Unit-III

ECOSYSTEM AND BIO-DIVERSITY

3.1. CONCEPT OF AN ECOSYSTEM:

Various kinds of life supporting systems like the forests, grasslands, oceans, lakes, rivers, mountains, deserts and estuaries show wide variations in their structural composition and functions. However, they all are alike in the fact that they consist of living entities interacting with their surroundings exchanging matter and energy. How do they differ in the type of their flora and fauna, how do they derive their energy and nutrients to live together, how do they influence each other and regulate their stability are the questions that are answered by Ecology.

The term Ecology was coined by Earnst Haeckel in 1869. It is derived from the Greek words Oikos- home + logos- study. So ecology deals with the study of organisms in their natural home interacting with their surroundings. The surroundings or environment consists of other living organisms (biotic) and physical (abiotic) components. Modern ecologists believe that an adequate definition of ecology must specify some unit of study and one such basic unit described by Tansley (1935) was ecosystem.

An ecosystem is a self-regulating group of biotic communities of species interacting with one another and with their non-living environment exchanging energy and matter as shown in fig 3.1. Now ecology is often defined as “the study of ecosystems”.

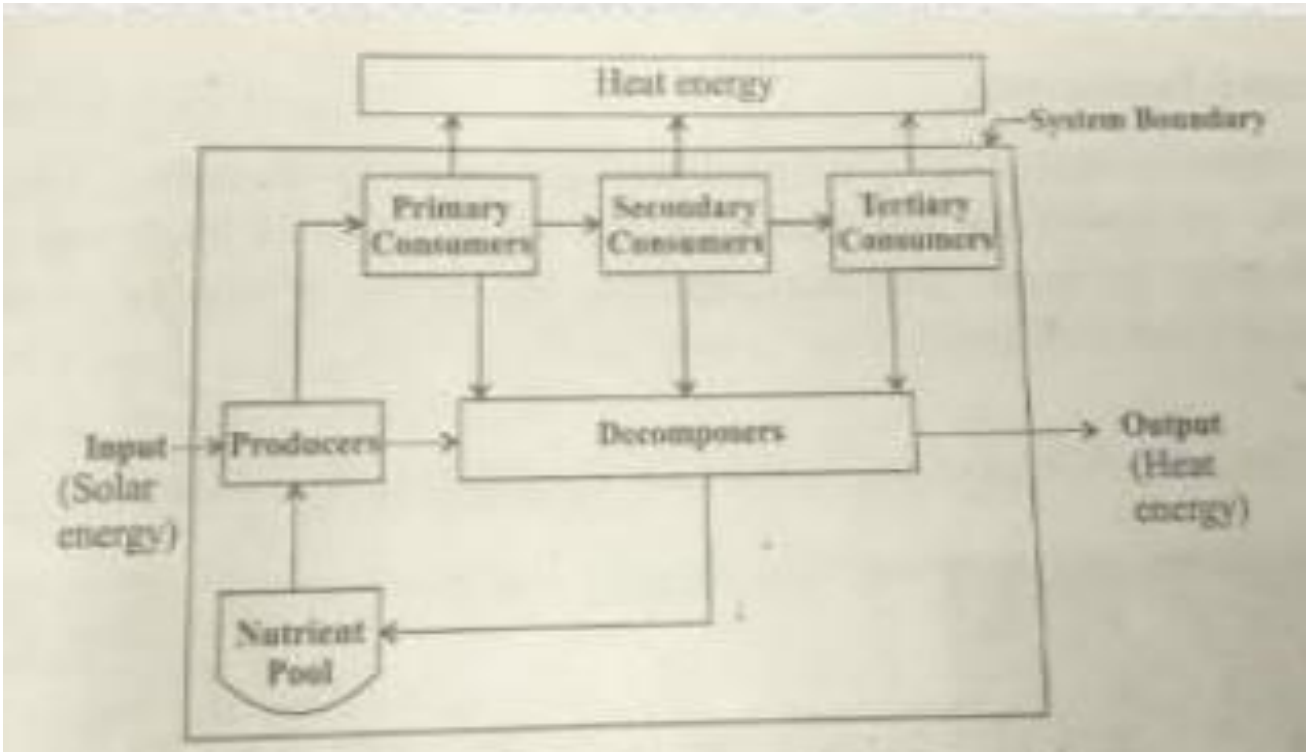


Fig. 3.1. Energy flow in an ecosystem

3.2. CLASSIFICATION OF AN ECOSYSTEM:

Ecosystems are classified on the basis of habitat as shown in fig .3.2.1.

3.2.1. Natural ecosystem:

An ecosystem that is developed under natural conditions is called a natural ecosystem. Natural ecosystem operate by themselves under natural conditions without interference by man.

Natural ecosystems can be terrestrial as well as aquatic. Habitats exhibit environmental conditions which determine the nature and characteristics of biotic communities.

3.2.2. Artificial ecosystem:

Artificial ecosystems are maintained artificially by human beings. In these ecosystems natural balance is disturbed regularly. In Artificial ecosystems humans try to control the biological and physiological properties of the ecosystem.

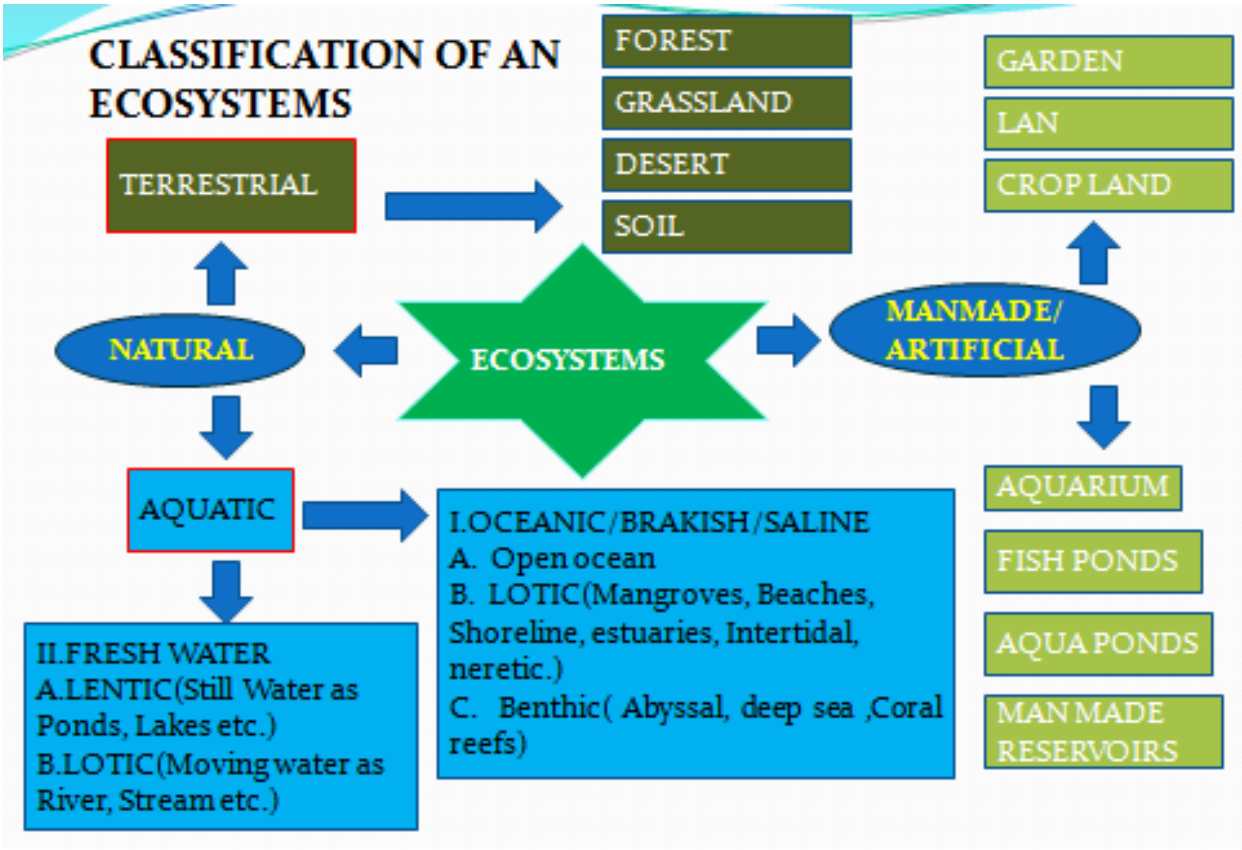


Fig.3.2.1. Broad classification of an Ecosystems

3.2.3. TERRESTRIAL ECOSYSTEM

Ecosystems that are found on land called terrestrial ecosystems (fig. 3.2.2). These are further subdivided in terms of physical conditions and their responses to biotic communities.

Forest, grassland, desert……are types of terrestrial ecosystems.

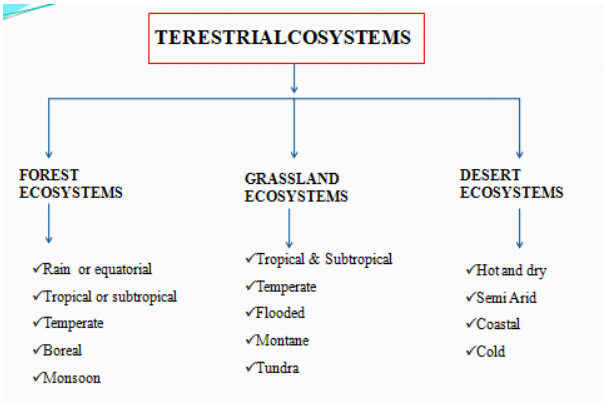


Fig.3.2.2. Terrestrial Ecosystems

MAJOR TERRESTRIAL ECOSYSTEM

Let us consider types, characteristic features, structure and functions of some major ecosystems.

A. FOREST ECOSYSTEM :

These are the ecosystems having a predominance of trees that are interspersed with a large number of species of herbs, shrubs, climbers, lichens, algae and a wide variety of wild animals and birds. As discussed above forests are found in undisturbed areas receiving moderate to high rainfall and usually occur as stable climax communities.

Depending upon the prevailing climatic conditions forests can be of various types:

(a) Tropical Rain Forests: They are evergreen broadleaf forests found near the equator. They are characterized by high temperature, high humidity and high rainfall, all of which favor the growth of trees. All through the year the climate remains more or less uniform. They are the richest in biodiversity. Different forms of life occupy specialized areas (niches) within different layers and spaces of the ecosystem depending upon their needs for food, sunlight, water, nutrient etc.

(b) Tropical deciduous forests: They are found a little away from the equator and are characterized by a warm climate the year round. Rain occurs only during monsoon. A large part of the year remains dry and therefore different types of deciduous trees are found here, which lose their leaves during dry season.

(c) Tropical scrub forests: They are found in areas where the dry season is even longer. Here there are small deciduous trees and shrubs.

(d) Temperate rain forests: They are found in temperate areas with adequate rainfall. These are dominated by coniferous trees like pines, firs, redwoods etc. They also consist of some evergreen broad-leaf trees.

(e) Temperate deciduous forests: They are found in areas with moderate temperatures. There is a marked seasonality with long summers, cold but not too severe winter and abundant rainfall throughout the year. The major trees include broad leaf deciduous trees like oak, hickory, poplar etc.

