope
D. In shallow soils, the removal of deep-rooted vegetation that binds colluvium to bedrock.
E. Construction, agricultural or forestry activities (logging) which change the amount of water which infiltrates the soil.

*** Soil erosion**

Soils support variety of crops. Misuse of an ecosystem leads to the loss of valuable soil through erosion by water/rainfall and wind. Soil erosion means soil is washed away into streams, transported into rivers and finally lost to the sea. It is more severe in hill slopes as in Himalayas and western ghats called as Ecologically Sensitive Areas (ESAs). Destruction of natural vegetation cover by overfelling and overgrazing is the genesis of soil erosion. Water and wind are the principal causes for the removal of soil from one place to another.

- **Causes for soil erosion**

1. When trees are cut or the soil ploughed, as the plant roots bind the soil, their destruction allows the soil to be readily moved by wind or flowing water.
2. Disturbance of the cycles involving humans and nitrogen. Dependency on fertilizers rich in nitrogen increases the nitrogen content of soil and adjacent water ways. If fertilizers are not used, soil fertility continues to decline.

*** Desertification**

It is the process by which an area becomes even more barren, less capable of retaining vegetation and progresses towards becoming a desert. This is often a cause of long term disasters. Deforestation, overgrazing etc. bring about changes in rainfall, temperature, wind velocity etc. and also lead to soil erosion. Such changes then lead to desertification of the area.

Land is a finite natural resource. Land is an important resource as it provides essential medium for development of agriculture, vegetation, forestry etc. Land degradation occurs whenever the natural balances in the landscape are changed by human activity, through misuse or overuse. Misuse of an ecosystem leads to the loss of valuable soil through erosion by water/rainfall and wind. There are four principle factors leading to soil erosion i.e. climate, soil characteristics, topography and ground cover.

*** Role of Individual in conservation of Natural resources:**

- **Conservation of energy:**
  1. Switch off light, fan and other appliances when not in use.
  2. Use solar heater for cooking.
  3. Dry the cloth in the sun light instead of driers.
  4. Use always pressure cookers
  5. Grow trees near the house to get cool breeze instead of using AC and ai cooler.
  6. Ride bicycle or just walk instead of using scooter for short distance.
- **Conservation of water:**
  1. Use minimum water for all domestic purposes.
  2. check the water leaks in pipes and repair them properly.
  3. Reuse the soapy water, after washing clothes for washing courtyard, carpets etc.
  4. Use drip irrigation.
  5. Rain water harvesting system should be installed in all the houses.
  6. Sewage treatment plant may be installed in all industries and institution.

7. Continuous running of water taps should be avoided.
8. Watering of plants should be done in the evening.

- **Conservation of soil:**
  1. Grow different type plants i.e trees, herbs and shrubs.
  2. In the irrigation process, using strong flow of water should be avoided.
  3. Soil erosion can be prevented by sprinkling irrigation.

- **Conservation of food resources:**
  1.Cook required amount of food.
  2.Don't waste the food, give it to some one before spoiling.
  3.Don't store large amount of food grains and protect them from damaging insects.
- **Conservation of forest:**
  1.Use non timber product.
  2.Plant more trees.

3.Grassing must be controlled
4.Minimise the use of paper and fuel.
5.Avoid the construction of dam, road in the forest areas.

*** Equitable use of resources for sustainable life style:**

*** Sustainable development:**

Development of healthy environment without damaging natural resources.
Unsustainable development;
Degradation of the environment due to over utilisation of natural resources.
Life style in more developed countries:
22% of world population, 88% of it's natural resources and 85% of total global income.
Consumption is more and pollution is more.
Life style in less developed countries:
78% of world population, 12% of it's natural resources and 15% of total global income.
Consumption is less and pollution is less.
Causes of unsustainability:
Main cause – difference between MDCs and LDCs.
Sustainable life style:
MDCs should have to reduce the utilisation of natural resources, that should have to be diverted to LDCs. This will reduce the gap between MDCs and LDCs, leads to sustainable development of the entire world.

MDC – More developed countries

LDC – Less developed countries

CHAPTER - III

INTRODUCTION, STRUCTURE AND FUNCTION OF AN ECOSYSTEM

3.1 Introduction

The term ecosystem is defined as the system resulting from the integration of all the living and non-living factors of the environment. The terms biocoenosis, microcosm, biocoenosis or geobiocoenosis, holocoen, biosystem, bioinert body and ecocosm, respectively are used to express similar ideas. However, the term ecosystem is most preferred, where eco refers the environment, and system implies an interacting and interdependent complex. The organisms of any community besides interacting among themselves always have functional relationship with the environment. This structural and functional system of communities and environment is called ecological system or ecosystem. It is the basic functional unit in ecology, since it includes both biotic and abiotic environment, influencing each other for maintenance of life.

An ecosystem may, in its simplest form, be defined as a self-sustained community of plants and animals existing in its own environment. An ecosystem may be as small as a drop of pond water (microecosystem) or as large as ocean. It can be of temporary nature, e.g., a fresh pool or a field of cultivated crops, or permanent e.g., a forest or an ocean. A balanced aquarium may be thought of as an artificially established self-sustained ecosystem.

*** Characteristics of Ecosystem**

According to Smith (1966), the ecosystem has the following general characteristics:

1. It is a major structural and functional unit of ecology.
2. Its structure is related to its species diversity; the more complex ecosystems have high species diversity and vice versa.
3. Its function is related to energy flow and material cycling through and within the system.
4. The relative amount of energy needed to maintain an ecosystem depends on its structure. The more complex the structure, the lesser the energy it needs to maintain itself.
5. It matures by passing from fewer complexes to more complex states. Early stages of each succession have an excess of potential energy and a relatively high energy flow per unit biomass. Later (mature) stages have less energy accumulation and its flow through more diverse components.
6. Both the environment and the energy fixation in any given ecosystem are limited and cannot be exceeded without causing serious undesirable effects.
7. Alternations in the environment represent selective pressures upon the population to which it must adjust. Organisms which are unable to adjust to the changed environment must necessarily vanish.

3.2.1 Structure of the Ecosystem

All ecosystems, whether terrestrial, fresh water, marine or man-engineered, consist of following major components:

1. Species components

2. Stratification
3. Trophic organisation—relationship of food between various layers
4. Nutrients—required for living organisms

3.2.1.1 Biotic (living) components

This comprises of all the living organisms. On the nourishment (or trophic) standpoint, they may be divided into two categories:

The autotrophs (autotrophic = self nourishing)

These are green plants and certain photosynthetic or chemosynthetic bacteria which can convert the light energy of sun into potential chemical energy in the form of organic compounds needed by plants for their own growth and development. Oxygen is produced as a by-product of photosynthesis, needed by all living organisms for respiration. These green plants are also known as producers because they produce food for all the other organisms.

The heterotrophs (heterotrophic = other nourishing)

They are dependent directly or indirectly upon the autotrophs for their food. The organisms involved are also known as consumers because they consume the materials built up by producers. These may be subdivided into two kinds:

Macroconsumers (or Phagotrophs, Phago = to eat)

These are organisms which ingest food and digest it inside their bodies. They may be herbivores (plant eating), carnivores (= animal eating), or omnivores (= eating all kind of food). The herbivores are primary consumers. For example, insects like grass hopers, chew up stems and leaves, animals like goat, cow, deer and rabbit eat up entire aerial portion of green plants, and man eats up plant products, are all primary consumers. Frog, a carnivore, is a secondary consumer as it eats the herbivores, the snake that eats the frog is a tertiary consumer, there is also a class of top consumers, which are not killed and eaten by any other animals e.g. lion, tiger, leopard, vulture, etc.

