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National Open University
School of Interdisciplinary and
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MSD-012
Ecosystem and Natural Resources

Block

1

ECOSYSTEM AND NATURAL RESOURCES

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BLOCK 1 ECOSYSTEM AND NATURAL RESOURCES

This is the first block of the course 'Ecosytem and Natural Resources'. In this block we have discussed about the ecology, ecosytem and its types, ecosytem services, importance of biodiversity, factors responsible for biodiversity loss and conservation and management of biodiversity in different units.

Unit 1 presents the concept of ecology and ecosystem, structure and function of a typical ecosystem. The unit also gives an insight about some important ecosystem services and provides information about the impacts of humans on some ecosystems and its services.

Unit 2 provides you an insight about the concept of biodiversity, its evolution, status and distribution. The main focus of the unit, however, is to give you an insight about the importance and uses of biodiversity.

Unit 3 takes you to the issue of loss of biodiversity, its causes and consequences, the magnitude and pattern of biodiversity loss. The unit also takes you to the factors responsible for biodiversity loss and the consequences of biodiversity losses.

Unit 4 introduces you to biodiversity conservation, approaches and programmes of biodiversity conservation. The unit also provides you different national and international programmes for conserving biodiversity.

UNIT 1 CONCEPT OF ECOSYSTEM

Structure

1.0 INTRODUCTION

Both the biotic (living) and abiotic (non-living) components of nature form an interacting and vibrant system called 'ecosystem'. In an ecosystem, producers, consumers and decomposers represent various trophic levels and these are linked by complex food relationships. Such ecosystems involve various on-going functions such as energy flow, production, decomposition, nutrient cycling and succession. It has been widely recognized that ecosystems are the planet's life-support systems. Nature's goods and services are the ultimate foundations of life for the human species and all other living beings. As a result of human actions, however, the structure and functioning of the world's ecosystems have changed more rapidly in the second half of the twentieth century than at any other time in human history. A number of negative impacts on many ecosystems have been reported by various scientific studies. It has therefore become indispensible to adjust our pattern of development so that various ecosystems remain intact and continue to provide their services for our wellbeing. This unit aims to provide a conceptual basis for understanding ecosystem processes and their sensitivity to human induced changes.

1.1 OBJECTIVES

After reading this unit, you will be able to:

- explain the concept of ecology and ecosystem;
- describe structure and function of a typical ecosystem;
- underline some important ecosystem services; and
- discuss how humans have negatively impacted some ecosystems.

1.2 CONCEPT OF ECOLOGY AND ECOSYSTEM

Throughout their life, the living beings keep on interacting among themselves as well as with their physical surroundings like soil, air and water. Study of the interrelationships of organisms with their natural environment is known as 'ecology'. This term is derived of two Greek words: *Oikos* (means house or living place) and *logos* (means study). It was coined by Ernst Haeckel in 1869.

E.P.Odum, an American ecologist, defined ecology as 'the study of the structure and function of nature, which includes the living world'. He referred ecosystem as the basic fundamental unit of ecology. In other words, ecology is the study of relationships between (i) biotic and abiotic components and also (ii) biotic and biotic components of the ecosystem. For practical purpose, ecology involves collecting information about organisms and their environment, looking for patterns of their distribution, abundance and adaptation to environmental changes and seeking to explain these patterns.

The biosphere, the living world, is composed of smaller units like ecosystems. Ecosystem refers to a whole community of organisms and its environment as one unit. It may thus be defined as a structural and functional unit of biosphere or a segment of natural systems consisting of community of living beings and their physical environment, both interacting and exchanging materials between them with consistent flow of energy across the system. The term ecosystem was coined in 1930 by Roy Clapham to mean the combined physical and biological components of an environment but the British ecologist Arthur Tansley later refined the term in 1935 to convey its meaning as we understand it today

An ecosystem includes all living organisms and the nonliving components of environment that are found in a particular place. In simple words, it can be defined as a piece of land or water body where life continues without the need of human support or intervention. A forest, grassland, pond, lake, coral reef provide some examples of natural ecosystems. Croplands and different farming systems, on the other hand, represent human made ecosystems.