(f) Evergreen coniferous forests (Boreal Forests): They are found just south of arctic tundra. Here winters are long, cold and dry. Sunlight is available for a few hours only. In summer the temperature is mild, sun-shines for long hours but the season is quite short. The major trees include pines, spruce, fir, cedar etc. which have tiny, needle-shaped leaves having a waxy coating so that they can withstand severe cold and drought. The soil is found to get frozen during winter when few species can survive. The leaves, also known as needles, fall on the forest floor and cover the nutrient poor soil. These soils are acidic and prevent other plants from growing. Species diversity is rather low in these forests.

B. GRASSLAND ECOSYSTEMS

Grasslands are dominated by grass species but sometimes also allow the growth of a few trees and shrubs. Rainfall is average but erratic. Limited grazing helps to improve the net primary production of the grasslands but overgrazing leads to degradation of these grasslands resulting in desertification.

Three types of grasslands are found to occur in different climatic regions:

(a) Tropical grasslands: They occur near the borders of tropical rain forests in regions of high average temperature and low to moderate rainfall. In Africa, these are typically known as Savannas, which have tall grasses with scattered shrubs and stunted trees. The Savannas have a wide diversity of animals including zebras, giraffes, gazelle, antelopes etc. During dry season, fires are quite common. Termite mounds are very common here. The termites gather the detritus (dead organic matter) containing a lot of cellulose and build up a mound. On the top of the mound fungi are found to grow which feed upon this dead matter including cellulose and in turn release methane, a greenhouse gas.

Tropical savannas have a highly efficient system of photosynthesis. Most of the carbon assimilated by them in the form of carbohydrates is in the perennating bulbs, rhizomes, runners etc. which are present underground. Deliberate burning of these grasslands can release huge quantities of carbon dioxide, another green house gas, responsible for global warming.

(b) Temperate grasslands: They are usually found on flat, gentle sloped hills, winters are very cold but summers are hot and dry. Intense grazing and summer fires do not allow shrubs or trees to grow.

In United States and Canada these grasslands are known as prairies, in South America as Pampas, in Africa as Velds and in central Europe and Asia they are known as Steppes.

Winds keep blowing and evaporation rate is very high. It also favours rapid fires in summer. The soils are quite fertile and therefore, very often these grasslands are cleared for agriculture.

(c) Polar grasslands (Arctic Tundra): They are found in arctic polar region where severe cold and strong, frigid winds along with ice and snow create too harsh a climate for trees to grow. In summers the sun-shines almost round the clock and hence several small annual plants grow in the summer. The animals include arctic wolf, weasel, arctic fox, reindeer etc. A thick layer of ice remains frozen under the soil surface throughout the year and is known as permafrost. In summer, the tundra shows the appearance of shallow lakes, bogs etc. where mosquitoes, different type of insects and migratory birds appear.

C. DESERT ECOSYSTEMS

These ecosystems occur in regions where evaporation exceeds precipitation (rainfall, snow etc.). The precipitation is less than 25 cm per year. About 1/3rd of our world's land area is covered by deserts. Deserts have little species diversity and consist of drought resistant or drought avoiding plants. The atmosphere is very dry and hence it is a poor insulator. That is why in deserts the soil gets cooled up quickly, making the nights cool.

Deserts are of three major types, based on climatic conditions:

(a) Tropical deserts like Sahara and Namib in Africa and Thar Desert, Rajasthan, India are the driest of all with only a few species. Windblown sand dunes are very common.

(b) Temperate deserts like Mojave in Southern California where day time temperatures are very hot in summer but cool in winters.

(c) Cold deserts like the Gobi desert in China has cold winters and warm summers.

Desert plants and animals are having most typical adaptations for conservation of water. Many desert plants are found to have reduced, scaly leaves so as to cut down loss of water due to transpiration or have succulent leaves to store water. Many a times their stems get flattened and develop chlorophyll so that they can take up the function of photosynthesis. Some plants show

very deep roots to tap the groundwater. Many plants have a waxy, thick cuticle over the leaf to reduce loss of water through transpiration. Desert animals like insects and reptiles have thick outer coverings to minimize loss of water. They usually live inside burrows where humidity is better and heat is less. Desert soil is rich in nutrients but deficient in water.

Due to low species diversity, shortage of water and slow growth rate, the desert plant communities, if faced with a severe stress take a long time to recover.

3.2.4. AQUATIC ECOSYSTEM

Ecosystems found in water are known as aquatic ecosystems (fig.3.2.4).

Ex: Tanks, oceans, rivers, lakes……..

Aquatic ecosystems are further divided into fresh water, brackish water and marine ecosystems.

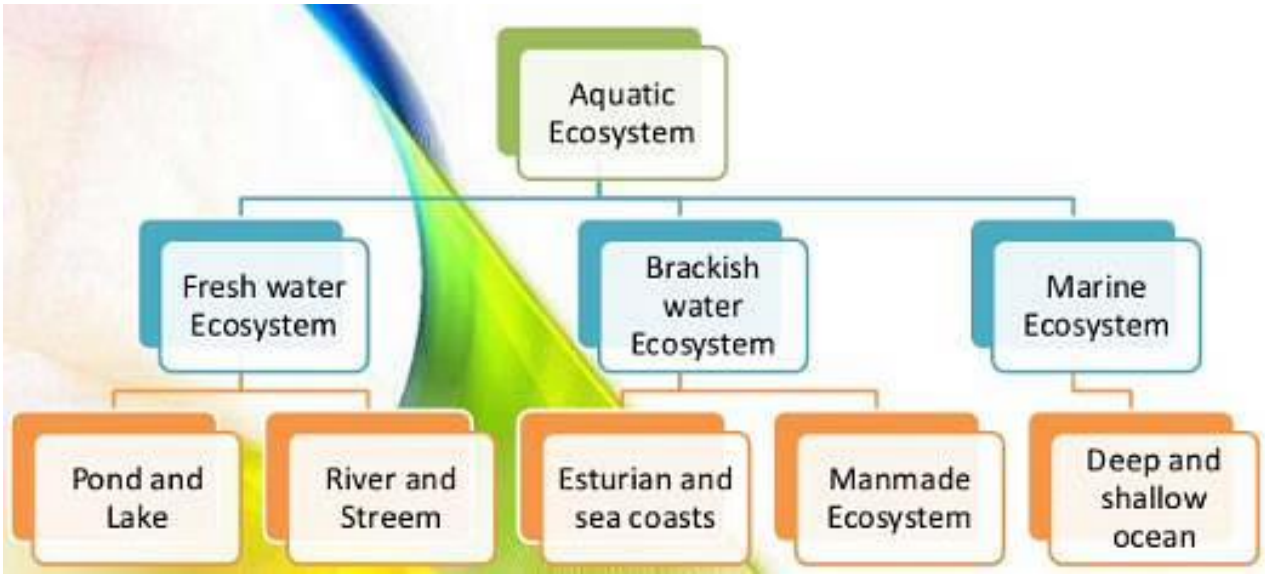


Fig.3.2.4. Types of Aquatic Ecosystem

MAJOR AQUATIC ECOSYSTEMS

I. FRESHWATER ECOSYSTEM

The Freshwater is found in the form of ponds, lakes, streams, frozen water, etc. other than oceans and seas. The freshwater ecosystem plays an important role in biodiversity.

An ecosystem characterized by low-salt content, making a suitable environment for various plants and animals is known as a freshwater ecosystem.

Freshwater resources also differ from each other in terms of their movement. Some freshwater bodies are moving continuously like rivers, whereas some others are stagnant like ponds.

Aquatic ecosystems dealing with water bodies and the biotic communities present in them are either freshwater or marine. Freshwater ecosystems are further of standing type (lentic) like ponds and lakes or free-flowing type (lotic), like rivers. Let us consider some important aquatic ecosystems.

A. POND ECOSYSTEM:

It is a small freshwater aquatic ecosystem where water is stagnant (fig.3.2.5). Ponds may be seasonal in nature i.e. receiving enough water during rainy season. Ponds are usually shallow water bodies which play a very important role in the villages where most of the activities center around ponds. They contain several types of algae, aquatic plants, insects, fishes and birds. The ponds are, however, very often exposed to tremendous anthropogenic (human-generated) pressures. They are used for washing clothes, bathing, swimming, cattle bathing and drinking etc. and therefore get polluted.

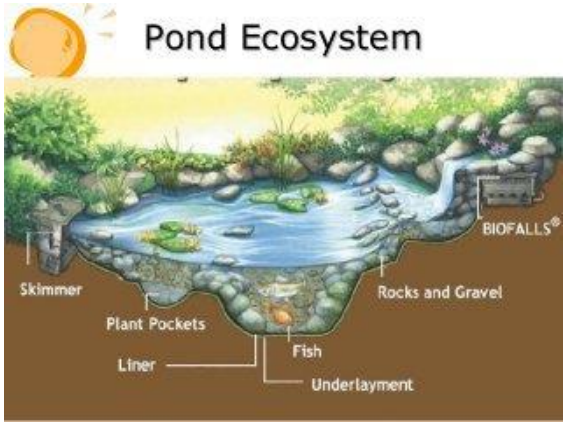


Fig.3.2.5 Pond Ecosystem

B. LAKE ECOSYSTEMS: Lakes are usually big freshwater bodies with standing water. They have a shallow water zone called Littoral zone, an open-water zone where effective penetration of solar light takes place, called Limnetic zone and a deep bottom area where light penetration is negligible, known as profundal zone in fig.3.2.6.

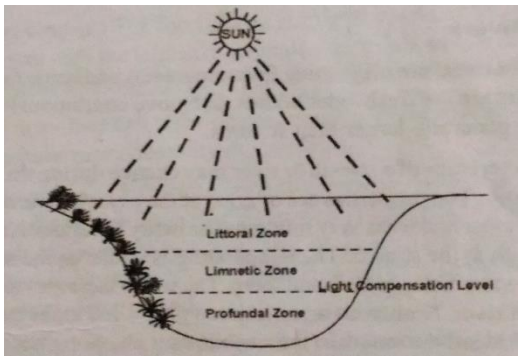


Fig.3.2.6 Lake Eosystem

Organisms: The lakes have several types of organisms:

(i) Planktons that float on the surface of waters e.g. phytoplanktons like algae and zooplanktons like rotifers.

(ii) Nektons that swim e.g. fishes.

(iii) Neustons that rest or swim on the surface.

(iv) Benthos that is attached to bottom sediments e.g. snails.

(v) Periphytons that are attached or clinging to other plants or any other surface e.g. crustaceans.

Stratification : The lakes show stratification or zonation based on temperature differences. During summer, the top waters become warmer than the bottom waters.

Therefore, only the warm top layer circulates without mixing with the colder layer, thus forming a distinct zonation:

Epilimnion : Warm, lighter, circulating surface layer.

Hypolimnion : Cold, viscous, non-circulating bottom layer.

In between the two layers is thermocline, the region of sharp drop in temperature.