Microconsumers (Saprotrophs, sapro = to decompose, or osmotrophs, osmo = to pass through a membrane)
These are the organisms which secrete digestive enzymes to breakdown food into simpler substances and then absorb the digested food. They are mostly parasitic and saprophytic bacteria, actinomycetes and fungi. They are also known as decomposers because of their role in decomposition of dead organic matter. However, the parasites are not decomposers and also some consumers (e.g. insects and such small animals) also which help in decomposition by breaking down the organisms into small bits. Keeping this in view, Wiegert and Owens (1970) suggested the classification of heterotrophs into two categories, biophages (= feeding on living organisms) and saprophages (= feeding on dead organic matter). Decomposers breakdown the complex compounds of dead or living protoplasm, absorb some of the decomposition products and release inorganic nutrients which are cycled back to the soil and the atmosphere from where they are once again made available to the primary producers.

Such a division of organisms based on the type of nutrition gives rise to the trophic structure of the ecosystem and the energy source used which is one kind of producer-consumer arrangement, where each food level is known as trophic level. The amount of living material in different trophic levels or in a component population is known as the standing crop, a term applicable to both, plants as well as animals. The standing crop may be expressed in terms of organism's mass, which can be measured as living weight, dry weight, ash-free dry weight or carbon weight or calories or any other convenient unit suitable for comparative purposes.

In nature simple food chains occur only rarely. There are several food chains linked together, and intersecting each other to form a network known as food web.

3.2.1.2 Abiotic components

Structurally abiotic components include -

1. Climate regime: Precipitation, temperature, light, and other physical factors.
2. Inorganic substances: Elements such as C, N, H, O, P, S, etc., involved in material cycles.
3. Organic Compounds: Carbohydrates, proteins, lipids and humic substances that link the abiotic components with the biotic components (for details see any elementary book on ecology).

The minerals and atmospheric gases keep on cycling. They enter into biotic systems and after the death and decay of organisms return to the soil and atmosphere. This is known as biogeochemical cycle. This circulation of materials involves trapping of the solar energy by the green plants which are ultimately lost by the organisms in several ways. The amount of abiotic materials present in an ecosystem is called standing stage.

3.2.2 Functions

The function of the ecosystem is to allow flow of energy and cycling of materials which ensures stability of the system and continuity of life. These two ecological processes including interaction between the abiotic environment and the communities. For the sake of convenience, the ecosystem dynamics may be analysed in terms of the following: (i) food chains, (ii) food pyramids, (iii) energy flow, (iv) nutrient cycles, (v) development and evolution of ecosystem, and (vi) homeostasis and stability of ecosystem.

3.4 ENERGY FLOW IN THE ECOSYSTEM AND ECOLOGICAL SUCCESSION

3.4.1 Ecosystem Functioning

To understand clearly the nature of the ecosystem, its function must be thoroughly investigated. The function of the ecosystem is to allow flow of energy and cycling of materials which ensures stability of the system and continuity of life. These two ecological processes including interaction between the abiotic environment and the communities may be considered as the ‘heart’ of the ecosystem functioning. For the sake of convenience, the ecosystem dynamics may be analysed in terms of the following: (i) food chains, (ii) food pyramids, (iii) energy flow, (iv) nutrient cycles, (v) development and evolution of ecosystem, and (vi) homeostasis and stability of ecosystem.

3.4.2 Ecological Energetics

In ecological energetics one is mainly interested in the (i) quantity of solar energy reaching an ecosystem, (ii) quantity of energy used by green plants in the process of photosynthesis and (iii) the quantity and path of energy flow from producers to consumers.

In the earth’s atmosphere about 15 X 10^8 calories m^{-2} yr^{-1} of solar energy is received (Phillipson, 1966). About 34% of the solar radiations reaching the earth’s atmosphere is reflected back into space by clouds and the suspended dust particles in the atmosphere; 9% is further held by ozone, water vapour and other atmospheric gases. Remaining 47% reaches the earth’s surface. In fact, only 1 to 5% of the energy reaching the ground is converted by green plants to chemical energy, and 42 to 46% is absorbed as heat by ground, vegetation or water. Water budget showed that 45% of the incoming radiation was dissipated by transpiration of 370 t ha^{-1} of water from the crop. The quantity of solar radiation received at any place not only depends upon the clarity of the atmosphere, but also on the latitude of the area. The equatorial region receives maximum solar radiation followed by other regions of the tropics. The quantity of energy goes on decreasing with increase in latitude both in the northern and southern hemispheres.

3.4.3 Energy flow in the ecosystem

The behaviour of energy in ecosystem can be conveniently termed as energy flow because of unidirectional energy transformations. Total energy flow that constitutes the energy environment has already been dealt in detail, and now we take up the study of that portion of the total energy flow that passes through the biotic components of the ecosystem. Entrance of energy, its retention within the ecosystem and dissipation into space, are governed by two laws of thermodynamics. According to the first law, the law of conservation of energy, in a closed system, no energy comes in or escapes out and

not created or destroyed but may be altered from one form to another. The second law of thermodynamics, the law of entropy, states that there is always a tendency for increase in entropy or degradation from a concentrated (non-random) to a dispersed (random) form leading to dissipation of heat. All the energy entering the earth's surface can be accounted for. Some energy is used in photosynthesis; the rest is used in converting the water into vapours or heating the soil and air. Ultimately the energy reflected back to outer space as heat.

Out of the amount of energy so fixed by green plants, some is released again in respiration. The fixed energy, in the form of food, then passes from plant source through herbivores to carnivores. At each stage of food transfer, potential energy is released, resulting in further loss of a large part of energy. The energy flow, thus follows the second law of thermodynamics.

3.4.3.1 Biogeochemical Cycles

The absorption and utilization of elements by organisms is compensated by their recycling and regeneration back into the environment by the breakdown of these organic compounds again. The more or less cyclic paths of these elements in the biosphere from environment to organisms and into the environment back are called biogeochemical cycles (Bio - living organisms, Geo - rock, soil, air, water).

Many elements enter living organisms in the gaseous state from the atmosphere or as water soluble salts from the soil. As the flux of these elements through an ecosystem gives some measure of its continuity and productivity, the analysis of exchange of various components of the biosphere is essential. Furthermore, society depends upon this life-support system of the earth for sustained and increased production of food, fodder, fibre and fuel.

These biogeochemical cycles may be categorized into three global types:

1. The hydrological cycle, involving the movement of water.
2. The gaseous cycle of carbon, oxygen and nitrogen
3. The sedimentary (non-gaseous) cycle of remaining nutrient elements e.g. phosphorus, calcium and magnesium. Sulphur is to extent intermediate, since H_2S or SO_2, formed under some circumstances, adds a gaseous component to its normally sedimentary cycle. These elements normally do not cycle through the atmosphere in the absence of a gaseous phase. The elements concerned in the sedimentary cycle are earthbound and follow a basic pattern of flow through erosion, sedimentation, mountain building, volcanic activity and biological transport (e.g. through the excreta of marine birds). Sedimentary cycles are much less perfect than gaseous in that some of the element may get stuck in certain phase of the cycle.