The simplest level of organization in any ecosystem is that of an organism, which refers to any plant, animal or microorganism inhabiting an ecosystem. A population includes all the members of the same organism that live in one place at one time. All the different populations that live in a particular area make up a community. The physical location of a community is called the habitat. An ecosystem is in turn is a level of organisation and has another higher level of organisation called biosphere.

In other words, an ecosystem is the basic functional unit of the biosphere. The major terrestrial ecosystems of the world with their groups of climax biotic community are called 'biomes'. The major terrestrial biomes are: tundra, taiga, deciduous forests, tropical rain forests, chapparals, savannah, grasslands and deserts. Extent of a biome is determined by climatic edaphic factors and geographic and geomorphic factors.

1.3 ECOSYSTEM STRUCTURE

An ecosystem can also be viewed as a piece of land or water-body where life continues naturally. Structurally it consists of a community of living organisms along with their abiotic environment. Ecosystem structure can be described in terms of its components, trophic organization, species composition, stratification, consideration of size scale and boundaries etc. These structural parameters will be discussed sequentially in the following sub-sections.

1.3.1 Ecosystem Components

As explained earlier, an ecosystem comprises biotic and abiotic components which keep interacting with each other to represent various ecosystem functions. Biotic components include all living beings, e.g., humans, animals, plants and microorganisms. Abiotic components include all physico-chemical entities like air, water, soil, rocks, minerals etc.

Biotic components comprises the living part of the environment, which includes the association of a number of interrelated populations belonging to different species in a common environment. The populations are that of animal community, plant community and microbial community. Biotic community is distinguished into autotrophs, heterotrophs and saprotrophs. Let us now understand these new terms.

Autotrophs (Greek: *auto* - self; *trophos* - feeder) are also called producers, convertors or transducers. These are photosynthetic plants, generally chlorophyll bearing, which synthesize high energy complex organic compounds (food) from inorganic raw materials with the help of sunlight, and the process involved is termed as photosynthesis. Certain autotrophs, for example certain bacteria, are called chemosynthetic as they synthesize their food by deriving energy from some chemical substances instead of sunlight. Autortophs form the basis of all ecosystems. In terrestrial ecosystems, they are mainly the rooted plants. In aquatic ecosystems, floating plants called phytoplankton and shallow water rooted plants called macrophytes are the dominant producers.

Heterotrophs (Greek: *heteros* - other; *trophs* - feeder) are also called consumers, which are generally animals feeding on other organisms. Consumers, also referred as phagotrophs (*phago* - to ingest or swallow) or macroconsumers, are mainly herbivores and carnivores. Herbivores are referred as the first order consumers or primary consumers, as they feed directly on plants. For example, terrestrial ecosystem consumers include cattle, deer, rabbit, grasshopper, etc. Aquatic ecosystem consumers like protozoans, crustaceans, etc. Carnivores are animals, which feed or prey upon other animals. Primary carnivores are the second order consumers comprising the animals which feed on the herbivorous animals. Familiar examples include fox, frog, predatory birds, smaller fishes, snakes, etc. Secondary carnivores are the third order consumers and include those animals, which feed on the primary carnivores, such as wolf, peacock, owl, etc. Secondary carnivores are preyed upon by some larger carnivores. Tertiary carnivores or quaternary consumers include the animals, which feed on the secondary carnivores, and include lion, tiger, etc. These are not eaten by any other animals. The larger carnivores, which cannot be preyed upon further are called the top carnivores.