TYPES OF LAKES : Some important types of lakes are:

1. **Oligotrophic** lakes which have low nutrient concentrations.
2. **Eutrophic** lakes which are over nourished by nutrients like nitrogen and phosphorus, usually as a result of agricultural run-off or municipal sewage discharge. They are covered with "algal blooms" e.g. Dal Lake.
3. **Dystrophic** lakes that have low pH, high humic acid content and brown waters e.g. bog lakes.
4. **Endemic** lakes that are very ancient, deep and have endemic fauna which are restricted only to that lake e.g. the Lake Baikal in Russia; the deepest lake, which is now suffering a threat due to industrial pollution.
5. **Desert salt** lakes that occur in arid regions and have developed high salt concentrations as a result of high evaporation. E.g. Great Salt Lake, Utah; Sambhar Lake in Rajasthan.
6. **Volcanic** lakes that receive water from magma after volcanic eruptions e.g. many lakes in Japan. They have highly restricted biota.
7. **Meromictic** lakes that are rich in salts and are permanently stratified e.g. Lake Nevada.
8. **Artificial lakes or impoundments** that are created due to con-struction of dams e.g. Govindsagar Lake at Bhakra-Nangal.

C. STREAMS:

These are freshwater aquatic ecosystems where water current is a major controlling factor, oxygen and nutrient in the water is more uniform and land-water exchange is more extensive. Although stream organisms have to face more extremes of temperature and action of currents as compared to pond or lake organisms, but they do not have to face oxygen deficiency under natural conditions. This is because the streams are shallow, have a large surface exposed to air and constant motion which churns the water and provides abundant oxygen.

Fig.3.2.7.Stream Ecosystem

Their dissolved oxygen level is higher than that of ponds even though the green plants are much less in number. The stream animals usually have a narrow range of tolerance to oxygen. That is the reason why they are very susceptible to any organic pollution which depletes dissolved oxygen in the water. Thus, streams are the worst victims of industrial development.

D. RIVER ECOSYSTEM: Rivers are large streams that flow downward from mountain highlands and flowing through the plains fall into the sea (fig.3.2.8). So the river ecosystems show a series of different conditions.

The mountain highland part has cold, clear waters rushing down as waterfalls with large amounts of dissolved oxygen. The plants are attached to rocks (periphytons) and fishes are cold-water, high oxygen requiring fish like trouts.

In the second phase on the gentle slopes, the waters are warmer and support a luxuriant growth of plants and less oxygen requiring fishes.

In the third phase, the river waters are very rich in biotic diversity. Moving down the hills, rivers shape the land. They bring with them lots of silt rich in nutrients which are deposited in the plains and in the delta before reaching the ocean.

Fig.3.2.8.River Eosystem

II. MARINE OR SALT WATER ECOSYSTEM/OCEANIC ECOSYSTEM

Ocean Ecosystem: These are gigantic reservoirs of water covering more than 70% of our earth's surface and play a key role in the survival of about 2,50,000 marine species, serving as food for humans and other organisms, give a huge variety of sea-products and drugs (fig.3.2.9). Oceans provide us iron, phosphorus, magnesium, oil, natural gas, sand and gravel.

The ocean is divided into various zones

- Intertidal (This Area affected by tidal changes and including Beaches, estuaries and tidal pools)
- Neritic (A gentle sloped and shallow(200 m) depth ocean extended to the edge of Continental shelf)
- Oceanic and (Steep slopes as continental slope area over the abyssal plain)
- Abyssal (Dark ocean floor consist of underwater mountains including volcanic rifts and mud etc.)

Based on depth and light penetration ocean divides as

✓ Epipelagic, mesopelagic, bathypelagic and abyss pelagic.

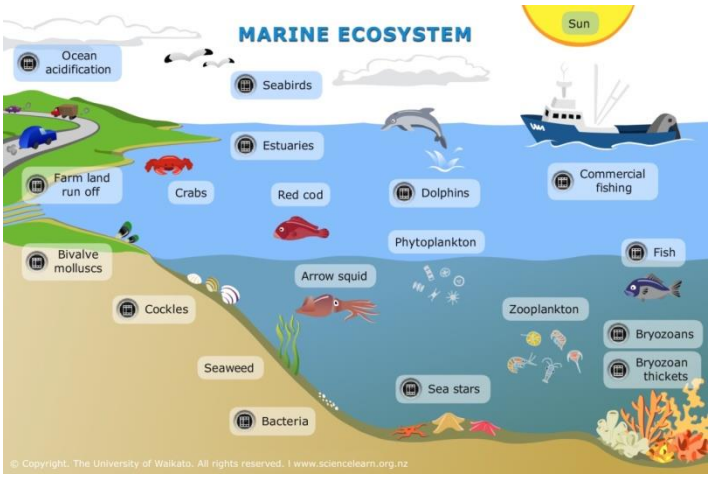


Fig.3.2.9. Marine Ecosystem

Oceans are the major sinks of carbon dioxide and play an important role in regulating many biogeochemical cycles and hydrological cycle, thereby regulating the earth's climate.

Coastal zone with relatively warm, nutrient rich shallow water. Due to high nutrients and ample sunlight this is the zone of high primary productivity.

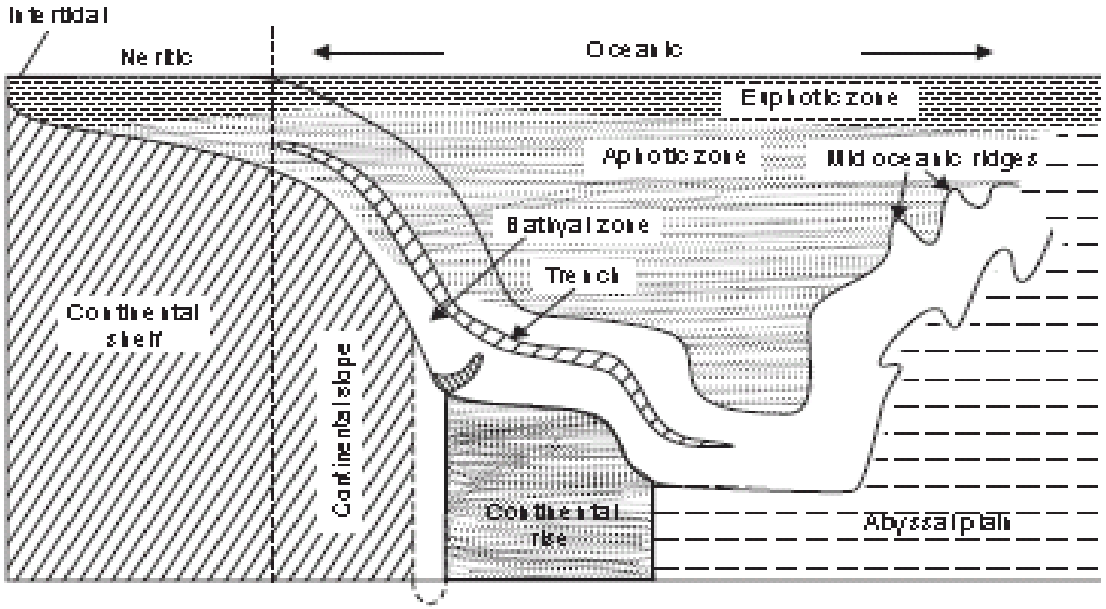


Fig.3.2.10 Regions of open sea.

Open sea: It is the deeper part of the ocean, away from the continental shelf (The submerged part of the continent). It is vertically divided into three regions:

(i) Euphotic zone which receives abundant light and shows high photosynthetic activity.
(ii) Bathyal zone receives dim light and is usually geologically active.
(iii) Abyssal zone is the dark zone, 2000 to 5000 metres deep. The abyssal zone has no primary source of energy i.e. solar energy.

It is the world's largest ecological unit but it is an incomplete ecosystem.

ECOSYSTEM CHARACTERISTICS:

- ✓ Ecosystem is a major ecological unit.
- ✓ It contains both biotic and abiotic components.
- ✓ The boundary of an ecosystem is not rigid and is flexible.
- ✓ Through biotic and abiotic components nutrient cycles and energy flow occur.
- ✓ The amount of energy needed to maintain an ecosystem depends on its structure.
- ✓ Ecosystem passes from less complex state to more complex state, which is called succession.

3.3. STRUCTURAL FEATURES/COMPONENTS OF AN ECOSYSTEM

Composition and organization of biological communities and abiotic components constitute the structure of an ecosystem. It divides into biotic and abiotic structure(fig.3.3.1).

Biotic structure

- Species population (Number)
- Species distribution
- Species life history

ABiotic structure

- Water, Soil and Nutrients
- Temparature,light,humidity,wind and wave action etc.

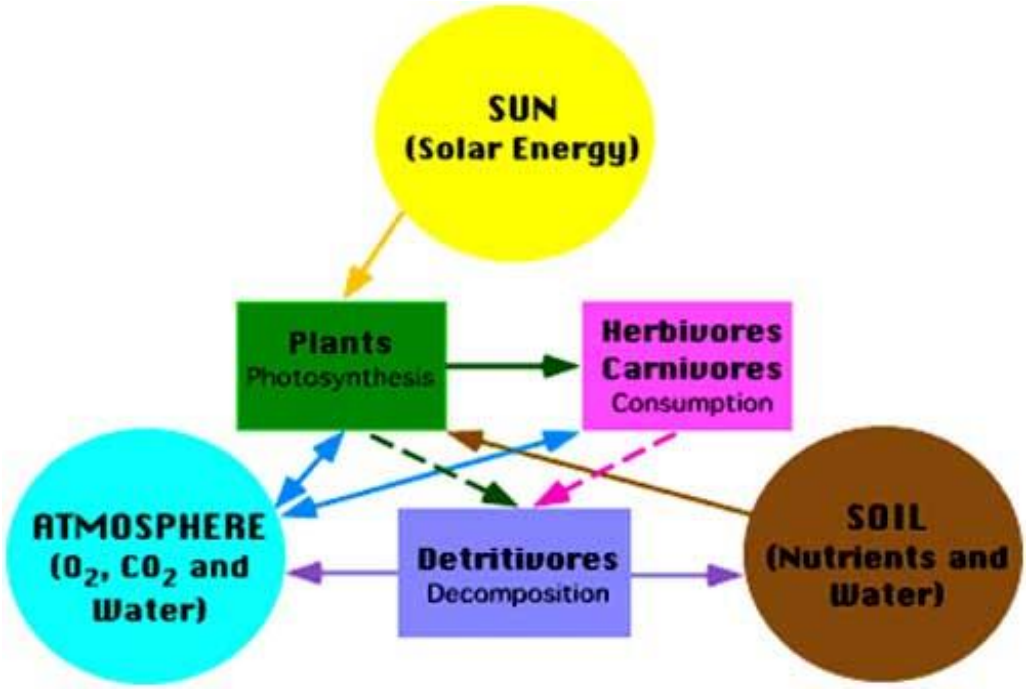


Fig.3.3.1 Structure of ecosystem

3.3.1. Biotic Structure :

The plants, animals and microorganisms present in an ecosystem form the biotic component. These organisms have different nutritional behavior and status in the ecosystems and are accordingly known as Producers or Consumers, based on how they get their food.

(a) Producers: They are mainly the green plants, which can synthesize their food themselves by making use of carbon dioxide present in the air and water in the presence of sunlight by involving chlorophyll, the green pigment present in the leaves, through the process of photosynthesis. They are also known as photo autotrophs (auto=self; troph=food, photo=light).