3.4.3.2 Hydrologic (Water) cycle

The important cycle among all the materials is that of water. Water is by far the most important substance necessary for life. It is very important ecological factor that determines the structure and function of the ecosystem, and regulates the plant environment to a large extent. The cycling of all other elements is also dependent upon water as it provides the solvent medium for their uptake. It provides H^+ for reduction of CO_2 in photosynthesis. It has moderating effect on the temperature of the surrounding area by virtue of its heat absorbing ability. Protoplasm the very basis of life is made up of 85 to 95% of water. The content varies in different tissues of the organism and in different plants and animals. Human blood is 90% water. Water cycle involves an exchange of water between the earth's surface and the atmosphere via precipitation and evapo-transpiration. Water covers about 75% of the earth's surface, occurring in lakes, rivers, seas, oceans, etc. The ocean occupies 70% of the surface and contains 97% of all the water on earth. Much of the remainder is frozen in the ice caps and glaciers. The water in rivers and lake is comparatively small. Less than 1% is in the form of ice-free fresh waters in rivers, lakes and aquifers. Yet this relatively negligible portion of the planet's water is crucially important to all forms of terrestrial and aquatic life. There is also a large underground supply of water. Soils near the surface also serve as reservoirs for enormous quantities of water.

Every year 4.46 G of water comes in the form of rainfall of which 3.47 G precipitates over the ocean's surface. About 1 G rainfall occurs over land mass of which 0.2 G runs away and 0.6 G evaporates again,

and only a small quantity (0.2 G) is stored as underground water. 0.13 G water moves in the form of water vapour and clouds from ice caps present on South and North poles and on the top of high mountains. Only about 0.004% (~10 G) of the total water is all the time moving in the cycle as much of earth's water is in cold storage. Glaciers and the ice caps cover 11% of the world's land area; permanent frozen ground holds another 10% area in its grip, while 30 to 50% of the land is covered with snow at any given time. Icebergs and pack ice occupy 25% of the ocean area. Therefore of all fresh water is locked up as ice, mostly in Antarctica and Greenland.

3.4.3.3 Carbon cycle

Carbon is present in atmosphere, mainly in the form of carbon dioxide, and thus it cycles in this gaseous phase. Though it is a minor constituent of the atmosphere (0.032% v/v), as compared to oxygen (~21% v/v) and nitrogen (~79% v/v), yet without carbon dioxide no life could exist, for it is vital to the production of carbohydrates through photosynthesis in plants, the basic building blocks for other organic compounds needed in metabolic synthesis and incorporation of the carbon with the protoplasm. Carbon from atmospheric pool moves to green plants (producers), then to animals (consumers), and finally from these to bacteria, fungi and other microorganisms (decomposers) that return it to the atmosphere, through decomposition of dead organic matter. Some of this is also returned to the atmosphere through respiration at various levels in the food chain. It is estimated that half of the carbon fixed is subsequently returned to the soil in the form of decomposing organic matter. The atmospheric pool (711×10^9 tons) is very small as compared to that of carbon in ocean ($39{,}000 \times 10^9$ tons) and in fossil fuels ($12{,}000 \times 10^9$ tons). Before the onset of industrial revolution flows among atmosphere, continents and oceans were balanced, but with industrialization and urban development this equilibrium appears to be disturbed. Fossil fuel burning, forest fire, deforestation and agriculture are some of the important sources of new input. On the contrary, forests are important carbon "sinks" as forest biomass is estimated to contain 1.5 times and forest humus 4 times the amount of carbon in the atmosphere.

There are two main sources of carbon in the abiotic world:

1. The rocks containing carbonates such as lime stone in the earth's crust.
2. The carbon dioxide of the air and that dissolved in water.

In addition, there is present large amounts of carbon in fossil fuel (coal, petroleum, natural gas, etc.) but this is not available to the plants until and unless it is burned to produce carbon dioxide.

Carbon dioxide is released from carbonate rocks by acids resulting from geological action and also by acids formed during fermentation and by bacteria that produce nitric acid and sulphuric acid. An insignificant amount of carbon dioxide is also produced by activity by bacterium Carboxydismonas oligocarbophila which oxidizes carbon monoxide to carbon dioxide. Carbon monoxide (a poisonous gas for aerobic organisms including man) is not of common occurrence in nature but may be produced due to partial combustion of fossil fuel. When carbon dioxide dissolves in water, some of it reacts to form carbonic acid (H_2CO_3) which immediately produces carbonate (CO^{2-}_3) and bicarbonate (HCO^-_3) ions.

The richest source of stored carbon today is in the ocean, and in the form of these ions. The oceans contain about 50 times more carbon dioxide than in the atmosphere. This regulates atmospheric carbon dioxide than in the atmosphere. This regulates atmospheric carbon dioxide content level to 0.03% despite photosynthetic uptake. Thus, there is a continuous exchange of carbon dioxide between the atmosphere and organisms on the one hand and between the atmosphere and sea on the other hand. However, the majority of ocean-dissolved CO_2 (HCO^-_3) is below the thermocline and inaccessible for rapid exchange with the atmosphere. The immediate source of CO_2 for exchange is thus restricted to relatively small quantity of epilimnic CO_2. The sea water being rich in calcium and being alkaline (NaOH) helps in accelerating the process of carbonate decomposition. About 48 ml l^{-1} CO_2 occurs as carbonate in sea water. Such deposits in the form of coral reefs and calcium carbonate rocks are common in the tropical regions of the oceans. In warm climates, high temperatures and greater salinity and alkalinity favour the process of carbonate decomposition, and it is also reflected in thicker, shells of moluscs.

The carbon dioxide has the unique property of absorbing infra-red radiations. While the small quantities of carbon dioxide are helpful in keeping the earth warm, the enhanced atmospheric carbon dioxide results in rise in the temperature of the atmosphere much in the same way as glass houses do (i.e. they permit the radiations to pass through and strike the earth, but once converted into heat and reflected upwards, the heat waves are absorbed by carbon dioxide rich atmosphere and cause rise in temperature) and in turn, causes rise in ocean level.

3.4.3.4 Oxygen cycle

Oxygen which is in abundance (20.9476% v/v) in the atmosphere is another indispensable material for life. According to Broecker (1970), each square metre of the earth's surface is covered by 60,000 moles (about a ton) of oxygen gas. Terrestrial, aquatic and marine plants, during photosynthesis release about 8 moles of oxygen annually for each square metre of the earth's surface. Nearly all of this gaseous oxygen is utilized in the process of respiration by plants, animals and bacteria with the result that the amount of oxygen consumed is almost equal to that of released in the atmosphere. However, there is a small net addition of oxygen to the atmosphere (about 1 part in 15 million parts of the oxygen present), which probably does not bring about any change in the oxygen content, as much of this is utilized in the oxidation of carbon, iron, sulphur and other minerals during the normal process of weathering.

Oxygen in bound state, occurs as oxides of carbonates in rocks, and in water. Oxygen dissolved in water is the main source of oxygen for aquatic plants, which may act as one of the limiting factors in their growth and development. Another important phase of oxygen is the ozone layer (oxygen acted on by short-wave radiation to produce ozone), of the outer atmosphere, which by shielding out the deadly ionizing short-wave ultraviolet radiations, protects the life. Oxygen is thus present in atmosphere in sufficiently large quantities and there is no possibility of oxygen deficiency on global scale even if all the earth's organic matter including the fossil fuel is burnt.