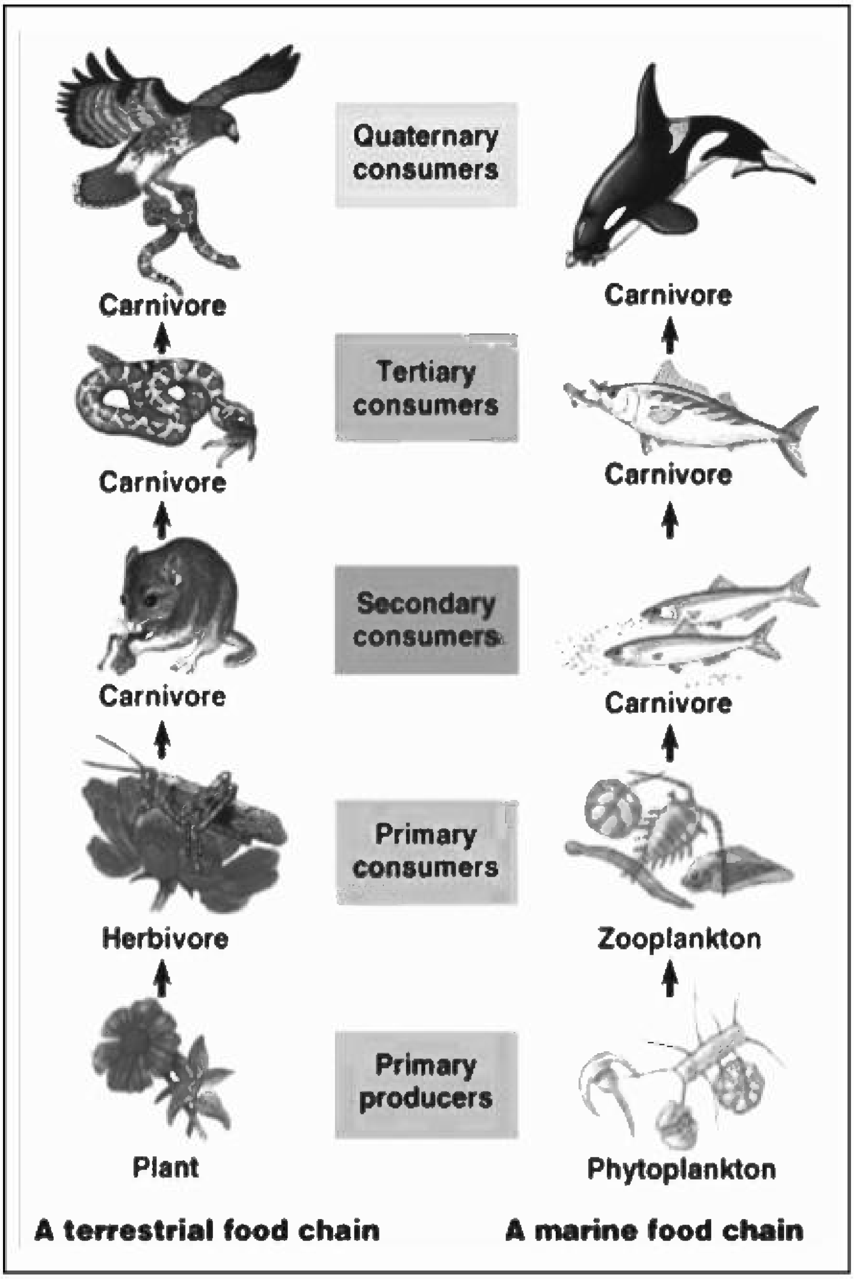

Fig.1.1: Food chains in different ecosystem

(**Source-**http://canarygeog.canaryzoo.com/Ecosystems%20Ecosystems.htm)

Saprotrophs (Greek: *sapros* - rotten; *trophos* - feeder) are also called decomposers or reducers. They break down the complex organic compounds of dead matter (of plants and animals). Decomposers do not ingest their food. Instead they secrete digestive enzymes into the dead and decaying plant and animal remains to digest the organic material. Enzymes act upon the complex organic compounds of the dead matter. Decomposers absorb a part of the decomposition products for their own nourishment while the remaining substances are added as minerals to the substratum (mineralisation). Released minerals are reused (utilised) as nutrients by the plants (producers).