There are some microorganisms also which can produce organic matter to some extent through oxidation of certain chemicals in the absence of sunlight. They are known as chemosynthetic organisms or chemo-autotrophs.

(b) Consumers: All organisms which get their organic food by feeding upon other organisms are called consumers, which are of the following types:

(i) Herbivores (plant eaters): They feed directly on producers and hence also known as primary consumers.

E.g. rabbit, insect, man.

(ii) Carnivores (meat eaters): They feed on other consumers. If they feed on herbivores they are called secondary consumers. (E.g. frog) and if they feed on other carnivores (snake, big fish etc.) they are known as tertiary carnivores/consumers.

(iii) Omnivores: They feed on both plants and animals.

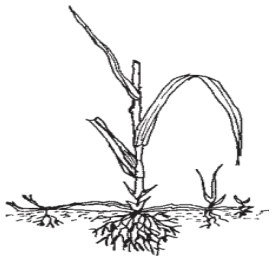
E.g. humans, rat, fox, many birds.

(iv) Detritivores (Detritus feeders or Saprotrophs): They feed on the parts of dead organisms, wastes of living organisms, and their cast-offs and partially decomposed matter.

E.g. beetles, termites, ants, crabs, earthworms etc.

(c) Decomposers: They derive their nutrition by breaking down the complex organic molecules to simpler organic compounds and ultimately into inorganic nutrients. Various bacteria and fungi are decomposers.

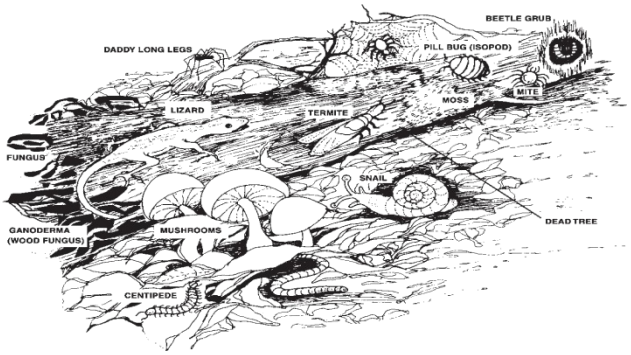
In all the ecosystems, this biotic structure prevails. However, in some, it is the primary producers which predominate (e.g. in forests, agro ecosystems) while in others the decomposers predominate (e.g. deep ocean).



Producer

herbivores

Carnivore



Detritivore

3.3.2 Abiotic Structure

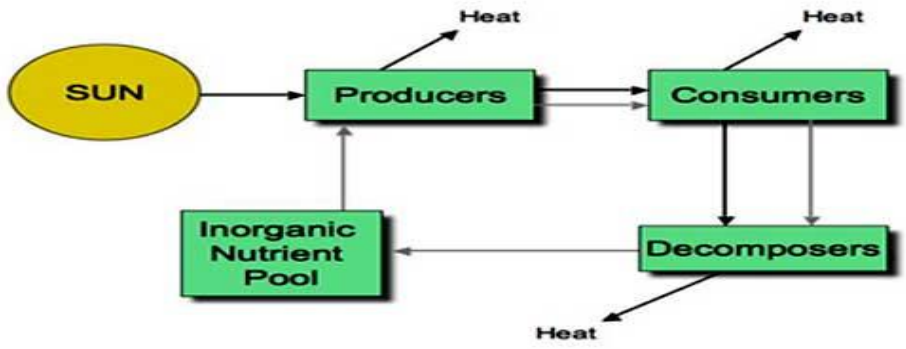
The physical and chemical components of an ecosystem constitute its abiotic structure. It includes climatic factors, edaphic (soil) factors, geographical factors, energy, nutrients and toxic substances.

(a) Physical factors: The sunlight and shade, intensity of solar flux, duration of sun hours, average temperature, maximum-minimum temperature, annual rainfall, wind, latitude and altitude, soil type, water availability, water currents etc. are some of the important physical features which have a strong influence on the ecosystem.

We can clearly see the striking differences in solar flux, temperature and precipitation (rainfall, snow etc.) pattern in a desert ecosystem, in a tropical rainforest and in tundra ecosystem.

(b) Chemical factors: Availability of major essential nutrients like carbon, nitrogen, phosphorus, potassium, hydrogen, oxygen and sulphur, level of toxic substances, salts causing salinity and various organic substances present in the soil or water largely influence the functioning of the ecosystem.

All the biotic components of an ecosystem are influenced by the abiotic components and vice versa, and they are linked together through energy flow and matter as shown.



3.4. FUNCTIONING OF AN ECOSYSTEM

Every ecosystem performs under natural conditions in a systematic way. It receives energy from the sun and passes it on through various biotic components and in fact, all life depends upon this flow of energy.

The major functional attributes of ecosystems are as follows:

(i) Food chain, food webs and trophic structure
(ii) Energy flow
(iii) Cycling of nutrients (Biogeochemical cycles)

TROPHIC STRUCTURE

The flow of energy is mediated through a series of feeding relation-ships in a definite sequence or pattern which is known as food chain. Nutrients to move along the food chain. The producers and consumers are arranged in the ecosystem in a definite manner and their inter-action along with population size is expressed together as *trophic structure*. Each food level is known as trophic level and the amount of living matter at each trophic level at a given time is known as standing crop or standing biomass.

3.4.1. FOOD CHAINS

The sequence of eating and being eaten in an ecosystem is known as food chain. All organisms, living or dead, are potential food for some other organism and thus, there is essentially no waste in the functioning of a natural ecosystem.

A caterpillar eats a plant leaf, a sparrow eats the caterpillar, a cat or a hawk eats the sparrow and when they all die, they are all consumed by microorganisms like bacteria or fungi (decomposers) which break down the organic matter and convert it into simple inorganic substances that can again be used by the plants-the primary producers.

The length of a food chain is a continuous variable providing a measure of the passage of energy through the linkages from the lowest to the highest trophic (feeding) levels.

a. Grass → Deer → Lion

a. Seeds → Mouse → Owl

b. Algae → Insects → Fish → Human

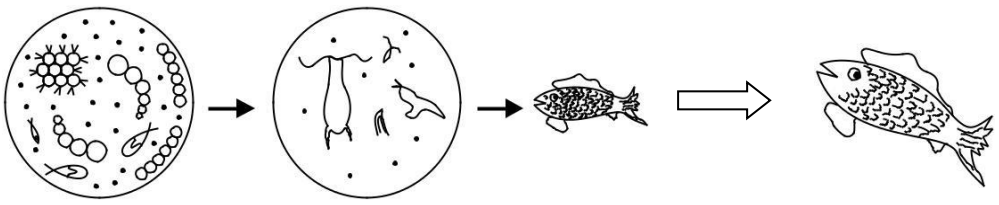
c. Sap → Aphid → Beetle → Spider → Lizard → Snake → Hawk

Bacteria ← Tick ← Wolf ← dead

dead ← Paracite ← dead

I. **Grazing food chain:** It starts with green plants (primary producers) and culminates in carnivores. All the examples cited above show this type of food chain.

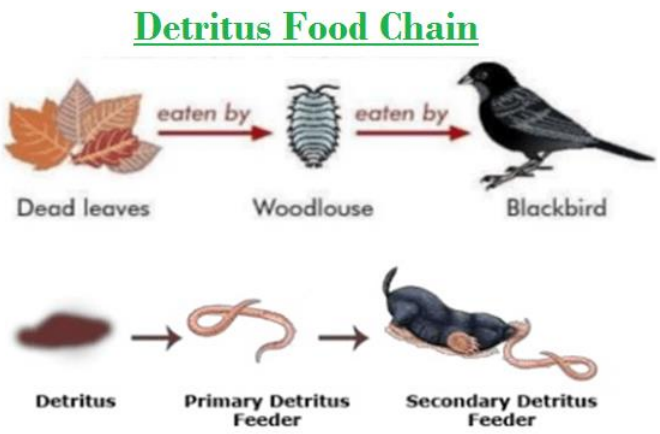
Another examples of grazing food chain in pond.



Phytoplanktons (Algae) Zooplanktons Small fish Carnivore fish

(A grazing food chain in a pond ecosystem)

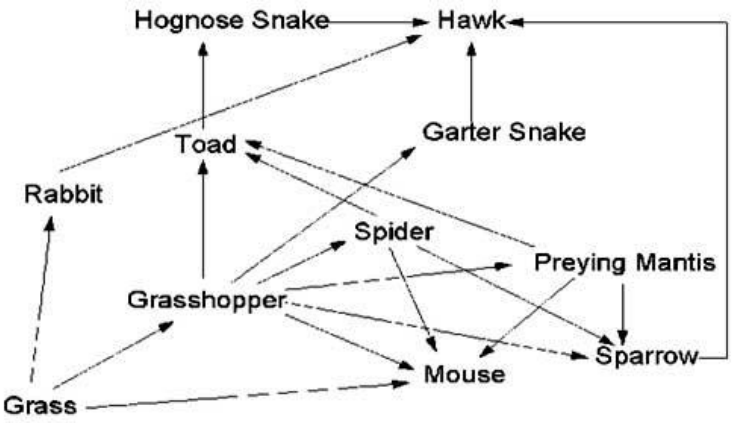
II. Detritus food chain: It starts with dead organic matter which the detritivores and decomposers consume. Partially decomposed dead organic matter and even the decomposers are consumed by detritivores and their predators. An example of the detritus food chain is seen in a Mangrove (estuary).



3.4.2 FOOD WEB :

Food web is a network of food chains where different types of organisms are connected at different trophic levels, so that there are a number of options of eating and being eaten at each trophic level.

In a tropical region, on the other hand, the ecosystems are much more complex. They have rich species diversity and therefore, the food webs are much more complex.



Significance of food chains and food webs :

❖ Food chains and food webs play a very significant role in the ecosystem because the two most important functions of energy flow and nutrient cycling take place through them.

❖ The food chains also help in maintaining and regulating the population size of different animals and thus, help maintain the ecological balance.

❖ Food chains show a unique property of biological magnification of some chemicals. There are several pesticides, heavy metals and other chemicals which are non-biodegradable in nature. Such chemicals are not decomposed by microorganisms and they keep on passing from one trophic level to another. And, at each successive trophic level, they keep on increasing in concentration. This phenomenon is known as biomagnification or biological magnification.

3.5A. ECOLOGICAL PYRAMIDS :

Graphic representation of trophic structure and function of an ecosystem, starting with producers at the base and successive trophic levels forming the apex is knows as an ecological pyramid.

Ecological pyramids are of three types:

3.5.1. PYRAMID OF NUMBERS: It represents the number of individual organisms at each trophic level. We may have upright or inverted pyramid of numbers, depending upon the type of ecosystem and food chain.