3.4.3.5 Nitrogen cycle

Gaseous nitrogen is the most abundant element of the atmosphere (78.084% v/v), and seems to have a highly complex nutrient cycle in the terrestrial and aquatic ecosystems. This substance is very important for plants and animals as an essential, constituent component of chlorophyll and proteins. Despite its immense value and indispensable nature it is never taken directly from the atmosphere by animals or higher plants. Atmospheric nitrogen is rather inert and does not readily participate in any reaction. A generalized nitrogen cycle is shown in .

The chief sources of nitrogen for plants are nitrates in the soil. The atmospheric nitrogen is fixed symbiotically as well as asymbiotically by a variety of microorganisms. The chief nitrogen fixers are bacteria belonging to the genus Rhizobium found in root nodules of legumes. Asymbiotic nitrogen fixers are some blue green algae, like Anabaena and Nostoc, aerobic bacteria like Azotobacter, and anaerobic bacteria like Clostridium. Certain photosynthetic bacteria like Rhodospirillum are also nitrogen fixers. Some proportion of atmospheric nitrogen is fixed during lightening also. The fixed atmospheric nitrogen reaches the soil as nitrates, which are taken up by plants for manufacture of complex nitrogenous compounds which in turn, are eaten by animals. The dead organic matter formed due to death of plants and animals is decomposed by various types of bacteria, actinomycetes and fungi occurring in soil and water. This releases nitrogen either in free stage or as ammonia gas in the atmosphere. Ammonia gas may reach the soil as nitrates through the activity of nitrifying microbes, Nitrosomonas and Nitrobacter. Some nitrates of soil due to activity of denitrifying microbes, Pseudomonas, may also be converted to free nitrogen gas returning to the atmosphere. This inorganic nitrogen is again recycled into the organic system upon absorption by higher plants. It is presumed that the fixation of nitrogen by microorganisms is generally in equilibrium with denitrification.

But in recent years there has been high quantity of atmospheric nitrogen fixation by Industrial process (Haber's process). Nitrogen so fixed is not readily and fully denitrified so as to cause accumulation of nitrates or ammonia in water and soil. The accumulation of nitrates in water causes eutrophication. NO_2 from the incomplete combustion of fossil fuel in automobiles further pollute the environment. It appears

that through photochemical and electrical fixation 2.5 x 107 ty^{-1} and through biological fixation 5-(6)x 10^9 ty^{-1} of nitrate is formed. Industrial nitrogen fixation including oxides of nitrogen formed during fossil fuel combustion is 8 x 10^7 ty^{-1}. Nitrogen fixed by microorganisms is 1-(2) x 10^8 ty^{-1}, which is presumed almost equal to that of denitrification. A tiny fraction of annual N-fixation is lost to fossilization in sediments because the anaerobic sedimentary environment is favourable to denitrifying bacteria.

3.4.3.6 Sulphur cycle

Sulphur is a component of sedimentary cycle. It is found in the gaseous forms (H2S, SO2, etc.) in the atmosphere, and as sulphates, sulphides and organic-sulphur in the soil. SO2 gas present in the atmosphere is produced volcanically, by burning of vegetation, and now in copious quantities by oxidation of sulphides and organo-S in fossil fuels. H_2S and dimethyl sulphide are commonly formed by the activity of anaerobic bacteria. The elemental and organic sulphur, and SO_4^{2-} are formed through oxidation of H2S. SO_2 and H_2S from the atmosphere are returned to the soil through precipitation. Sulphur in the form of sulphates (SO_4^{2-}) is the principal available form that is reduced and incorporated into proteins by autotrophs. Sulphur is an essential constituent of certain amino acids (cysteine, cystine, and methionine), the peptide glutathione and certain vitamins or enzyme cofactors (thiamine, biotine, and thiotic acid). It is the mercaptan, containing the thiol (-SH, or sulphydryl) group, and as the corresponding oxidized disulfide form that sulphur is most reactive in the plant.

The sulphur cycle links air, water and soil, where microbes play a key role. The sulphur is incorporated in the tissues of autotrophs as -SH in the proteins. It passes through the grazing food chain and excess of it is released through the faeces of animals. Within the detritus food chain the decomposition of proteins releases sulphur. Under aerobic conditions Aspergillus and Neurospora and under anaerobic conditions the bacteria like Escherichia and Proteus are largely responsible for the decomposition. In anaerobic soils and sediments H2S is formed by sulphate reducing bacteria like Desulphonovibrio desulfuricans which utilize the oxygen in the sulphate molecule to obtain energy and in turn reduce the sulphate in deep sediments to H2S gas:

In iron-rich materials, much of this H2S is scavenged by ferrous iron to produce the very insoluble, black FeS. Many photosynthetic and chemosynthetic bacteria play an important role in sulphur metabolism. Chemoautotrophic colourless bacteria like Beggiatoa, Thiothrix and Thiobacillus occurring in H2S containing water oxidizes H_2S to S or S to SO_4^{2-} when the H_2S supply is exhausted.

- Sulphur cycle plays a key role in the metabolism of other nutrients like iron, copper, cadmium, zinc, cobalt etc. For example, when iron is precipitated as sulphide, phosphorus is converted from insoluble to soluble form and thus becomes available to organisms.

3.4.3.7 Phosphorus cycle

Like sulphur, phosphorus is also a component of sedimentary cycle. It is an essential component as in the form of ATP it acts as an energy carrier. It is comparatively less abundant in natural ecosystems, particularly in terrestrial ecosystems and occurs in meager amounts in aquatic ecosystems too. The phosphorus is made available to the plants form the phosphatic rocks by slow weathering process. The phosphatic (inorganic phosphates typically orthophosphate ions) are metabolised in the plant body and pass through the food chain to animals, and then to decomposers (as food as well as through death and decay) in the form of organic phosphate, which is subsequently made available in the soil for reutilization through mineralisation and decomposition. However, a major proportion of phosphorus becomes lost to this central cycle through run off to the deep sediments of the oceans and in biological processes, such as formation of teeth and bones. On the contrary some quantities of phosphates are returned back to the earth in the form of bird guana (excreta) and fishes. In recent years the excessive use of phosphate fertilizers and the detergents is a problem of global concern as it has been considered responsible for accelerated eutrophication of water bodies.

3.4.3.8 Calcium cycle

It is important element needed by plants for building their cell walls and by animals for bone formation. It is being regularly added to the soil pool through the weathering of rocks and through atmosphere. A large proportion of this is kept in a state of cycling by uptake from soil into the biotic pool of plants and animals and their return through litter fall, death and decay via detritus food chain. Only a small portion is lost out of the ecosystem through stream flow and this is replenished by weathering and precipitation.

*** Cycle of toxic elements**

Several non-essential elements like mercury, lead, cadmium, arsenic and fluorine, despite their substantial toxicity are freely cycled through biological systems in well regulated and balanced manner. Growing industrial use, mining operations and other man's activities tended to perturb this equilibrium and upset the balance towards greater accumulation and lesser dispersion of toxic elements. A very significant role in the mobility and dispersion of these elements in the biosphere is played by microorganisms.