Abiotic components represent the physico-chemical environment of the earth and include different physical entities like air, water, soil etc. as well as conditions such as temperature, light etc. These are also referred as factors as they influence the behavior of any individual in an ecosystem. Abiotic components are further classified under three categories: climatic, geographic or geomorphic and edaphic components or factors. Climatic factors include the climatic conditions like light, humidity, atmospheric temperature, wind, etc. Geographic or geomorphic factors include land topography, slope, aspects (direction towards the sun), altitude, latitude, etc. Edaphic factors are related to the structure and composition of soil and include inorganic substances like water, carbon, sulphur, nitrogen, phosphorus etc., as well as organic substances like proteins, lipids, carbohydrates, humic substances etc.

1.3.2 Trophic Organization

An ecosystem can be represented by its 'trophic organization'. Pattern of food relationships in ecosystem is called trophic organization. There are several trophic levels in the ecosystem which are sequentially represented by Producers, Primary Consumers, Secondary Consumers, Tertiary Consumers and Top Consumers. The trophic level, or feeding level, is a way of delineating the position of an organism in the food chain or food web. The producers (green plants) always form the first trophic level. Herbivores, which feed on producers, are at the second trophic level followed by secondary consumers, tertiary consumers and so on.

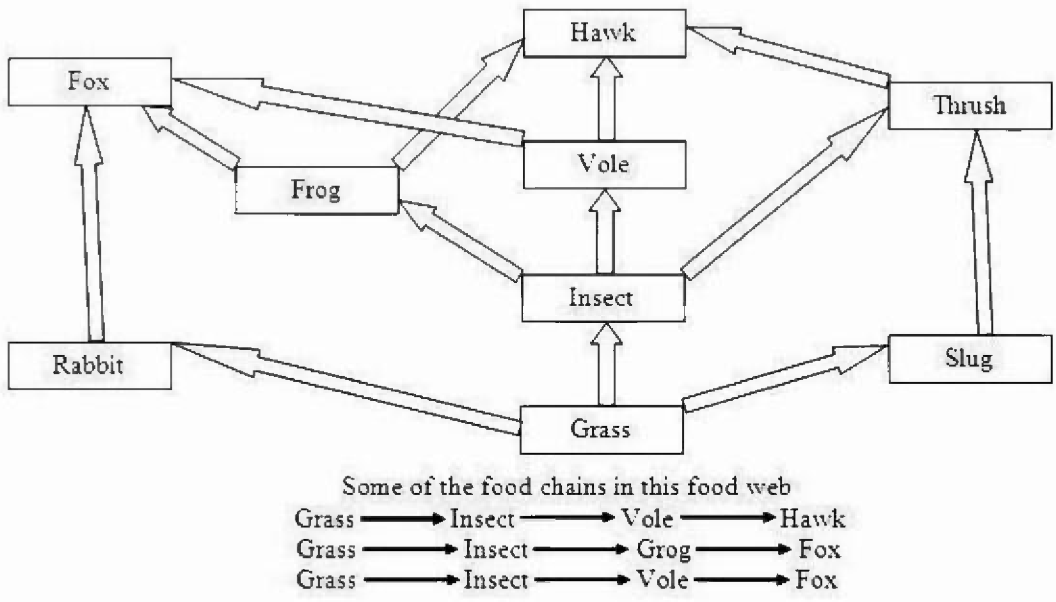

Fig 1.2: Diagrammatic representation of food web and food Chain

Trophic organization can be graphically represented by means of ecological pyramids. Graphical representation of ecological parameters like number of individuals, amount of biomass and amount of energy results in the ecological pyramid of number, pyramid of biomass and pyramid of energy respectively. Pyramids of number and biomass can be upright and inverted both. Pyramid of energy is always upright. Trophic structure of an ecosystem can also be described in terms of total amount of nutrients or the amount of living material. The amount of nutrients in the soil at any given time is referred as 'standing state' whereas the amount of living material is referred as 'standing crop'.

