CHAPTER III

ECOSYSTEM

3.1. Ecology and concept of ecosystem

The term ecology is now widely used. It is derived from the Greek roots ***oikos*** (meaning home) and ***logos*** (meaning study or discourse) which imply study of organisms 'at home'. There is uncertainty about the first coinage of the term. Probably, Henry David Thureau in 1858 first used this term. Subsequently, German Biologist Hanns Reiter in 1865 also used this term but without any definition. The credit of precisely defining ecology goes to another celebrated biologist Ernst Haeckel. In 1870, he defined ecology as the "scientific study of the relationships of living organisms with each other and with their environments".

In ecology, the term population is used to denote groups of individuals of any one kind of organism. Likewise, 'community' includes all of the populations occupying a given area. The term 'ecosystem' was first proposed by the British ecologist Tansley in 1935. The living organisms or community (biotic) and their nonliving (abiotic) environment function together as an ecological system or ecosystem. Hence, ecosystem may be defined as a functional unit where the biotic and abiotic components of the environment interplay in such a manner that through it flow of energy and matter takes place. The community with all the plants and animals forms the biotic component, while the organic and inorganic substances together with climatic factors constitute the nonliving or abiotic component of the ecosystem.

3.1.1. Abiotic and biotic components of ecosystem

The earth upon which we live may be considered a vast ecosystem. The portion of the earth in which the biotic components are present is called the biosphere or ecosphere which obtain energy from the sun. The earth comprises the soil, water and air which are nonliving (abiotic) materials but provide sustenance to the vast array of living forms.

From the nutritional (trophic) standpoint, an ecosystem has two components such as (a) ***autotrophic*** component (autotrophic means self-nourishing) in which the organisms fix light energy and utilize substances like carbon dioxide and water to produce complex food materials, and (b) ***heterotrophic*** component (heterotrophic means 'other-nourishing in which the organisms utilize, rearrange and decompose the complex materials synthesized by the autotrophic components.

From a structural standpoint, six components are recognized as comprising the ecosystem. These are : ***(i) inorganic substances,*** such as carbon, nitrogen, carbon dioxide, water etc., ***(ii) organic compounds,*** such as proteins, carbohydrates, lipids, humic substances etc., ***(iii) climatic conditions,*** such as temperature, soil and other physical factors. These three

items form the abiotic components of the ecosystem. The three items, constitute the biotic components of the ecosystem : ***(iv) producer components***—these are autotrophic organisms, generally green plants which are able to manufacture food from abiotic elements carbon dioxide, water, nitrogen etc., ***(v) macroconsumers*** or ***phagotrophs*** (phago means 'to eat')—this includes relatively big heterotrophic organisms, largely animals which ingest other organisms or food synthesized by the producers, and ***(vi) microconsumers*** or ***saprotrophs*** - these are heterotrophic usually microscopic organisms like bacteria and fungi which break down and decompose the complex substances of dead organisms (producers and macroconsumers), absorb the decomposition products and release inorganic nutrients for reuse by the producers.

Ecosystem has great importance because maintenance of equilibrium in the environment is performed by the system which operates through feedback mechanisms. If the stabilized system is disturbed, lots of environmental anomalies develop which adversely affect the biosphere including mankind. The steady state or dynamic equilibrium condition of the ecosystem would persist and sustain itself if there is no human intervention.

3.1.2. Biomes

The biome is the largest recognizable land community unit. In a given biome, the life-form of the regional climatic climax is uniform. Thus the climax vegetation of the grassland biome is uniform. Actually, biomes may provide a sound basis of natural ecological classification, because the nature of the vegetation of one region reflects the major features of the climate as well as the habitat.

The principal biomes of the world are the Tundra, Temperate, Coniferous Forest, Temperate Deciduous Forest, Temperate Grassland, Tropical Savanna, Desert, and Tropical Rain Forest.

(i) **The Tundra Biome :** Tundra lies north of latitude 60°N(i.e. between the Arctic ocean and polar ice caps) and is characterized by the absence of trees, the presence of dwarfed plants, and an upper ground surface that is wet, spongy and uneven as a result of freezing and thawing of this poorly drained land. The most characteristic tundra plant is the lichen known as 'reindeer moss' (*Cladonia* sp.) which is actually a symbiotic association of a fungus and an alga. The animals are reindeer, the arctic hare, arctic fox, polar bear, wolves and a host of migratory birds.