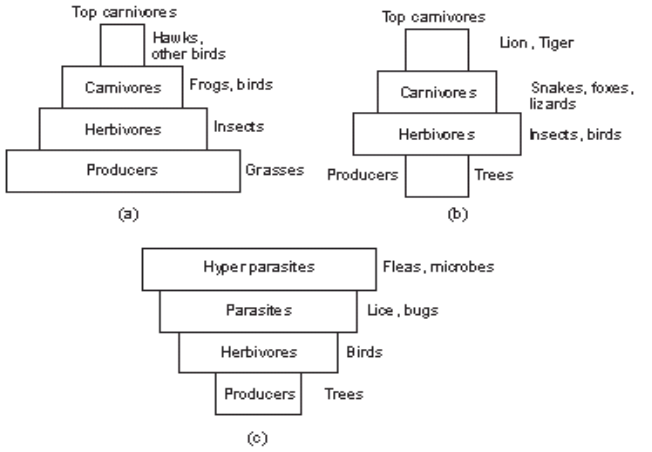


Fig. 3.5. Pyramid of numbers (*a*) grassland (*b*) forest (*c*) Parasitic food chain.

3.5.2. PYRAMID OF BIOMASS: It is based upon the total biomass (dry matter) at each trophic level in a food chain. The pyramid of biomass can also be upright or inverted.

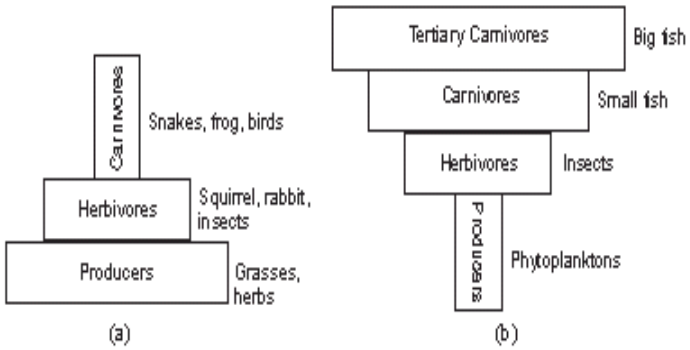


Fig. 3.6. Pyramid of biomass (*a*) Grassland (*b*) Pond.

3.5.3. PYRAMID OF ENERGY: The amount of energy present at each trophic level is considered for this type of pyramid. Pyramid of energy gives the best representation of the trophic relationships and it is always upright.

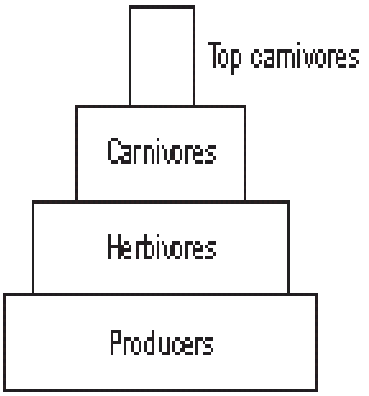


Fig. 3.7. Pyramid of energy.

At every successive trophic level, there is a huge loss of energy (about 90%) in the form of heat, respiration etc. Thus, at each next higher level only 10% of the energy passes on. Hence, there is a sharp decline in energy level of each successive trophic level as we move from producers to top carnivores. Therefore, the pyramid of energy is always upright.

3.5.B. ECOLOGICAL SUCCESSION

It is defined as the process in which communities of plant and animal species in a particular area are replaced overtime by a series of different communities.

Classification of succession :

A. **Primary succession :** This succession taking place in areas that have not already been occupied by any community is known as primary succession.

The first group of organisms established in such an area is called pioneer community.

Ex: forest developing on new soil.

B. **Secondary succession :** Development of a new community in an area where the previously existing community was removed and the ecological conditions are favorable is termed as secondary succession.

Ex: abandoned crop lands, ploughed fields

Process of succession :

Process of succession includes the following stages.

Pioneer stage ------→ Seral stage -----→ Climax stage

1. **Pioneer stage :** Pioneer is the first stage to migrate and become established in a bare area from the surrounding area in either primary or secondary succession.

The individual organisms of such community are called pioneer species and such community is known as pioneer community.

Charecteristics of pioneer species :

- It has less population.
- Its nutrient requirement is very less.
- The rate of growth should be as low as possible.
- It should be more dynamic to inter and intra specific competitions.

The pioneer community normally exists for a short interval of time. The death and decay of pioneer species leads to considerable increase of the organic matter, moisture and nitrogen content in the soil.

2. **Seral stage :** It is the development of secondary community from the pioneers. Each seral stage appears, grows and finally disappears as environmental changes occure.

   Each seral stage has its particular community called seral community.

3. **Climax stage :** A community finally appears that is not supported by another one, as long as climatic changes do not occure. This relatively stable community is called climax community.

Theories of succession :

There are three theories concerning climax communities.

a) **Mono climax theory :** According to this theory, there is only one climax community in a given climatic or geographical region. This theory was proposed by Fredrick Clements, an American ecologist in 1916.

b) **Poly climax theory :** According to this theory, a number of different climax communities may be present in a climatic or geographical region.

c) **Climax pattern theory :** According to this theory, the structure, composition and other characters of the climax communities are determined by the total environment of the ecosystem and not by a single factor.

Thus the climax community may be represented by a pattern of animal communities which have close interrelationship into the flora and fauna of the area, soil and climate.

NUTRIENT CYCLES IN ECOSYSTEMS

Besides energy flow, the other important functional attribute of an ecosystem is nutrient cycling. Nutrients like carbon, nitrogen, sulphur, oxygen, hydrogen, phosphorus etc. move in circular paths through biotic and abiotic components and are therefore known as biogeochemical cycles. Water also moves in a cycle, known as hydrological cycle.

The nutrients to move through the food chain and ultimately reach the detritus compartment (containing dead organic matter) where various micro-organisms carry out decomposition. Various organically bound nutrients of dead plants and animals are converted into inorganic substances by microbial decomposition that is readily used up by plants (primary producers) and the cycle starts afresh.

Nitrogen cycle

Cycling of one such important nutrient nitrogen is shown in Fig. Nitrogen is present in the atmosphere as N_2 in large amount (78%) and it is fixed either by the physical process of lightening or biologically by some bacteria and/or cyan bacteria (blue green algae).

The nitrogen is taken up by plants and used in metabolism for biosynthesis of amino acids, proteins, vitamins etc. and passes through the food chain. After death of the plants and animals, the organic nitrogen in dead tissues is decomposed by several groups of ammonifying and nitrifying bacteria which convert them into ammonia, nitrites and nitrates, which are again used by plants. Some bacteria convert nitrates, into molecular nitrogen or N_2 which is released back into the atmosphere and the cycle goes on.

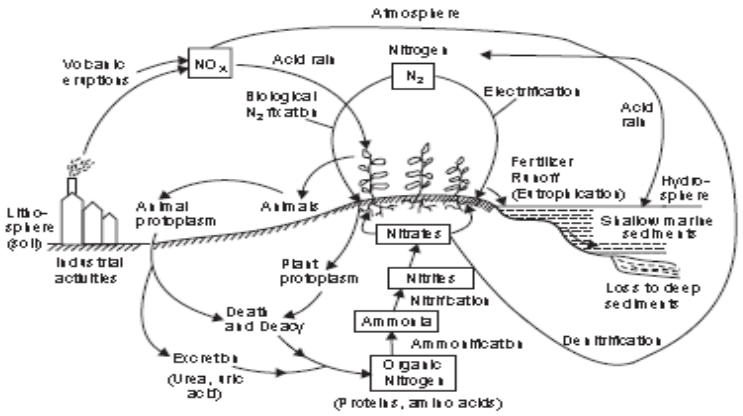


FIG: Nitrogen cycle

Carbon Cycle

Sometimes human interferences disturb the normal cycling of such nutrients and create imbalances. For example, nature has a very balanced carbon cycle (Fig. 3.12). Carbon, in the form of carbon dioxide is taken up by green plants as a raw material for photosynthesis, through which a variety of carbohydrates and other organic substances are produced. Through the food chain it moves and ultimately organic carbon present in the dead matter is returned to the atmosphere as carbon dioxide by microorganisms. Respiration by all organisms produces carbon dioxide, while the latter is used up by plants.

In the recent years carbon dioxide levels have increased in the atmosphere due to burning of fossil fuels etc. which has caused an imbalance in the natural cycle and the world today is facing the serious problem of global warming due to enhanced carbon dioxide emissions.

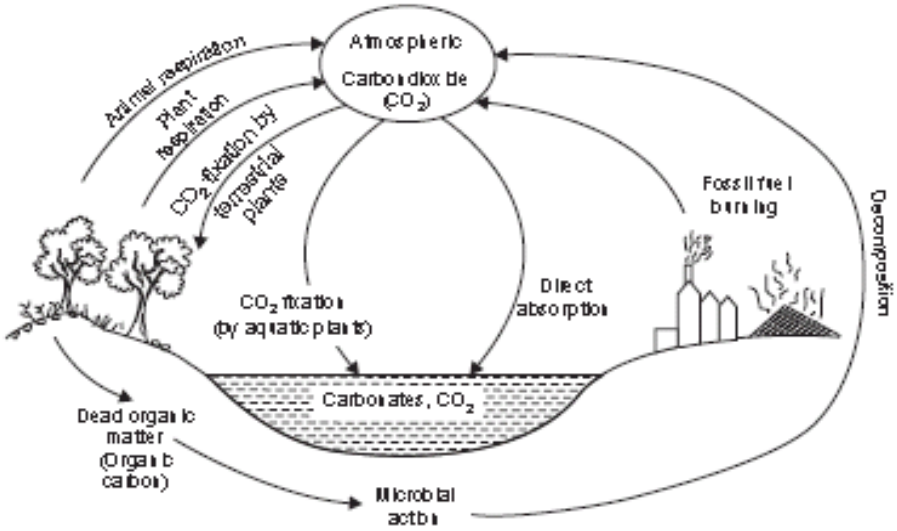
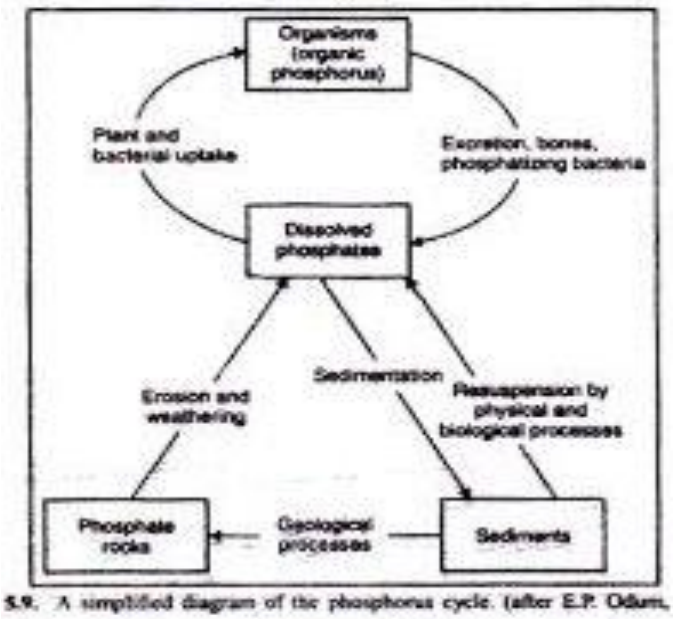


Fig. 3.12. Carbon cycle.

Phosphorous cycle

Phosphorous cycle is another important nutrient cycle-which is shown in Fig. 5.9. The reservoir of phosphorus lies in the rocks, fossils etc. which is excavated by man for using it as a fertilizer. Farmers use the phosphate fertilizers indiscriminately and as a result excess phosphates are lost as run-off, which causes the problem of eutrophication or overnourishment of lakes leading to algal blooms as already discussed .