Food relationships in an ecosystem are also represented in form of foodchain and foodweb. The patterns of eating and being eaten forms a linear chain called food chain which can always be traced back to the producers. On the basis of nature, basically two types of food chains are recognized: grazing food chain and detritus food chain. Grazing food chain starts from the living green plants, goes to grazing herbivores and on to the carnivores. Detritus food chain start from the detritus or dead organic matter and goes through a series of saprophytic or decomposer organisms. Both types of food chains are essential for flow of energy and nutrient cycling in ecosystem. In nature various food chains are linked together and form multichannel pattern or complex network of food relationship that is called food web.

1.3.3 Species Composition and Stratification

'Species composition' and 'stratification' are two additional structural features of ecosystem. Species composition means number of species present in an ecosystem. It is also called as species richness, or species diversity. Species are the basic unit of classification, consisting of a population or series of populations of closely related and similar individuals that freely interbreed with one another in natural conditions but not with members of other species. Species can show different functional states in ecosystem. Species can perform unique functions but many times they also show redundancy. Some species are called 'Keystone species' since they perform critically important role in the ecosystem and if they are destroyed, entire ecosystem can collapse. Species diversity is generally proportionate to productivity and stability of the ecosystem.

Stratification means presence of layers (stratum) in vertical structure of an ecosystem. Plants or trees in an ecosystem constitute several height classes. Plants belonging to same height class can be viewed as one stratum. Several such strata are found in an ecosystem. Ecosystem vary in terms of degree of stratification which is often proportional to diversity, productivity and stability of the ecosystems.

1.3.4 Size, Scale and Boundaries

The size and scale of an ecosystem can vary widely. They may be very large, such as a tropical rain forest, Sahara desert, or very small, such as a test tube experiment of phytoplankton, or an aquarium tank with plants and fish. Some even define a biome as an extensive ecosystem, although generally an ecosystem is viewed as having a more defined abiotic environment than a biome, and a biome as a group of ecosystems sharing broad environmental characteristics.

The boundary of an ecosystem is not always easy to delineate. Dif ferent ecosystems are often separated by geographical barriers, like deserts, mountains, or oceans, or are isolated otherwise, like lakes or rivers. As these borders are never rigid, ecosystems tend to blend into each other. For example, the boundary of a river may seem clear, yet crocodile crawl from the river to bask in the sun, water birds get food from the river but nest in trees, and tapirs (pig like animal) may swim in the water and yet live on the land. To some extent, the whole earth can be seen as a single ecosystem, or a lake can be divided into several ecosystems, depending on the scale used.

Check Your Progress 1

Note: a) Use the space given below for your answer.

b) Compare your answers with those given at the end of the unit.

1) What is the difference between community and ecosystem?

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2) Can the size and the boundaries of an ecosystem be defined?

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1.4 ECOSYSTEM FUNCTIONS

By now we understand that an ecosystem is a dynamic assemblage of biotic and abiotic components which interact among themselves and perform different ecosystem functions. Major functional aspects of an ecosystem include energy flow, production, decomposition and nutrient cycling.

Energy flow means transfer of energy from one trophic level to the next trophic level and it is always unidirectional, flowing from producers to top consumers. Production means production or assimilation of biomass by different component of an ecosystem. The rate of biomass production by living beings in an ecosystem is called productivity. Decomposition is breaking down of dead plant and animals and their excreta into simple compounds like carbon dioxide (CO_2), water (H_2O) and nutrients. Bacteria and fungi are the major decomposers. Nutrient cycling means movement of elements or compounds through living beings and across the ecosystem in form of characteristic pathways. Succession is the sequential change in the community structure resulting in establishment of stable or climax community. These functions have been described in detail in the following sub-sections.