(ii) **Temperate Coniferous Forest Biome :** Adjacent to the tundra region is the temperate coniferous or boreal forest. These are cold regions with high rainfall, with long winters and short summers and are characterized by boreal coniferous forest which is transcontinental. Such forest is dominated by spruce (*Picea glauca*), fir (*Abies balsamea*) and pine (*Pinus resinosa, Pinus strobus*) trees and by animals like snow hare, the lynx, the wolf, bear, red fox, squirrels etc., and amphibians such as *Hyla, Rana* (frog) etc.

(iii) **Temperate Deciduous Forest Biome :** This is characterized by a moderate climate

and broad-leaved deciduous trees, which shed their leaves in autumn, are bare over winter and grow new foliage in spring. In India, at elevations of 3000–4000 m in the Himalayas occur temperate deciduous vegetation including pines, fir and juniper trees with an undergrowth of rhododendrons. The animals present in temperate deciduous forest are deer, bears, fox, mountain lions, turtles, lizards, snakes, horned owls and hawks.

(iv) **Temperate Grassland Biome :** The grassland biome is found where rainfall is about 25 to 75 cm per year, not enough to support a forest, yet more than that of a true desert. Grasslands occur in the interior of continents and include tall grass prairies, short grass prairies of North America, as well as the steppes of southern Russia, Siberia and Asia, the veldt of Africa and the pampas of South America. Grasses growing on grasslands can be divided into two basic groups, the tall grasses and the short grasses while the typical animals tend to be rather small in size. Rodents such as prairie dogs, rabbits and ground squirrels are common. The characteristic birds of grassland are prairie chicken, meadow larks and rodent hawks. The common insects of steppes are termites, locusts and bees. Lizards and snakes are also met with in large numbers.

(v) **Tropical Savanna Biome :** Savanna are tropical grasslands with scattered, drought-resistant trees, generally not exceeding 10 m in height and do not form a canopy. Thus a savanna is an intermediate between a forest and grassland. Savanna constitute extensive areas in eastern Africa, Australia and South America, which support the richest diversity of grazing mammals. Large herbivorous animals like elephants, wild buffaloes, giraffes, zebras, wildebeests, antelopes as well as the predators like lions and leopards are found in the African Savanna.

(vi) **Desert Biome :** Desert biomes are formed in extremely dry environments. The temperature may range from very hot as in hot deserts to very cold as in cold deserts. Major hot deserts of the world are situated near the Tropics of Cancer and Capricorn with annual rainfall of less than 10 mm. Cold deserts occur in extremely cold and dry regions in which drought conditions cause adaptive modifications of plants through reduced leaf size and succulence. The animals present in the arid desert biomes are reptiles, insects and burrowing rodents such as desert rats.

(vii) **Tropical Rainforest Biome :** Tropical rainforests occur near the equator and are among the most diverse communities on earth. Here both temperature and humidity are high and nearly constant. The annual rainfall which exceeds 200-225 cm is evenly distributed throughout the year. The extremely dense vegetation of the tropical rainforests is comprised of tall trees often covered with vines, creepers, lianas, epiphytic orchids and bromeliads. Under the tall trees is a continuous evergreen carpet composed of herbs and shrubs. Invertebrate animal density and abundance are very high in tropical rain-forests where diverse types of vertebrates are also present.

3.2. Ecosystems of the world

The ecosystems of the world may be studied in terms of particular habitats in which these predominate. This gives us an idea about the organisms and physical factors actually associated with a particular ecosystem. There are three major habitats in the geosphere, viz. lithosphere (land or terrestrial) hydrosphere (marine, fresh water, aquatic and wet land) and atmosphere. It may be mentioned that atmosphere does not have any permanent inhabitant. Both lithosphere and hydrosphere have a wide variety of flora and fauna.

3.2.1. Land based ecosystem

Of the major environmental components, land is considered to be the most variable in terms of age, topography and structure. Land (terrestrial) ecosystems are largely determined by the climate (temperature, moisture, light etc.) and the substrate (soil).

Higher plants and animals have developed on land. These include the seed plants, the insects, the warm-blooded vertebrates which are dominant on land today. A growing human population exerts a great impact on the terrestrial ecosystem. The microorganisms belonging to the lower groups from the evolutionary standpoint also play a significant role.

The large rooted green plants are present on land. These green plants manufacture food, provide shelter for other organisms and play a vital role in holding and modifying the earth's surface. These are the basic producers of the land and are autotrophs requiring only light and inorganic nutrients. Land plants, however, may depend on other microorganisms for their nutrition, as we have seen in the symbiotic mycorrhizae and symbiotic bacteria (in root nodules of leguminous plants). Mycorrhiza is the symbiotic association between a fungus and the roots of a plant. The plant is able to draw the mineral nutrients from the soil made available by the fungus which in turn derives the carbohydrate supply from the plant. The situation is almost similar in case of symbiotic bacteria. The major terrestrial communities include several life-forms like herbaceous plants, shrubs and grasses and woody trees. Another classification refers to adaptations along environmental gradients, viz., hydrophytes (wet), mesophytes(moist), xerophytes(dry) and halophytes (salt). The variety and abundance of insects and other arthropods is another important feature of terrestrial communities. Another very conspicuous group represented by birds of numerous species and varieties is found in almost every land community.