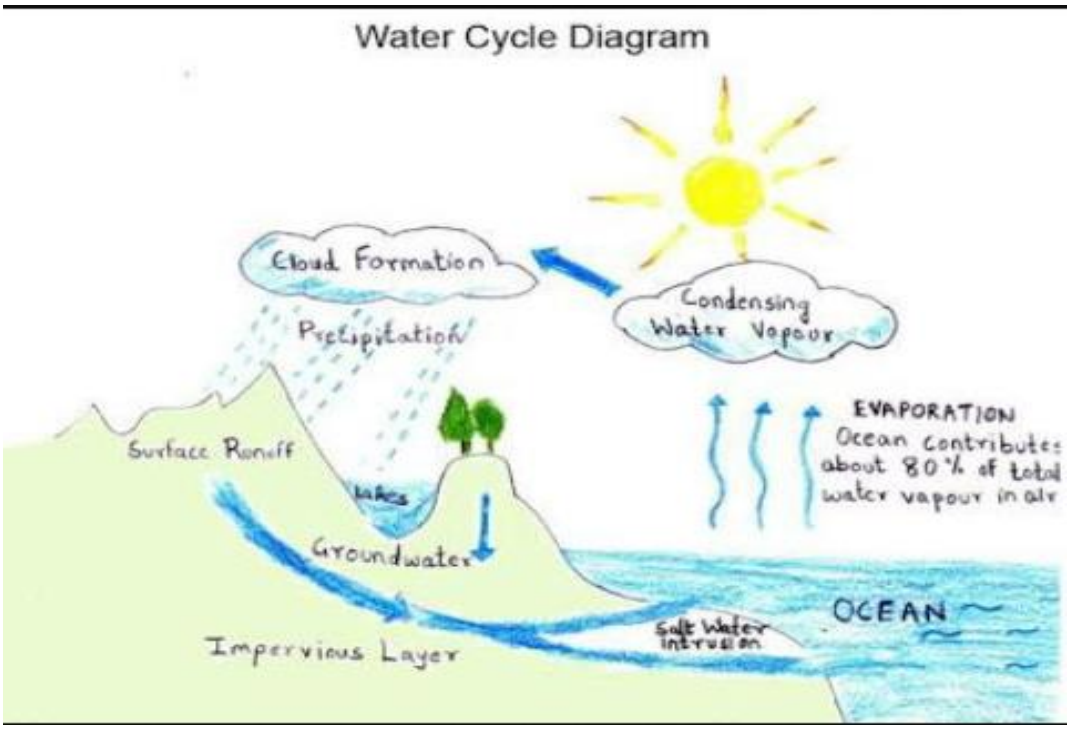


5.9. A simplified diagram of the phosphorus cycle. (after E.P. Odum,

A good proportion of phosphates moving with surface run-off reaches the oceans and are lost into the deep sediments. Our limited supply of phosphorus lying in the phosphate rocks of this earth are thus over-exploited by man and a large part is taken out of the normal cycle due to loss into oceans. So human beings are making the phosphorous cycle acyclic. Sea birds, on the other hand, are playing an important role in phosphorus cycling. They eat sea-fishes

which are phosphorus rich and the droppings or excreta of the birds return the phosphorus on the land. The Guano deposits on the coasts of Peru are very rich sources of phosphorus.

Hydrological cycle :



The water cycle is powered by the sun and gravity.
Solar energy causes water to evaporate from the ocean, rivers, lakes and other waterbodies.
Plants extract the water from the soil through their roots and transport it to their leaves from where it evaporates. This process is called transpiration.

Wind and air move water vapour through the atmosphere. When vapour cools, it condenses into tiny droplets that form clouds. The next stage is precipitation as rain or snow, mostly over the ocean and partly over land.

The water thet falls on the land may percolate trough the soil and collect in aquifers, or it may flow back to the ocean as run-off through the rivers and streams.

BIODIVERSITY AND ITS CONSERVATION

3.6. INTRODUCTION AND CLASSIFICATION OF BIO-DIVERSITY

Today most of us live in a socially and technologically evolved society where our exploitive potential and knowledge of nature has increased academically. The problem is that our contact with it has diminished morally. It may have diminished to such an extent as to be dangerous to us and to the nature itself. Biodiversity is the vast array of all the species of plants, animals, insects and the microorganisms inhabiting the earth either in the aquatic or the terrestrial habitats. The human civilization depends directly or indirectly upon this biodiversity for their very basic needs of survival–food, fodder, fuel, fertilizer, timber, liquor, rubber, leather, medicines and several raw materials. This diversity's the condition for the long-term sustainability of the environment, continuity of life on earth and the maintenance of its integrity.

'Biodiversity refers to the variety and variability among all groups of living organisms and the ecosystem complexes in which they occur.'

Although our understanding of the earth's organisms–its biological resources- is still imperfect, there is no doubt that the abundance and diversity of living organisms provide many benefits and make our world a beautiful and interesting place to live.

TYPES/CLASSIFICATION OF BIODIVERSITY

Biodiversity is generally described in terms of its 3 fundamental and hierarchically related levels of biological organisms. These are

GENETIC DIVERSITY

It includes the genetic variations within species, both among geographically separated populations and among individuals within single population.

SPECIES DIVERSITY

It includes full range of species from micro organisms to giants and mammoth varieties of plants and animals, *e.g.* single celled viruses and bacteria etc. and multi-cellular plants, animals and fungi.

ECOSYSTEMS DIVERSITY

It studies variation in the biological communities in which species Jive, exist and interact.

Because genes are parts of species, and the species make up ecosystems- the concept of biodiversity reflects an interrelationship among its three components. Biodiversity is distributed uniformly across the globe. It is substantially greater in some areas than in the others. Generally, species diversity increases from the poles towards the tropics- for instance, among the terrestrial systems, the tropical moist forests, which cover only 57% of the earth's land area, possess as much as over 50% of the world's species.

3.7. VALUES OF BIODIVERSITY

The value of biodiversity in terms of its commercial utility, ecological services, social and aesthetic value is enormous. We get benefits from other organisms in innumerable ways. Sometimes we realize and appreciate the value of the organism only after it is lost from this earth. Very small, insignificant, useless looking organism may play a crucial role in the ecological balance of the ecosystem or may be a potential source of some invaluable drug for dreaded diseases like cancer or AIDS. The multiple uses of biodiversity or biodiversity value has been classified by McNeely et al in 1990 as follows:

(i) Consumptive use value: These are direct use values where the biodiversity product can be harvested and consumed directly e.g. fuel, food, drugs, fibre etc.

Food: A large number of wild plants are consumed by human beings as food. About 80,000 edible plant species have been reported from wild. About 90% of present day food crops have been domesticated from wild tropical plants. A large number of wild animals are also our sources of food.

Drugs and medicines: About 75% of the world's population depends upon plants or plant extracts for medicines. The wonder drug Penicillin used as an antibiotic is derived from a fungus called Penicillium. Likewise, we get Tetracyclin from a bacterium. Quinine, the cure for malaria is obtained from the bark of Cinchona tree, while Digitalin is obtained from foxglove (Digitalis) which is an effective cure for heart ailments. Recently vinblastin and vincristine, two anticancer drugs, have been obtained from Periwinkle (Catharanthus) plant, which possesses anticancer alkaloids. A large number of marine animals are supposed to possess anti-cancer properties which are yet to be explored systematically.

Fuel: Our forests have been used since ages for fuel wood. The fossil fuels coal, petroleum and natural gas are also products of fossilized biodiversity. Firewood collected by individuals are not normally marketed, but are directly consumed by tribals and local villagers, hence falls under consumptive value.

(ii) Productive use values: These are the commercially usable values where the product is marketed and sold. It may include lumber or wild gene resources that can be traded for use by scientists for introducing desirable traits in the crops and domesticated animals. These may include the animal products like tusks of elephants, musk from musk deer, silk from silk-worm, wool from sheep, fir of many animals, lac from lac insects etc, all of which are traded in the market. Many industries are dependent upon the productive use values of biodiversity

e.g.- the paper and pulp industry, Plywood industry, Railway sleeper industry, Silk industry, textile industry, ivory-works, leather industry, pearl industry etc.

Despite international ban on trade in products from endangered species, smuggling of fur, hide, horns, tusks, live specimen etc. worth millions of dollars are being sold every year. Developing countries in Asia, Africa and Latin America are the richest biodiversity centers and wild life products are smuggled and marketed in large quantities to some rich western countries and also to China and Hong Kong where export of cat skins and snake skins fetches a booming business.

(iii) Social Value: These are the values associated with the social life, customs, religion and psycho-spiritual aspects of the people. Many of the plants are considered holy and sacred in our country like Tulsi (holy basil), Peepal, Mango, Lotus, Bael etc. The leaves, fruits or flowers of these plants are used in worship or the plant itself is worshipped. The tribal people are very closely linked with the wild life in the forests. Their social life, songs, dances and customs are closely woven around the wildlife. Many animals like Cow, Snake, Bull, Peacock, Owl etc. also have significant place in our psycho-spiritual arena and thus hold special social importance. Thus biodiversity has distinct social value, attached with different societies.

(iv) Ethical value: It is also sometimes known as existence value. It involves ethical issues like "all life must be preserved". It is based on the concept of "Live and Let Live". If we want our human race to survive, then we must protect all biodiversity, because biodiversity is valuable.

(v) Aesthetic value: Great aesthetic value is attached to biodiversity. No one of us would like to visit vast stretches of barren lands with no signs of visible life. People from far and wide spend a lot of time and money to visit wilderness areas where they can enjoy the aesthetic value of biodiversity and this type of tourism is now known as eco-tourism. The "Willingness to pay" concept on such eco-tourism gives us even a monetary estimate for aesthetic value of biodiversity. Ecotourism is estimated to generate about 12 billion dollars of revenue annually that roughly gives the aesthetic value of biodiversity.

(vi) Option values: These values include the potentials of biodiversity that are presently unknown and need to be explored. There is a possibility that we may have some potential cure for AIDS or cancer existing within the depths of a marine ecosystem, or a tropical rain-forest.

Thus option value is the value of knowing that there are biological resources existing on this biosphere that may one day prove to be an effective option for something important in the future. Thus, the option value of biodiversity suggests that any species may prove to be a miracle species someday. The biodiversity is like precious gifts of nature presented to us.

Different categories of biodiversity value clearly indicate that ecosystem, species and genetic diversity all have enormous potential and a decline in biodiversity will lead to huge economic, ecological and socio-cultural losses.

3.8. HOT SPOTS OF BIODIVERSITY

Areas which exhibit high species richness as well as high species endemism are termed as hot spots of biodiversity. The term was introduced by Normen Myers (1988). There are 25 such hot spots of biodiversity on a global level out of which two are present in India, namely the Eastern Himalayas and Western Ghats.

These hotspots covering less than 2% of the world's land area are found to have about 50% of the terrestrial biodiversity. According to Myers et al. (2000) an area is designated as a hotspot when it contains at least 0.5% of the plant species as endemics.