1.4.1 Energy Flow

The main source of energy in almost all natural ecosystems is radiant energy coming from the sun. Primary producers or autotrophic organisms, such as plants, algae, and photosynthetic bacteria, take radiant energy and fix it into organic molecules by photosynthesis, such a creating glucose from carbon dioxide. Only a small portion of radiant energy actually is converted into biochemical form via photosynthesis. Studies suggest that ecosystems generally fix about 3 percent or even less of the radiant sunlight. In fact, for most ecosystems, this figure is probably less than 1 percent. There are also other autotrophic organisms, such as chemosynthetic bacteria living around deep-sea vents that can manufacture their own food from chemical energy. Energy then flows through the system when organisms eat each other. The trophic level, or feeding level, is a way of delineating the position of an organism in the food chain, that is, the relationship between what the organism eats and what it is eaten by.

Energy flows through an ecosystem in the form of carbon-carbon bonds. As carbon-carbon bonds are broken, energy is released, which then can be used by the organism or dissipated as heat. While the energy flows through an ecosystem, only a portion of the energy available to an organism is actually stored by the organism. Thus, the total energy in one trophic level never flows to the next level. That simply means that the lower trophic levels always contain more total energy than the higher trophic levels. Energy does not recycle, but ultimately all energy that is brought into an ecosystem is lost as heat.

Lindemann (1942) put forth the Ten Percent law for the transfer of energy from one trophic level to the next. According to this notion, during the transfer of organic food from one trophic level to the next, only about ten percent of the organic matter is stored as flesh. The remaining is lost during transfer or gets broken down in respiration. Plants utilise sun energy for primary production and can store only about 10% of the utilised energy as net production available for the herbivores. When these plants are consumed by an animal, about 10% of the energy in the food is fixed into animal flesh which is available for next trophic level (carnivores). When a carnivore consumes that animal, only about 10% of energy is fixed in its flesh for the higher level. So, at each transfer, 80 - 90% of potential energy is dissipated as heat (second law of thermodynamics) while only 10 - 20% of energy is available to the next trophic level.

Energy transformations, which occur within an ecosystem are considered in ecological energetics. The quantity of solar energy entering the earth's atmosphere is about 15.3×10^8 cals/m^2/year (1 cal = 4.184 J). But the average amount of solar energy (per unit area per unit time), actually available to autotrophs, depends upon their geographical location. Only the photosynthetically active radiation (PAR) is the energy available to autotrophs. A major portion (90 - 95%) of this energy is lost in the form of heat of evaporation and sensible heat while only around 1 to 5% is used for photosynthesis (primary production). Hence the energy transfer is not 100% efficient and there is degradation of energy from a non-random to a random form. Energy conserving efficiency is about 1.5% for grassland, 0.9% for savannah, 0.81% for mixed forest, 5% for most crops and 10 - 12% for a sugarcane field.