3.2.2. Marine ecosystem

Oceans cover three-fourth portion of the earth's surface, harbouring a vast variety of plants (mainly algae),animals like zooplankton, shrimps, crabs, oysters, krills, fishes, reptiles, birds and mammals. This system also receives a huge quantity of run-off materials and wastes from terrestrial systems directly from coastal regions and indirectly by rivers from distant inland regions.

Marine water has a high salt content of about 3.5% by weight. Fertility status of marine water is poor as compared to fresh water which contains dissolved nitrates and phosphates.

The marine ecosystem is the entire region extending from the coastal land visited by tides to the deepest zone in the open sea. It can be divided as follows :

(i) The supratidal belt—the region in the sea coast upto which the high tides just reach submerging the land and plants thereon.

(ii) The intertidal belt — this zone extends from subtidal to supratidal zones, i.e., the region which is periodically covered by sea water.

(iii) The neritic zone — this is the shallow coast line belt that is flat in most part and abruptly drifts down to deeper zone. It receives enough light and bears diverse kinds of marine vegetation, those growing on bottom rocks are called benthic and those that occur in water above as pelagic. This marine belt is sometimes called littoral .

(iv) The euphotic zone — this zone refers to the upper layer of water in continuation from shallow shoreline to the far off oceanic belt, where light is abundant.

(v) The dysphotic and aphotic zones — these are zones where light is insufficient (dysphotic zone) or where there is no light (aphotic zone).

(vi) The oceanic belt - the zone of sea far away from land is called oceanic belt. The top 100-200 m layer is euphotic zone. From' 200 m to about 2000 m is called the bathyal zone. Very deep and dark zone of water below 2000 m is called abyssal zone which is free of any photosynthetic organisms. Primary producers and consequently herbivores are absent here because of lack of light.

In the oceanic belt, life is concentrated in the euphotiç zone, where both the macroplankton and microplankton are the main primary producers on which big fishes flourish. In the shore line or in the continental shelf, the marine life is most abundant and the diversity of flora and fauna is very high. There are some fauna that dig narrow holes in the bottom and are called infauna and there are others that live on the surface either attached or free moving and are called epifauna. Commercial fishes are also abundant in this region. Other important animals are large sea mammals like whales and seals. Pearl harvest and pearl culture is an important commercial activity dependent on marine ecosystem.

3.2.3. Freshwater ecosystem

Freshwater bodies contribute a very small (only 3%) fraction of total area of water, but from the point of view of human use these are among the most important natural water resources. Freshwater bodies are of various sizes and depths. They are either surrounded by land from all sides and the water, therefore, is stationary, or lentic (lentis means calm), as in a land-bound lake or floating water body (open on two ends and land-bound on the other two

sides) like rivers, streams etc. representing flowing or lotic water (lotus means washed). These two types or water bodies differ in their ecological nature because of replacement of water in lotic water due to its flowing nature, and of non-replacement or almost permanent nature of lentic water in ponds, lakes, etc.

Like marine ecosystem, a similar classification of freshwater ecosystem can be made on the basis of depth, light penetration and temperature condition.

(i) **Photic stratification :** The level of illumination in a water body is dependent on the depth of water column and the clarity of water. On the basis of illumination, the freshwater ecosystem is divided into three zones, namely littoral, limnetic and profundal zones. Littoral zone is on the margin of lake with shallow depth. Plants like ***Typha sp, Eliocharis sp.*** and ***Cyperus sp.*** grow on the margin. Free floating and rooted plants with floating leaves such as ***Lemna*** (khudipana), ***Azolla*** (jostapana), ***Nymphaea*** (shaluk) and ***Nelumbium*** (padma) grow further away from the margin. Submerged plants like ***Vallisnaria, Ottelia*** and ***Potamogeton*** also occur in this zone. Here phytoplankton and zooplankton are also found. Limnetic zone refers to an open expanse of water from surface to only as much depth as is illuminated, sufficiently to cause photosynthesis. This zone is rich in phytoplankton, large floating algae and macrophytes which produce enough oxygen through photosynthesis suitable for good growth of fishes. On the basis of light penetration, both littoral and limnetic zones are euphotic. Here light penetration is either minimum (dysphotic) or totally absent (aphotic). Profundal zone is the lowest zone found in deep lakes. It refers to the depths ranging from the limnetic layer downwards up to the bottom. The primary producers or the green plants cannot grow here, because light is not sufficient for photosynthesis. Instead, the dead plant and animal bodies sink and become the food substrate for decomposer organisms like bacteria and fungi. Fishes that eat dead remains of plants and animals also occur here.