About 40% of terrestrial plants and 25% of vertebrate species are endemic and found in these hotspots. After the tropical rain forests, the second highest number of endemic plant species are found in the Mediterranean (Mittermeier). Broadly, these hot spots are in Western Amazon, Madagascar,West Africa. These are the areas of high diversity, endemism and are also threatened by human activities

(a) Eastern Himalayas: They display an ultra-varied topography that fosters species diversity and endemism.

These are numerous deep and semi-isolated valleys in Sikkim which are extremely rich in endemic plant species. In an area of 7298 Km^2 of Sikkim about 4250 plant species are found of which 60% are endemic.

The forest cover of Eastern Himalayas has dwindled to about 1/3rd of its original cover. Certain species like Sapria himalayana, a parasitic angiosperm was sighted only twice in this region in the last 70 years.

Out of the world's recorded flora 30% are endemic to India of which 35,000 are in the Himalayas.

(b) Western Ghats: It extends along a 17,000 Km^2 strip of forests in Maharashtra, Karnataka, Tamil Nadu and Kerala and has 40% of the total endemic plant species. 62% amphibians and 50% lizards are endemic to Western Ghats.

Forest tracts upto 500 m elevation covering 20% of the forest expanse are evergreen while those in 500-1500 m range are semi-evergreen. The major centers of diversity are Agastyamalai Hills and Silent Valley—the New Amambalam Reserve Basin. It is reported that only 6.8% of the original forests are existing today while the rest has been deforested.

Although the hotspots are characterized by endemism, interestingly, a few species are common to both the hotspots in India. Some common plants include Ternstroemia japonica, Rhododendron and Hypericum, while the common fauna includes laughing thrush, Fairy blue bird, lizard hawk etc. indicating their common origin long back in the geological times.

INDIA AS A MEGA-DIVERSITY NATION

India is one of the 12 mega diversity countries in the world. The Ministry of Environment and Forests, Govt. of India (2000) records 47,000 species of plants and 81,000 species of animals which is about 7% and 6.5% respectively of global flora and fauna.

- **Endemism:** Species which are restricted only to a particular area are known as endemic. India shows a good number of endemic species. About 62% of amphibians and 50% of lizards are endemic to India. Western ghats are the site of maximum endemism.
- **Center of origin:** A large number of species are known to have originated in India. Nearly 5000 species of flowering plants had their origin in India. From agro-diversity point of view also our country is quite rich. India has been the center of origin of 166 species of crop plants and 320 species of wild relatives of cultivated crops, thereby providing a broad spectrum of diversity of traits for our crop plants.
- **Marine diversity:** Along 7500 km long coastline of our country in the mangroves, estuaries, coral reefs, back waters etc. there exists a rich biodiversity. More than 340 species of corals of the world are found here. The marine diversity is rich in mollusks, crustaceans (crabs etc.), polychaetes and corals. Several species of Mangrove plants and seagrasses (Marine algae) are also found in our country.

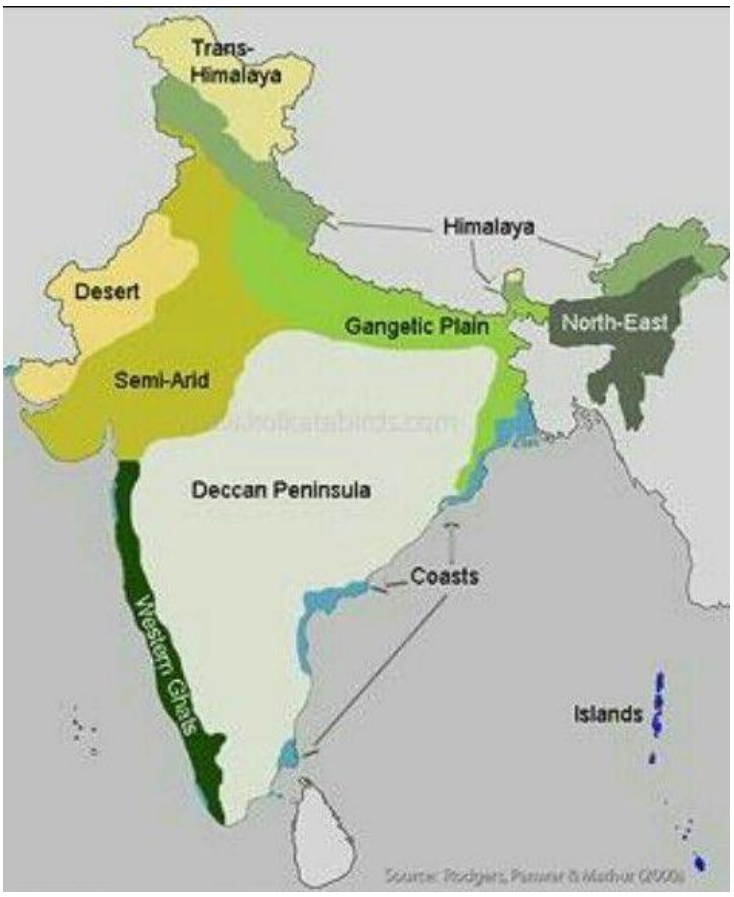
A large proportion of the Indian Biodiversity is still unexplored. Indian forests cover 64.01 million hectares having a rich biodiversity of plants in the Trans-Himalayan, north-west, west, central and eastern Himalayan forests, western ghats, coasts, deserts, Gangetic plains, deccan plateau and the Andaman, Nicobar and Lakshadweep islands. Due to very diverse climatic conditions there is a complete rainbow spectrum of biodiversity in our country.

BIOGEOGRAPHICAL CLASSIFICATION OF INDIA

The study of the geographical distribution of biological species relating to the geological, evolutionary, climatological, geographical, biological reasons for the distribution is called biogeography.

India has different types of climate and topography in different parts of the country and these variations have induced enormous variability in flora and fauna. India has a rich heritage of biological diversity and occupies the tenth position among the plant rich nations of the world.

It is very important to study the distribution, evolution, dispersal and environmental relationship of plants and animals in time and space.



There are 10 biogeographical zones in India. They can be classified as under.

1. **Trans-Himalayas :** It is the extinction of Tibetan plateau. This region has harboring high altitude cold desert in Laddakh(Jammu &Kashmir) and Lahaul Spiti(Himachal Pradesh). It comprises 5.7% of the country's land mass.
2. **Himalayas :** These are the northen boundaries of India. The entire mountain chain is running from Kashmir to Assam. The Himalayas comprises a diverse range of biotic provinces and biomes.
3. It covers an area of 7.2% of the country's land mass.
4. **Desert :** It is the extremely arid area west of Aravalli hill range, is comprising both salty desert of Gujarat and sand desert of Rajasthan. These are occupying about 6.9% of country's land mass.
5. **Semi-arid region :** It is the zone between desert and Deccan plateau. It includes the Aravalli hill range. It covers about 15.6% of country's land mass.
6. **Gangetic plain :** It cover from the south of Himalayas to the north of the Trophic of Cancer. These plains were formed by the Ganges river system. The world famous Sunderbans forests are in this region. It covers about 11% of country's land mass.
7. **Deccan Plateau :** It is the large triangular plateau south of the Narmada valley. The three sides of the plateau are covered with mountains and slopes towards east. Satpura mountain covers the north side, the Western ghats covers the west side ans the Eastern ghats civers the east side of this plateau. This is covering about 4.3% of country's land mass.
8. **North-East India :** The plains and non-himalayan hill ranges of northeastern India. It has a wide variation of vegetation. It covers about 4.3% of the country's land mass.

9. **Western Ghats :** These are the mountain range that runs along the western coast of India. They are a range extending from Gujarat to Kanyakumari. These mountains cover an area of about 1,60,000sq.kms. Some high peaks are also present in the southern part of Western ghats like Dodda Betta in Nilagiri mountains and Anaimudi in the Anamalai hills. It covers about 4.3% of the country's land mass.
10. **Islands :** The Andaman and Nicobar islands in the Bey of Bengal has 300 islands which are both small and large. Of these only five islands have human population. Only tribes are living in most of the Nicobar islands and it has a set of biomes. These islands are occupying about 0.03% of the country's land mass.
11. **Coasts :** A large coast line distributed both to the west and east sides of India.

3.9. THREATS TO BIODIVERSITY

The biggest reason for the current increase in extinctions is habitat loss. Destruction of tropical forests, coral reefs, estuaries. Marshes, and other biologically rich ecosystems threaten to eliminate thousands or even millions of species in a human-caused mass extinction that could rival those of geologic history.

By destroying habitat, we eliminate not only prominent species but also many obscure ones of which we may not even be aware. Over harvesting of food species is probably the most obvious way in which humans directly destroy biological resources. There are many, historic examples of human disturbances of natural systems.

(i) Habitat Destruction

Deforestation has been one of the major causes for the depletion of wildlife. With the increase in human population and the growing need for resources, forests were cleared or for agricultural operations, for human habitation and for grazing their livestock. Technological advance and human progress had a direct bearing on the exploitation of natural resources. Forest trees were cut to yield timber for building houses, for making furniture and for collecting wood as fuel. Industries made a heavy demand on forest resources such as wood for paper- making, exploitation of gums and resins, mining. of forestland for mineral ores, building materials, etc.

Habitat destruction thus has an adverse impact on wildlife as it leads to the loss of an environment, which provides them food and breeding grounds or nesting sites to facilitate rearing of their young ones. Wild animals are left with no alternative but to adapt, migrate or perish. Widespread habitat loss all over the country has diminished the population of many species, making them rare-and endangered. In our race for progress and prosperity we have disturbed the delicate balance of Nature.

(ii) Hunting and Poaching

Uncontrolled hunting of wildlife for pleasure, food, furs. Skins, horns, tusks, etc. pose a serious threat to the survival of wildlife. In India, the Cheetah was hunted to extinction. The illegal trade in animal skins has been responsible for the destruction of a large number of tigers, leopards, deer, fishing cat, crocodiles and snakes, as well as birds with beautiful plumage. Elephants were hunted for ivory.

There are laws in the country to prevent such illegal trade, but unscrupulous elements, traders and exporters often violate these. Added to this is the practice of trade in exotic mammals, birds and reptiles and use of wild animals in biomedical research.

(iii) Pollution

Pollution of air, water and soil due to various industrial activities not only affect our health, but the health and well being of animal population also. Industrial effluents one reaching water bodies adversely affect aquatic life. Pesticides like DDT and Dieldrin are very harmful. These have a major effect particularly sea birds and their eggs. Oil pollution is another serious problem affecting the seas through leakage from cargo ships or accidents.

Besides there are other numerous factors that affect wildlife population, which are mostly anthropogenic.

(iv) Man and Wildlife Conflict

Man by virtue of his nature is destructive and self-centred despite the fact that he is known as social animal. Until he realizes the need of time no rules and regulations may help. The exploitation of forests and wildlife or rare species for commercial purposes should be stopped. A good tiger skin is worth more than five thousand rupees. The tusks of an elephant and the skin of big cats also fetch a good prize. The horns of rhinoceros carry a highly fancy prize. This high market value has lead to unlimited slaughter of these animals.

ENDANGERED SPECIES OF INDIA

The International Union for Conservation of Nature and Natural Resources (IUCN) publishes the Red Data Book which includes the list of endangered species of plants and animals. The red data symbolizes the warning signal for those species which are endangered and if not protected are likely to become extinct in near future.