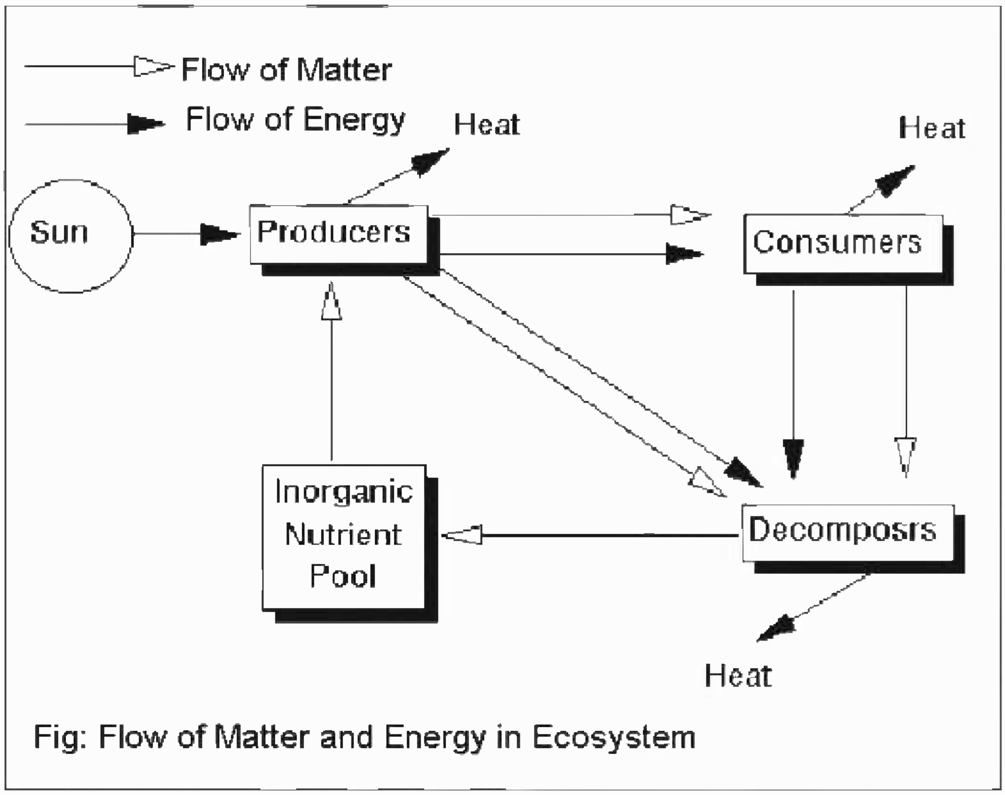

Fig. 1.3: Flow of matter and energy in an ecosystem

1.4.2 Production Processes

In an ecosystem, autotrophs, which include green plants, algae and certain bacteria, synthesize organic food by the process of photosynthesis or chemosynthesis. In the process of photosynthesis, plants take CO_2 from atmosphere, water from environment and radiant energy from the sun and produce food in the form of carbohydrate. This accumulation of organic matter by plants is called primary production. Heterotroph organisms feed on autotrophs and accumulate biomass in their body: that is termed as secondary production.

The amount of organic matter or biomass produced by an individual organism, population, community or ecosystem during a given period of time is called productivity. The total amount of solar energy converted (fixed) into chemical energy by green plants is called 'Gross Primary Production' (GPP). A certain portion of gross primary production is utilised by plants for maintenance (largely respiratory energy loss) and the remainder is called 'Net Primary Production (NPP)' which appears as new plant biomass. Primary production is of special importance in ecology, since it is the energy fixed by plants by converting solar energy into chemical energy of food material that supports life in other trophic levels. The biochemical equation that describes the process of photosynthesis is,

$$6CO_2 + 12H_2O \xrightarrow{\text{(Green-plants in Sunlight)}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

Secondary production refers to the net quantity of energy transferred and stored in the bodies of heterotrophs over a period of time. Some heterotrophs (consumers and decomposers) feed on net primary production and some on other heterotrophic organisms. The rate of increase in the biomass of heterotrophs per unit time and area is called secondary productivity. Secondary productivity serves as an index of significance of the population in terms of food resources available to the heterotrophic populations, including man, in the food chain.

Herbivores and carnivores ingest the food material where a part of this is assimilated and a part is egested. A large part of assimilated food (energy) is utilised for metabolism (largely respiration), growth, reproduction, maintenance of body and other activities. Remaining part is stored in somatic and reproductive tissues and thus compared to net production.