(ii) **Thermal stratification.** On the basis of temperature variations in the vertical column of water, three zones in a lake ecosystem are (a) upper warm epilimnion (epi — upper, limnos — lake), (b) middle transitional or intermediate thermocline, and (c) lower cold water zone, the hypolimnion.

3.2.4. Wetland ecosystem

Wetlands form a valuable natural ecosystem bringing benefits to people. These harbour a wide variety of plants, animals and microorganisms. Wetlands are ecotones (lands transitional between terrestrial and aquatic systems) where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands, at least periodically, have hydrophytes and the substrate is predominantly undrained hydric soil. They include the swamps, bogs, marshes and fens. Wetlands are also defined as areas where during a large part of the year water stands at 2.5 cm to around 300 cm.

According to the Asian Wetland Bureau, wetlands are "estuaries and deltas, salt

marshes, mangroves and mudflats, coastal lagoons, fresh water lakes and marshes, salt marshes, flood plain wetlands, swamp forests, rivers and streams, man-managed systems such as rice fields, fish ponds and reservoirs"

Wetlands are of great help in controlling flood, in recharging aquifier, in the treatment of waste water, in growing finfish and shellfish and also as a source of water supply. They serve as reservoirs of rich biodiversity. But unfortunately wetlands are threatened as a result of increasing urbanization and other developmental activities.

3.2.5. Mangroves : forests between land and sea

Mangroves are unique forest communities in tidal zones of equatorial and tropical coasts. Chapman in 1977 used the term "mangal" for such communities and reserved "mangrove" for the specialized trees inhabiting this saline ecosystem. Such trees which are permanently affected by salinity during their whole life cycle have to cope with extreme conditions. This characteristic halophytic vegetation is found in saline and semisaline coastal areas in many places of the world. The Gangetic estuarine delta touching the Bay of Bengal—the Sundarbans is a typical example. It is also found in western India near the sea coasts of Bombay and Kerala, and in south India in the banks and creeks of Godavari, where the river meets the sea. The mangrove forests are also highly developed in the Andaman and Nicobar Islands. The predominant genera, which belong to different families, are ***Avicennia, Bruguiera, Ceriops, Rhizophora, Aegiceros, Aegialitis, Laguncularia, Lumnitzera, Kandelia*** and ***Xylocarpus***

The characteristic adaptive features of the mangroves are described here.

(i) Several species of ***Sonneratia*** and ***Avicennia*** develop breathing roots, the pneumatophores, to improve their oxygen supply in muddy, regularly inundated substrates (figure 3.1).

Fig 3.1. Breathing roots (pneumatophores) in a mangrove forest of the Sundarbans.
(Courtsey : Dr. Kumud Sankar Naskar)

(ii) Some mangrove trees like ***Rhizophora, Avicennia*** and ***Kandelia*** have peculiarly shaped fruits with viviparous seeds, which germinate inside the fruit while still attached to the mother plant. In this way, the seedling stage is shortened and they can rapidly occupy their habitat.

(iii) Another adaptation is the formation of stilt roots arising from the main trunk of the trees for efficient anchorage in the loose soil.

3.3. Environment, flora and fauna : interrelations and interactions

Environment has been defined as the sum total of all conditions that affect the development and life of organisms. Every living organism, from the lowest to the highest, including human beings, has its own environment. Indian and southeast Asian region is rich in flora and is considered to be the centre of origin of many cultivated plants. This region is particularly suitable for rice, millets, soybean, cowpea and other important legumes, cucumber, egg plant, tropical fruits like banana, citrus, mango, plantation crops like pepper, betelnut, arecanut, sagopalm, coconut, cardamom, nutmeg, tea, cotton, jute and a number of tuberous crops like ***Dioscorea, Alocasia, Colocasia, Amorphophalus,*** ornamentals like orchids, rhododendron, jasminum, and the introduced rubber and oil-yielding plants like ***Hevea*** and oil palm.

The region is equally rich in fauna. Thousands of species of insects, crustaceans, molluses, other invertebrates, fishes, amphibians, reptiles, birds and mammals are found. There is also a great diversity in domesticated animals like cattle, sheep, goat etc. Equally important are the microorganisms like fungi and bacteria which are very important component of the biosphere since they are responsible for the degradation of dead biomass and release of nutrients which are assimilated by plants and subsequently by animals.