- ***Mercury***

It is one of the most important toxic elements which is now increasingly (about four-fold) discharged in soils and water as an unwanted by-product of certain industrial and agricultural activities. Mercury cycle is better known and the potential rate determining the role of biomethylation of mercury in an ecosystem involving lakes, rivers, coastal environment, soil, etc., is now well established. The natural level of mercury in soils is as high as 0.04 ppm, and in water 0.06 ppm. The amount of mercury found in the air depends on conditions of the environment. The element is poisonous in the metallic state, as inorganic salts of mercury or in the form of organic mercury compounds. It does not have to be ingested being poisonous. Metallic mercury gives off vapours at room temperature; some of the metal even vaporizes at the freezing point of water and this being highly volatile gets dispersed into biosphere. Elemental mercury can exist in three alternative states, viz., $Hg2^{2+}$, Hg^{2+} and HgO and certain microorganisms are capable of interconverting the three forms. Naturally occurring methyl-vitamin B_{12} compounds can aid the synthesis of methyl mercury as well as dimethyl mercury in natural habitats. The bioaccumulation of mercury is greatly facilitated by the natural synthesis of stable alkylmercury compounds (Wood, 1974). About 25% of the world mercury production form chlorine plant, where mercury is used as in electrolyte electrode, escapes in fuel gases. Methyl mercury compounds formed probably in sulphide-rich sediments by the activity of Methanobacterium amelankis are also highly toxic and move in the ecosystem either in solution or as atmospheric volatiles. Methyl mercury chloride is particularly toxic to animals as it is easily passed across cell membranes. Dimethyl mercury, which is highly volatile, passes into the air and decomposes into CH_4, C_2H_6 and Hg_2O, thus causing air pollution.

The mercury cycle shows that the mercury in ecosystem passes through food chain or by inhalation of dust or ingestion of surface-contaminated food. Mercury pollution can be best assessed by measuring the concentration of total mercury in sediments and also the rate of uptake of methyl mercury by fish.

- ***Arsenic***

It also has a biological cycle in nature. It is an element that is intermediate between the metals and non-metals. It is more abundant in nature as compared to mercury. In drinking water it may occur at levels of upto 50 ppm, whereas mercury levels commonly do not exceed 1 ppm. Arsenic compounds are known as to accumulate through food chains (Summers and Silver, 1978), with the result that even small doses can be lethal. Severe poisoning of human can be caused by as little as 100 mg, and 130 mg found to be fatal. It occurs in rocks, soils and water at much higher levels than does in mercury. It is found in many vegetables and fruits. Some marine organisms, especially shellfish tend to concentrate arsenic within their bodies, which may contain more than 100 ppm. For example, 174 ppm in prawn, 42 ppm in shrimp, and 40 ppm in bass. In moist soils, it is present upto 500 ppm. It has also been detected at concentration of 10 to 70 ppm in several commonly marketed house hold detergents. It may often stimulate plant growth in very low

concentrations, but is injurious in excessive quantities. Destruction of chlorophyll appears to be the main effect. As little as 1 ppm of arsenic trioxides in the water has caused injury into plants. U.S. Public Health Service in 1942 set a safe limit of 0.05 ppm, and in 1962 it recommended a maximum of 0.01 ppm in drinking water. There is also evidence that arsenic accumulates in the livers of mammals. Skin cancer has been found to be associated in several regions with arsenic intake in drinking water.

Arsenate is reduced to arsenite and then microbially methylated to form dimethylarsine and trimethylarsine. The conversion of arsenate through arsenite and methylarsenic acid occurs in lake sediments; di-and tri-methylarsines are released in water. These become oxidized in air to less toxic dimethylarsenic acid. The dimethylarsenic acid is thus cycled between air and sediment (Wood, 1974). Dimethylarsine is highly toxic to fish and other organisms.

- ***Lead***

The lead is prevalent in the natural environment. The earth's crust contains an average of about 10 to 15 ppm lead, though the content in rock, soil and water is extremely variable. Lead enters the environment in enormous quantities and particularly efficiently dispersed to the atmosphere by the use of tetraethyl and tetramethyl lead as antiknock additives to petrol (gasoline), which may contain about 2 g Pb gal^{-1}. About 2.5 X 108 kg y^{-1} Pb enters the oceans from this source and the mean sea-water concentration has increased almost seven fold during the past 50 years and is now about 0.07 µ g kg^{-1} (Goldberg, 1971).

Normally lead is not strongly absorbed from soil, by plants. The main toxicity hazard is therefore, from inhalation of dust or ingestion of surface-contaminated food. However, plants grown on heavily contaminated soil absorb several thousand µ g g^{-1} compared as the normal plant content of between 1 and 15 µ g g^{-1} (Johnston and Proctor, 1977).

- ***Cadmium***

Cadmium belongs to same family of elements as zinc and mercury. A major source of cadmium is zinc mining and smelting in addition to its release by other industries such as metal plating, and in making pigments, ceramics, photographic equipments, and nuclear reactors as well as those engaged in textile printing, lead mines and various chemical industries.

There is no evidence that cadmium has any role in nutrition of plants and animals. It is toxic in relatively small amounts. Being highly mobile in soil and water it is taken up freely by plants and passed on to grazing food chain (Coughtrey and Martin, 1976). In animals and humans, cadmium tends to accumulate in kidneys, pancreas and bones. In Japan the disease itai itai was caused by people's consumption of heavy metals, primarily cadmium either by drinking water or by eating rice which had accumulated the metal from the irrigation water. The affliction is characterized by kidney malfunction, a drop in phosphate level of blood serum, loss of minerals from the bones, and a condition called osteomalacia, which is a rickets-like condition characterized by pathogenic bone fracture and intense pains.

- ***Fluorine***

Fluorine makes up about 0.1 per cent of the earth's crust. In its elemental state it is a gas. However, in nature it is always found in various combinations. The greater proportion is in the form of the mineral fluorspar (Calcium fluorate, CaF) and in large deposits of mineral cryolite (sodium aluminium fluoride, NaAIF). Sources of atmospheric fluorine are aluminium smelting using cryolite as a flux, coal burning and the firing of clays in brick manufacture.

Fluorine is freely mobile in the atmosphere and ultimately appears in rainfall as fluoride. Plants take it from soil and water. In gaseous form, it enters open stomata, causes collapse of mesophyll cells, loss of photosynthetic activity and necrosis. Animals derive it from food, water, and minerals. The effect on tooth decay from drinking the water deficient in fluorine was noted. On the other hand, teeth impairment, called dentineri or black teeth, was observed among

people.

3.5 Ecological Succession

Ecological succession is the phenomenon or process by which an ecological community undergoes more or less orderly and predictable changes following disturbance or initial colonization of new habitat. Succession was among the first theories advanced in ecology and the study of succession remains at the core of ecological science. Succession may be initiated either by formation of new, unoccupied habitat (e.g., a lava flow or a severe landslide) or by some form of disturbance (e.g. fire, severe wind throw, logging) of an existing community.

3.5.1 Primary succession

Succession that begins in new habitats, uninfluenced by pre-existing communities is called primary succession. In primary succession pioneer species like lichen, algae and fungus as well as other abiotic factors like wind and water start to "normalize" the habitat. This creating conditions nearer optimum for vascular plant growth; pedogenesis or the formation of soil is the most important process.