In India, nearly 450 plant species have been identified in the categories of endangered, threatened or rare. Existence of about 150 mammals and 150 species of birds is estimated to be threatened while an unknown number of species of insects are endangered. It may not be of direct relevance here to give a complete list of endangered flora and fauna of our country. However, a few species of endangered reptiles, birds, mammals and plants are given below:

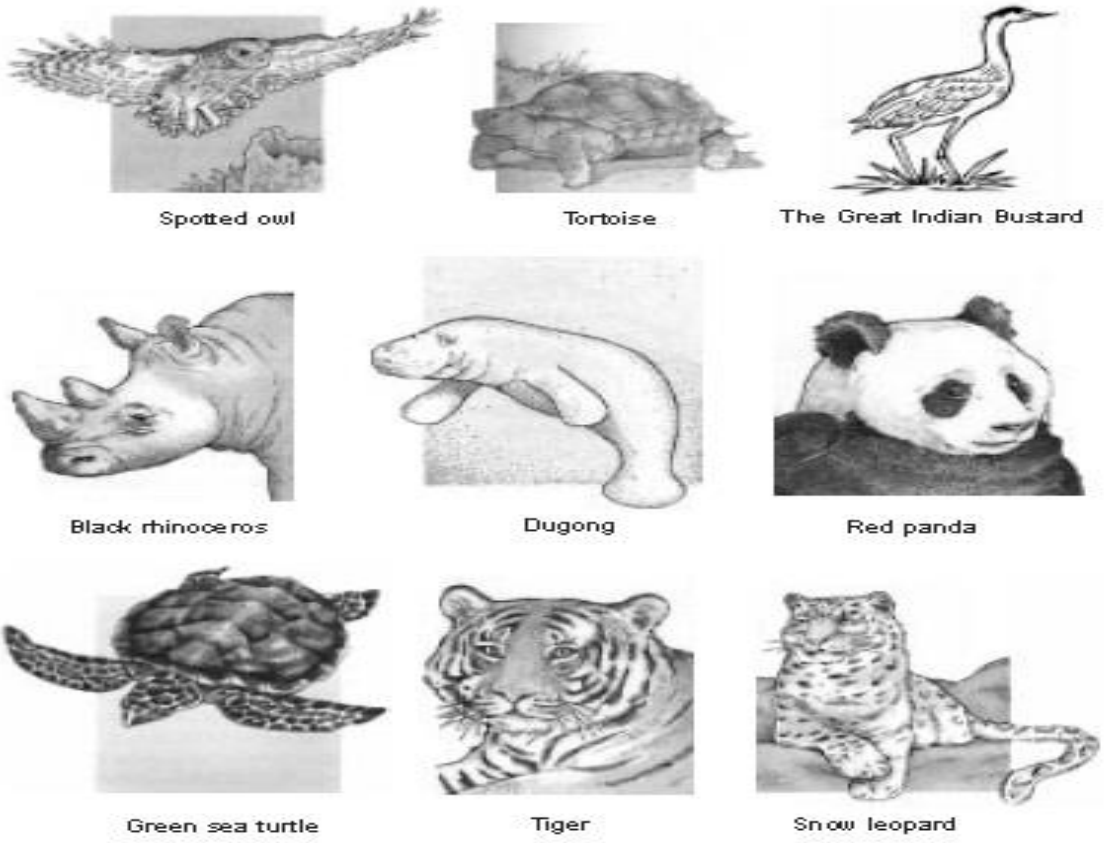
Examples: Tortoise, Peacock, Indian Wolf, Indian Lion, Species of orchids, Rhododendrons, Medicinal plants etc.

- A species is said to be endangered when its number has been reduced to a critical level or whose habitats, have been drastically reduced and if such a species is not protected and conserved, it is in immediate danger of extinction.

- A species is said to be in vulnerable category if its population is facing continuous decline due to overexploitation or habitat destruction. Such a species is still abundant, but under a serious threat of becoming endangered if causal factors are not checked.

- Species which are not endangered or vulnerable at present, but are at a risk are categorized as rare species. These taxa are usually localized within restricted areas.

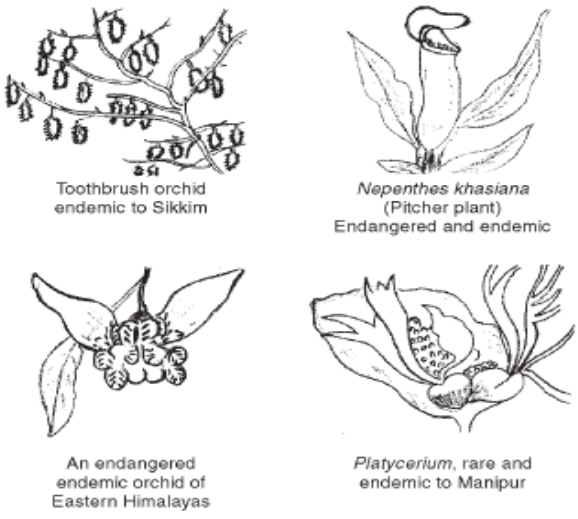
Some important endangered and extinct species are shown



ENDEMIC SPECIES OF INDIA

India has two biodiversity hot spots and thus possesses a large number of endemic species. Out of about 47,000 species of plants in our country 7000 are endemic. Thus, Indian subcontinent has about 62% endemic flora, restricted mainly to Himalayas, Khasi Hills and Western Ghats.

Some of the important endemic flora include orchids and species like Sapria himalayana, Uvaria lurida, Nepenthes khasiana, Pedicularis perroter etc.



A large number out of a total of 81,000 species of animals in our country is endemic. The western ghats are particularly rich in amphibians (frogs, toads etc.) and reptiles (lizards, crocodiles etc.). About 62% amphibians and 50% lizards are endemic to Western Ghats.

3.10. CONSERVATION OF BIODIVERSITY

The enormous value of biodiversity due to their genetic, commercial, medical, aesthetic, ecological and optional importance emphasizes the need to conserve biodiversity. Gradually we are coming to realize that wildlife is not just 'a game to be hunted', rather it is a 'gift of nature' to be nurtured and enjoyed. A number of measures are now being taken the world over to conserve biodiversity including plants and wildlife.

There are two approaches of biodiversity conservation:

A. In situ conservation (within habitat): This is achieved by protection of wild flora and fauna in nature itself.

e.g. Biosphere Reserves, National Parks, Sanctuaries, Reserve Forests etc.

B. Ex situ conservation (outside habitats): This is done by establishment of gene banks, seed banks, zoos, botanical gardens, culture collections etc.

A. *In Situ* Conservation :

At present we have 7 major Biosphere reserves, 80 National Parks, 420 wild-life sanctuaries and 120 Botanical gardens in our country covering 4% of the geographic area.

A National Park is an area dedicated for the conservation of wildlife along with its environment. It is also meant for enjoyment through tourism but without impairing the environment. Grazing of domestic animals, all private rights and forestry activities are prohibited within a National Park. Each National Park usually aims at conservation specifically of some particular species of wildlife along with others.

Wildlife sanctuaries are also protected areas where killing, hunting, shooting or capturing of wildlife is prohibited except under the control of highest authority. However, private ownership rights are permissible and forestry operations are also permitted to an extent that they do not affect the wildlife adversely.

B. *Ex situ Conservation:*

This type of conservation is mainly done for conservation of crop varieties, the wild relatives of crops and all the local varieties with the main objective of conserving the total genetic variability of the crop species for future crop improvement or afforestation programmes.

In India, we have the following important gene bank/seed bank facilities:

(i) National Bureau of Plant Genetic Resources (NBPGR) is located in New Delhi. Here agricultural and horticultural crops and their wild relatives are preserved by cryo-preservation of seeds, pollen etc. by using liquid nitrogen at a temperature as low as -196°C. Varieties of rice, pearl millet, Brassica, turnip, radish, tomato, onion, carrot, chilli, tobacco, poppy etc. have been preserved successfully in liquid nitrogen for several years without losing seed viability.

(ii) National Bureau of Animal Genetic Resources (NBAGR) located at Karnal, Haryana. It preserves the semen of domesticated bovine animals.

(iii) National Facility for Plant Tissue Culture Repository (NFPTCR) for the development of a facility of conservation of varieties of crop plants/trees by tissue culture. This facility has been created within the NBPGR.

3.11. BIODIVERSITY AT DIFFERENT LEVELS :

GLOBAL BIODIVERSITY: Following the 1992 "Earth Summit" at Rio de Janeiro, it became evident that there is a growing need to know and scientifically name, the huge number of species which are still unknown on this earth. Roughly 1.5 million species are known till date which is perhaps 15% or may be just 2% of the actual number. Tropical deforestation alone is reducing the biodiversity by half a percent every year. Mapping the biodiversity has therefore, been rightly recognized as an emergency task in order to plan its conservation and practical utilization in a judicious manner.

Terrestrial biodiversity of the earth is best described as biomes, which are the largest ecological units present in different geographic areas and are named after the dominant vegetation e.g. the tropical rainforests, tall grass prairies, savannas, desert, tundra etc.

The tropical rainforests are inhabited by teeming millions of species of plants, birds, amphibians, insects as well as mammals. They are the earth's largest storehouse of biodiversity. Many of these species have developed over the time in highly specialized niches and that makes them more vulnerable to extinction when their natural home or niche is destroyed. About 50 to 80% of global biodiversity lies in these rainforests. More than one-fourth of the world's prescription drugs are extracted from plants growing in tropical forests. Out of the 3000 plants identified by National Cancer Research Institute as sources of cancer fighting chemicals, 70% come from tropical rain forests. Very recently, extract from one of the creeping vines in the rainforests at Cameroon has proved effective in the inhibition of replication of AIDS virus. It is interesting to note that the common Neem tree, so popular in tropical India, known for its medicinal properties has now come into lime light even in the western temperate countries.

There is an estimated 1,25,000 flowering plant species in tropical forests. However, till now we know only 1-3% of these species. Need-less to say, we must try in every way to protect our tropical rainforests. The Silent Valley in Kerala is the only place in India where tropical rain forests occur.

BIOLOGICAL DIVERSITY AT NATIONAL LEVEL (Indian Biodiversity): Every country is characterized by its own biodiversity depending mainly on its climate. India has a rich biological diversity of flora and fauna. Overall six percent of the global species are found in India. It is estimated that India ranks 10th among the plant rich countries of the world, 11th in terms of number of endemic species of higher vertebrates and 6th among the centers of diversity and origin of agricultural crops.
Out of a total of 25 biodiversity hot-spots in the world, India possesses two, one in the North-East region and one in the Western Ghats. Indian is also one of the 12 mega-biodiversity countries in the world.

REGIONAL OR LOCAL BIODIVERSITY: Biodiversity at regional level is better understood by categorizing species richness into four types, based upon their spatial distribution as discussed below

(i) Point richness refers to the number of species that can be found at a single point in a given space.

(ii) Alpha **(α)** richness refers to the number of species found in a small homogeneous area

(iii) Beta **(β)** richness refers to the rate of change in species com-position across different habitats.

(iv) Gamma **(γ)** richness refers to the rate of change across large landscape gradients.-richness is strongly correlated with physical environmental variables.