Almost all the phases of environment have potential influence on organisms, but all factors are not equally important at any one time. Each single factor becomes more limiting in effect either in greater intensity when the organism will not be able to tolerate or in lower intensity when the organism may not be able to survive. For example, each plant has a maximum and minimum temperature tolerance and between these extremes lies a range which is the optimum range for this factor. Generally, the combination of factor intensities most favourable to the benefit of a plant differs at different stages of the life cycle. For example, the seeds of certain trees growing in marshy places prefer water content for maximum germination that is far above the requirement of the best growth of the mature trees. Another common experience in ecology is that one factor compensates for deficiencies in another. A high water table or an abundance of fog or low temperature, each may compensate for low rainfall. Again, there is good evidence that the effect of every nutrient element in the soil depends to some extent on the quantity of other elements present at the same time. So the wide range of environment tolerated by many plants may be partly due to the fact that deficiencies in one factor may be compensated for by others.

The occurrence and abundance of fauna are also regulated by environmental factors such as temperature, humidity, pH, salinity, BOD, food substances and many other factors. Organisms respond to the changes in their environment in four principal ways : (i) structural adaptations, (ii) physiological adjustments, (iii) behaviour patterns, and (iv) community relations. Population of two species may interact in various ways of which, competition, predation, parasitism, mutualism and commensalism are basic types of interactions.

3.4. Forest ecology

Forest ecology is defined as the study of a forest in reciprocal relationship with its environment. Since forests are to meet both physical and economic needs of the population, forest ecology combines in itself the study of all those factors that affect both natural and economic importance of forests. Forest management, a relatively new concept in plant ecology, has become an important ecofriendly practice in forest ecology. Thus forest ecology may be considered as a branch of applied plant ecology.

3.4.1. Importance of forests

Forests are among the most important biotic resources and forestry is gaining in importance as an integral part of National Development Program of countries throughout the world. The forest covers of the world carry great value for mankind ensuring economic development of the country, preserving environmental quality, providing employment to the weaker sections and meeting the basic needs of the rural population. Forests not only provide wood, fibre, fuel and shelter, but these have immense importance in the protection of the soil and maintenance of the climatic and environmental stability.

3.4.2. Management of forests

Indiscriminate felling of trees as a result of urbanization, industrialization, mining operations and the use of fire-wood and fuelwood for domestic and other purposes is causing a great depletion of forests. According to official statistics relased by the Forest Department, India has lost between 1952 and 1972 about 3.4 million hectares of forest lands to pave way for dams, new crop lands, roads and industries, which means an annual rate of removal of good forest cover of about 0.15 million hectares. If the present state of depletion is allowed to continue unabated, the country will be heading towards the situation of zero forest in about 20 years.

The most important object of forest management is to maintain and to improve site quality, specially when the soil is liable to erosion. Besides this, forests are to be managed in such a way that periodical removal of forest produce would not endanger future yields. Sound forest management should ensure an adequate regeneration of trees. Regeneration may be by seeds or coppice. In the coppice system, timber is cut leaving about one metre of the tree from the base which regenerates into new shoots.

Silviculture is the term for forest management which deals with the planting and production of timber trees. For the management of forests under silviculture system, the knowledge of climatic conditions, drainage pattern, ecological life cycle of important plant species and their biotic interrelationship is necessary.

Conservation of forests : Management practices should also include the protection and conservation of forests. In India, an organized movement to save trees was started in 1972 which has now become famous as Chipko Movement. This movement has brought a country-wide general awareness about the importance of conserving forests and the trees. The integrity and proper function of forest ecosystems are intimately associated with the health and prosperity of living beings. Tree planting can be done in private individual lands, vacant land on the banks of ponds, embankments and along the railway tracks. The aim of the forestry program will be two-fold : (i) creation of green belts for changing landscape in a planned manner, and (ii) planting of such trees which will increase the economic resources and help in the livelihood of the people.

3.5 Problems of sustainability of stable ecosystems

Under normal condition, each ecosystem tends to remain stable. But if there is any kind of qualitative and quantitative change in the components comprising the ecosystem, the sustainability of the system gets disturbed. It means that the power of self-maintenance and self-regulation of the ecosystem is jeopardized which may adversely affect environmental health. This ultimately causes human misery. In order to maintain the sustainability of the ecosystem, there should be least intervention in the working of the ecosystem. But mankind without understanding and appreciating the subtle links among the components of the ecosystem very often disrupts a natural ecosystem at times irrevocably damaging its stable structure and functional efficiency.