These pioneer plants are then dominated and often replaced by plants better adapted to less odd conditions, these plants include vascular plants like grasses and some shrubs that are able to live in thin soils that are often mineral based.

For example, spores of lichen or fungus, being the pioneer species, are spread onto a land of rocks. Then, the rocks are broken down into smaller pieces and organic matter gradually accumulates, favouring the growth of larger plants like grasses, ferns and herbs. These plants further improve the habitat and help the adaptation of larger vascular plants like shrubs, or even medium- or large-sized trees. More animals are then attracted to the place and finally a climax community is reached.

3.5.2 Secondary succession

Succession that follows disruption of a pre-existing community is called secondary succession. (e.g. forest fire, harvesting, hurricane) that reduces an already established ecosystem (e.g. a forest or a wheat field) to a smaller population of species, and as such secondary succession occurs on preexisting soil whereas primary succession usually occurs in a place lacking soil.

Simply put, secondary succession is the succession that occurs after the initial succession has been disrupted and some plants and animals still exist. It is usually faster than primary succession as:

1. Soil is already present, so there is no need for pioneer species;
2. Seeds, roots and underground vegetative organs of plants may still survive in the soil.

3.6.1 Food Chain

- The transfer of food energy from the source in plants through a series of organisms with repeated stages of eating and being eaten is known as the food chain. The green plants, in the food chain, occupy the first trophic (nutritional or energy) - the producer level, the herbivores that eat the plants the second trophic - the primary consumer level, the carnivores that eat the herbivores the third trophic - the secondary consumer level and perhaps even a fourth- the tertiary consumer level. Some organisms are omnivores that eat the plant as well as animals at their lower level in the food chain and they may occupy more than one trophic level in the food chain. Thus, in any food chain, energy flows from producers -----> primary consumers (herbivores) -----> secondary consumers (carnivores) A tertiary consumers (carnivores), and so on. At each step of food transfer, a large proportion, 80 to 90% of the potential energy is lost through dissipation of heat

resulting in continuous diminution of available energy. This is the reason that rarely more than five trophic levels occur in a food chain. The efficiency of energy transfer also varies from one trophic level to another.

In nature, three types of food chains have been distinguished:

- **Grazing food chain**

  The consumers which utilise the living plant parts as their food or energy source constitute the grazing food chain. The food chain, thus begins from a green plant base. It is common in the terrestrial and aquatic ecosystems where most of the primary production is edible by herbivores.

- **Parasitic food chain**

  It also begins from a green plant base and goes to herbivores, which may be the host of a huge number of lice living as ectoparasites.

- **Detritus food chain**

  The food chain goes from dead organic matters of decaying animal and plant bodies to the microorganisms and then to detritus feeding organisms (detrivores or saprovores) and their predators is known as “detritus food chain”. Soil organisms are thus less dependent on direct solar energy and depend chiefly on the influx of organic matter produced in another system. In the brackish zone of Southern Florida, leaves of the red mangrove (Rhizophore mangle) fall into the warm, shallow waters. The fallen leaf fragments acted on by such saprotrophs as fungi, bacteria, and protozoa, and colonised by phytoplanktonic and benthic algae are eaten and reeaten by a group of small animals. These animals include crabs, copepods, insect larvae, mysids, nematodes, grass shrimps, amphipods, etc. All these animals are called detritus consumers. These animals, in turn, are eaten by some minnows, small game fish, etc. The small carnivores, which in turn, serve as the food for large game fish, and so on. Mangrove leaves, through detritus food chain make substantial contribution to the food chain that is upto 90% of the stored energy in the dead organic material is consumed through detritus food chain. This chain is further important from the view point of mineral cycles within the ecosystem.

3.6.2 Food Web

Food chain, normally do not operate in isolated but are interlocked with each other forming some sort of pattern known as food web. An organism in the ecosystem may operate at more than one trophic level, i.e. it derives its food from more than one source and in turn, may serve as a source of food for several organisms of higher trophic level. This results into linking together, but intersecting each other, of several food chains. Another reason for the formation of food web seems to be successive loss of energy at higher trophic levels till no more energy is available to support yet another link in the food chain. A food web delineated for small organisms of a stream community in South Wales. This illustrates: (i) the interlinking of food chain, (ii) three trophic levels, (iii) intermediate position of the organisms e.g. Hydropsyche, and (iv) an “open” system in which part of the basic food is “imported” from outside the stream.

The food webs are very important in maintaining the stability of an ecosystem, in nature. For example, in grazing food chain of a grassland, in the absence of rabbit, grass may be eaten by mouse. The mouse in turn may be eaten directly, either by hawk or snake. The snake then may be eaten by hawk.

Absence of rabbit thus would not disturb the ecosystem as the alternative (mouse) may serve for the maintenance of its stability. Moreover, a balanced ecosystem is essential for the survival of all the living organisms of the system. For example, if the primary consumers (herbivores) are not in nature than the producers would perish due to overcrowding and competition. In the same way, the survival of the primary consumers is linked with the secondary consumers (carnivores) and so on. Thus each species of an ecosystem is indeed kept under some sort of a natural check so

that the system may remain stable.

A food web, unlike a food chain has therefore, several alternative pathways for flow of energy. Sudden decrease in population of one category of consumers at any trophic level does not affect much the functioning of an ecosystem, as at that trophic level, the second category of consumers multiply and build up their numbers. An ecosystem is, therefore, more stable, if it has a greater number of alternative pathways.

3.6.3 Ecological Pyramids

The concept of ecological pyramids was developed by Charles Elton (1927), the pioneer British Ecologist. There is some sort of relationship between the number, biomass and energy content of the primary producers, consumers of the first and second orders and so on to top carnivores in the ecosystem. This relationship may be represented graphically by means of pyramids which is referred to as ecological pyramids, where the first or producer level forms the base of the pyramid and the successive levels (the tiers) making the apex. Ecological pyramids are of three general types: (i) Pyramid of numbers, showing the number of organisms at each trophic level (number m^{-2}), (ii) Pyramid of biomass, showing the total dry weight or any other suitable measure of the total amount of living matter (g m^{-2}), and (iii) Pyramid of energy, showing the amount of energy flow and/or productivity at successive trophic levels (calories m^{-2} $year^{-1}$).

*** Pyramid of numbers**

The relationship between the number of producers, consumers of primary, secondary and tertiary orders constitutes the pyramid of numbers. The form of the pyramid of numbers will vary widely with different communities, depending on whether producers are small (phytoplankton, grass) or large (oak trees). Sometimes, number of individuals varies so widely that it is difficult to represent the entire ecosystem on the same numerical scale. Such data could best be presented in a tabular form. In a grassland, the producers which are mainly grasses, are always maximum in number. This number then shows a successive decrease towards apex, as the primary consumers (herbivores), which are rabbits, mice, etc., are lesser in number than the grasses; the secondary consumers, the snakes and lizards are lesser in number than the rabbits and mice. Finally, the top (tertiary) consumers, the hawks and birds, are least in number. Thus, the pyramid becomes upright. Similarly, in pond ecosystem, the pyramid is upright. Here the producers, which are mainly phyto-planktons as algae, bacteria, etc. are maximum in number; the herbivores which are very small fish, rotifers, etc., are lesser in number than the producers; and the secondary consumers (carnivores), such as water beetles and small fish, etc., are lesser in number than the herbivores. Finally, the top (tertiary, consumers), the bigger fish and birds are least in number.

In a forest ecosystem, however, the pyramid of numbers is somewhat different in shape the producers which are mainly large-sized trees are lesser in number, and form base of the pyramid. The herbivores, which are the fruit eating birds, deers, etc., are more in number than the producers. Then, there is a gradual decrease in the number of successive carnivores, thus making the pyramid again upright one.

However, in a parasitic food chain, the pyramids are always inverted. This is due to the fact that a single plant may support the growth of many herbivore birds and each one of these, in turn, may provide nutrition to several hyperparasites like bugs and lice. Thus from the producers towards consumers, the number of organisms successively shows an increase, making the pyramid inverted one. In crop ecosystem, the pyramid is upright one where primary consumers, viz., grasshoppers are lesser in number than the crops; frogs, snakes, and eagle- the primary, the secondary and the top consumers respectively are present in decreasing number.

*** Pyramids of biomass**

In this type of pyramid, the relationship between different trophic levels is presented in terms of weight of organisms (biomass). In grassland and forest, there is generally a gradual decrease in mass of organisms at successive levels from the producers to the top consumers. Thus, pyramids are upright. In an aquatic ecosystem (like pond), however, the biomass of producers is least. This

value gradually shows an increase towards the apex of the pyramid, thus making the pyramid inverted one. In this case the biomass of diatoms and phytoplanktons (primary consumers) that feed on them. The biomass of large carnivore fishes (secondary consumers) which feed on smaller fishes is the highest of all the trophic levels. In English Channel the biomass of primary producers is only 4 g m^{-2} whereas that of the consumers is 21 g m^{-2}. Infact, this is the case in most aquatic bodies . In lakes and sea, on the other hand, the phytoplanktons usually outweigh their grazers (zooplanktons) during periods of high primary productivity, as during the spring “bloom”, but at other times, as in winter the reverse may be true. This difference in biomass trend can be explained if the time is also taken into account.

*** Pyramid of energy**

The pyramid of energy represents the total quantity of energy utilized by different trophic level organisms of an ecosystem per unit area over a set period of time (usually, per square metre per year). The primary producers of an ecosystem trap the radiant energy of the sun and covert it into potential chemical energy. This trapped energy flows in the food chain from the producers to the top carnivores, decreasing at successive trophic levels. If the relationship of total quantity of energy utilized in unit area over a particular period of time by different trophic levels is diagrammatically represented, an upright pyramid is invariably formed. As against the pyramid of numbers and biomass, the shape of the pyramid of energy is always upright because in this the time factor is taken into account. In a grassland the green plants (primary producers) trap the maximum light energy in a particular area over a fixed period of time. Similarly, in a pond ecosystem, the phytoplanktons, in a particular area, trap and accumulate much more energy than the herbivore fishes in the course of year because of their large numbers and quicker rate of multiplication. Comparatively, the amount of energy utilized in a year by the top carnivores is much less than that of herbivore fishes.

Of the three types of pyramids as discussed above, the energy pyramid gives by far the best overall picture of the functional role of communities in an ecosystem. This is because of the fact that energy pyramid is a picture of rate of passage of food mass through the food chain, whereas number and biomass pyramids are pictures of standing states, i.e. organisms present at any moment. Its shape is invariably an upright one, and not affected by variation in the size and metabolic state of individuals, if all the sources of energy in the ecosystem are considered. The number and biomass pyramids on the other hand, may be upright or inverted depending upon the size and biomass of the producer organisms as compared to consumers.

3.8 What Is a Forest Ecosystem?

A forest ecosystem is an ecosystem of forests and resources. Forests are renewable natural resources. Forests are formed by a group of plants that are structurally defined by their trees, shrubs, herbs, climbers, and ground cover. Soil, animals, insects, microorganisms, and birds are the most important interacting units of a forest ecosystem. In India, the forests occupy about 18-20% of the total land area.
1. **Abiotic Components** of the forest include inorganic and organic components present in the soil along with temperature, rainfall, light, etc.

2. **Biotic Components** are represented by producers, consumers, and decomposers.

What Are the Types of Forest Ecosystems?

There are a few types of forest ecosystems listed below:

1. **Tropical Evergreen Rainforest:** Only a small percentage of tropical forests are rainforests where average rainfall is 80-400 inches in a year. This forest is characterised by deep and dense vegetation consisting of tall trees reaching different levels.

2. **Tropical Deciduous Rainforest:** The main characteristic of tropical deciduous rainforest are broad-leaved trees along with dense bushes, shrubs, etc. Two main seasons – summer and winter – are distinctly visible there. This type of forest is found in many parts of the world. A large variety of flora and fauna are found here.

3. **Temperate Evergreen Forest:** Temperate evergreen forest is a type of forest that is characterised by a smaller number of trees but an adequate number of ferns and mosses.

4. **Temperate Deciduous Forest:** Temperate deciduous forest evolves in the moist temperate region with sufficient rainfall. Here also, winter and summer are well defined, and trees shed their leaves during winter. Dominant trees are maple, oak, peach, etc.

5. **Taiga/Boreal:** Situated just south of the Tundra, Taiga is characterised by evergreen conifers. The average temperature is below the freezing point for almost half of the year.

3.8.1 Characteristics of Forest Ecosystem

1. Warm temperatures and sufficient rainfall are characteristics of forests, resulting in the formation of numerous ponds, lakes, etc.
2. The forest maintains climate and rainfall.
3. The forest supports many wild animals and protects biodiversity.
4. The soil is rich in organic matter and nutrients, which support the growth of trees.

3.8.2 Structure of Forest Ecosystems:

Different organisms exist within the forest layers. These organisms interact with each other and their surroundings. Each organism has a role or niche in sustaining the ecosystem.

Some provide food for other organisms; others provide shelter or control populations through predation:

Producers:

All living organisms' intake energy in order to survive. In a forest ecosystem, trees and other plants get their energy from sunlight. Plants produce their own food, in the form of carbohydrates. Plants are, therefore, called the primary producers, since they produce the basic foodstuffs for other organisms within food chains and food webs. Photosynthesis is the chemical reaction that allows plants to produce their own food.

Consumers*:*

Animals cannot produce their own food. They must consume food sources for die energy they need to survive. All animals, including mammals, insects, and birds, are called consumers. Consumers rely on plants and other animals as a food source. Details of these animals in a forest ecosystem have been given earlier.

Primary consumers only eat plants and are referred to as herbivores. Secondary consumers are referred to as carnivores and feed on herbivores. Tertiary consumers are carnivores that feed on other carnivores. Omnivores eat both plant and animal matter.

Decomposers:

Leaves, needles, and old branches fall to the forest floor as trees grow. Eventually all plants and animals die. So what happens to all of this plant and animal material? Does it sit on the forest floor forever? Thankfully no. These materials are decomposed by worms, microbes, fungi, ants, and other bugs.

Decomposers break these items down into their smallest primary elements to be used again. Decomposers are important in that they sustain the nutrient cycle of ecosystems.

Humans are part of Forest Ecosystem:

Humans are consumers. We get food and materials from forests. Because of this, we are a part of the forest ecosystem. Human consumption alters forest ecosystems. Human intervention may be necessary to sustain forest communities under the increased pressure of human use.

3.8.3 Functions of Forest Ecosystem

1. **Goods Obtained from Forests:** There are various types of food products such as honey, wild meat, fruits, mushrooms, palm oil and wine, and medicinal plants obtained from forests. Other than edible parts, we can obtain timber, wood biomass, cork, etc. from forests. The fuel can be extracted from old trees that are buried under the soil.

2. **Ecological Functions:** Forests play an important role in maintaining ecological factors such as climate, carbon storage, nutrient cycling, and rainfall.

3. **Culture and Social Benefits:** The tribal people who live in the forests treat forests as nature goddesses. The traditional beliefs and spirituality save wild animals from hunters and cutting down of trees by urban people. A few modern people visit forests for recreation.

3.9 Introduction of Aquatic Ecosystem

An ecosystem is defined as a functional unit wherein all living organisms interact with their surroundings and one another to sustain themselves in the environment. In a broad sense, an ecosystem can be categorized as a land/terrestrial ecosystem or a water/aquatic ecosystem.

Many lives are undoubtedly supported by water. Furthermore, aquatic creatures are those that can thrive in water. They also rely on water for food, shelter, reproduction, and a variety of other life functions. This particular article will offer you a fair idea of the types of aquatic ecosystems and their importance in brief!

3.9.1 What is the Aquatic Ecosystem?

The aquatic ecosystem definition states it is a water-based environment, wherein, living organisms interact with both physical and chemical features of the environment. These living creatures whose food, shelter, reproduction, and other essential activities depend on a water-based environment are known as aquatic organisms.

Water plays a significant role in the management of world-scale ecosystem processes in aquatic systems, connecting the atmosphere, lithosphere, and biosphere by transferring material between them and allowing chemical reactions to occur. Water has unique physicochemical features that reflect the water body's quality. The physicochemical characteristics of an aquatic ecosystem determine how well it functions and how long it can support life forms. In the same way as sediments in terrestrial ecosystems provide substrate, nutrients, and a home for live aquatic resources, sediments in aquatic ecosystems are equivalent to the soil in terrestrial ecosystems. Sediments are significant catalysts in environmental food cycles and the two water quality dynamics.
The quality of sediment has a direct or indirect impact on the functioning of an aquatic ecosystem. The many physicochemical properties of sediment determine its quality. Similarly, the biotic mix of an aquatic environment determines how well it functions. In the aquatic environment, they serve as a trophic level and a source of energy. Fish have a significant ecological role in the whole food web at the trophic level.
Some of the most common aquatic organisms are – nekton, plankton, and benthos. Additionally, lakes, oceans, ponds, rivers, swamps, coral reefs, wetlands, etc. are a few popular aquatic ecosystem examples.

3.9.2 Features of Aquatic Ecosystem

Salient features of the aquatic ecosystem are highlighted in this figure below –

- Freshwater or saltwater can be used to make them.
- They serve as a home for a variety of aquatic animals.
- The majority of the vegetation is made up of algae and corals.
- They have a lot of biological diversity, which makes them the most productive and wealthiest ecosystems on the planet.
- They help regulate the hydrological cycle and act as a pollution filter, among other things.

3.9.3 Types of Aquatic Ecosystem

In general, there are two types of aquatic ecosystems, namely marine ecosystems and freshwater ecosystems. Both marine and freshwater ecosystems are further divided under different aquatic ecosystems.

Let's Take a Look at the Aquatic Ecosystem and its Types Below.

A. Marine Water Ecosystem

This particular ecosystem is the largest aquatic ecosystem and covers over 70% of the earth's total surface. This ecosystem is relatively more concentrated in terms of salinity. Nonetheless, the body of aquatic organisms is well-adjusted to saline water, and they may find it challenging to survive in freshwater. The following categories comprise the marine ecosystem.

- **Ocean Ecosystem**

  Pacific Ocean, Atlantic Ocean, Indian Ocean, Arctic Ocean, and the Southern Ocean are the five major oceans on earth. Notably, the Pacific Ocean is the largest and deepest of these five, while the Atlantic is the second largest in terms of size. Also, the Southern Ocean harbors the largest population of Krill among them. Other than that, the oceans serve as home to aquatic organisms like – turtles, crustaceans, plankton, corals, shellfish, blue whale, sharks, tube worms, reptiles, etc.
- **Estuaries**

  Typically, it is the meeting point of a sea and rivers, which makes the water slightly more saline when compared to freshwater and more diluted when compared to the marine ecosystem. Biologically, estuaries are considered to be productive as they stimulate primary production and trap plant nutrients. Some examples of estuaries include – tidal marshes, river mouth, and coastal bays.
- **Coral Reefs**

  These are fondly referred to as the Rain Forest of Oceans as they harbor a wide diversity of aquatic flora and fauna. A coral reef is an aquatic ecosystem made up of corals that form reefs. Coral polyps are held together by calcium carbonate in the formation of reefs. Stony corals, whose polyps cluster in groups, make up the majority of coral reefs.

  The animal phylum Cnidaria includes sea anemones and jellyfish, and coral is part of the class Anthozoa. Corals secrete hard carbonate exoskeletons that support and protect them, unlike sea anemones. Warm, shallow, clear, sunny, agitated water is ideal for most reefs. At the beginning of the Early Ordovician, 485 million years ago, coral reefs displaced the Cambrian's microbial and sponge reefs.

- **Coastal Ecosystem**

  Coastal ecosystems are formed when land and water meet. The structure, variety, and energy flow of these ecosystems are all unique. The bottom of the coastal environment is dominated by plants and algae. Insects, snails, fish, crabs, shrimp, lobsters, and other animals make up the fauna. It is one of the major aquatic ecosystems and is quite distinct in terms of structure and diversity. The coastal ecosystem is formed in the union of land and water. Coastal ecosystems harbor a variety of plants and algae and serve as a home to snails, shrimps, crabs, lobsters, and fish.

B. Freshwater Ecosystem

This aquatic ecosystem covers less than 1% of the earth's surface and is broadly divided into – wetlands, lentic and lotic ecosystems.

- **Swamps and Wetlands**

  These are marshy areas that are often covered in water and harbor a variety of flora and fauna. Wetlands are known to be a home of water lilies, marshes, swamps, Northern Pikes, dragonflies, Green Heron, etc.
- **Lentic Ecosystems**

  It includes standing water bodies like ponds and lakes and is a home to both floating and rooted plants, algae, and invertebrates. All standing water habitats, such as lakes and ponds, are included in lentic ecosystems. Algae, rooted and floating-leaved plants, and crustaceans like crabs and shrimp live in these habitats. Frogs and salamanders, as well as reptiles like alligators and water snakes, can be found here. Salamanders, frogs, water snakes, and alligators are commonly found in lentic ecosystems.
- **Lotic Ecosystems**

  These aquatic ecosystems are characterized by rapid flowing water moving in one direction. They are a hub of a wide variety of insects like beetles, mayflies, and stoneflies, among others. Also, it harbors species like river dolphins, beavers, otters, eel, minnow, and trout.

3.9.4 Functions of Aquatic Ecosystem

These pointers highlight the importance of aquatic ecosystem -

- Facilitates recycling of nutrients
- Helps to purify water
- Recharges groundwater
- Is a habitat for aquatic flora and flora
- Mitigates flood