Carbon that enters ecosystems as gross primary production (GPP) accumulates within the ecosystem, returns to the atmosphere via respiration or disturbance, or is transported laterally to other ecosystems. About half of GPP is respired by plants to provide the energy that supports their growth and maintenance. Plants lose carbon through several pathways besides respiration. The largest of these releases is typically the transfer of carbon from plants to the soil. This occurs through litter fall (the shedding of plant parts and death of plants), root exudation (the secretion of soluble organic compounds by roots into the soil), and carbon transfers to microbes that are symbiotically associated with roots (e.g., mycorrhizae and nitrogen-fixing bacteria). These carbon transfers from plants to soil eventually give rise to soil organic matter (SOM), which is typically the largest pool of ecosystem carbon.

Herbivores also remove carbon from plants. Herbivory often accounts for 5 to 10% of NPP in terrestrial ecosystems but can be less than 1% in some forests or greater than 50% in some grassland. Herbivores account for most of the carbon loss from plants in aquatic ecosystems. Plants also release carbon to the atmosphere through emission of volatile organic compounds or by combustion in fires. Volatile emissions typically account for less than 1% of NPP but give plants their distinctive smells, which govern the behavior of many herbivores and are an important component of atmospheric chemistry. Finally, carbon can be removed from vegetation by human harvest or other disturbances.

The carbon balance of ecosystems depends not only on the carbon balance of vegetation but also on the respiration of heterotrophs, organisms that eat live or dead organic matter. Heterotrophic respiration by microbes and animals converts organic matter to CO_2, which is lost from the ecosystem to the atmosphere. In some ecosystems fire transforms additional organic matter to CO_2, which moves to the atmosphere. Finally carbon leaches from ecosystems in dissolved and particulate forms and moves laterally through erosion and deposition of soil, movement of animals etc.

Biomass production by plants determines the amount of energy available to sustain all organisms, including humans. We depend on plant production directly for food and fiber and indirectly because of the critical role of vegetation in all ecosystem processes. Much of the carbon produced by plants eventually moves to the soil, where it influences the capacity of soils to retain water and nutrients and therefore to support plant production. Carbon cycling through ecosystems also directly affects Earth's climate by modifying the concentration of atmospheric CO_2. Because of the many critical roles of carbon balance in the biosphere and the Earth System, the recent rapid change in carbon cycling of plants and ecosystems is an issue of fundamental societal importance.

1.4.3 Decomposition

Decomposition is the physical and chemical breakdown of detritus or dead organic matter (i.e.,dead plant, animal, and microbial material), which results into release of carbon to the atmosphere and of nutrients in forms that can be used for plant and microbial production. If there were no decomposition, ecosystems would quickly accumulate large quantities of detritus, leading to a sequestration of nutrients in forms that are unavailable to plants and a depletion of atmospheric CO_2. Depletion of these resources in non-decomposing detritus would eventually cause many biological processes to a halt. There have been times such as the Carboniferous period when decomposition did not keep pace with primary production, leading to vast accumulations of carbon-containing coal and oil. The balance between NPP and decomposition therefore strongly influences carbon cycling at ecosystem and global scales.

If the global warming associated with anthropogenic CO_2 emissions were to cause even small changes in the balance between net primary prouction (NPP) and decomposition, the CO_2 concentration in the atmosphere would be greatly altered and therefore so would the rate of global warming. Understanding the impacts of decomposition on carbon cycling is thus critical for making projections about the future state of Earth's climate.

Decomposition results from three types of processes with different controls and consequences.

1) Leaching by water transfers soluble materials away from decomposing organic matter into the soil matrix. These soluble materials are absorbed by organisms, react with the mineral phase of the soil, or are lost from the system in solution.

2) Fragmentation by soil animals breaks large pieces of organic matter into smaller ones, which provide a food source for soil animals and create fresh surfaces for microbial colonization. Soil animals also mix the decomposing organic matter into the soil.

3) Chemical alteration of dead organic matter is primarily a consequence of the activity of bacteria and fungi, although some chemical reactions also occur spontaneously in the soil without microbial mediation.

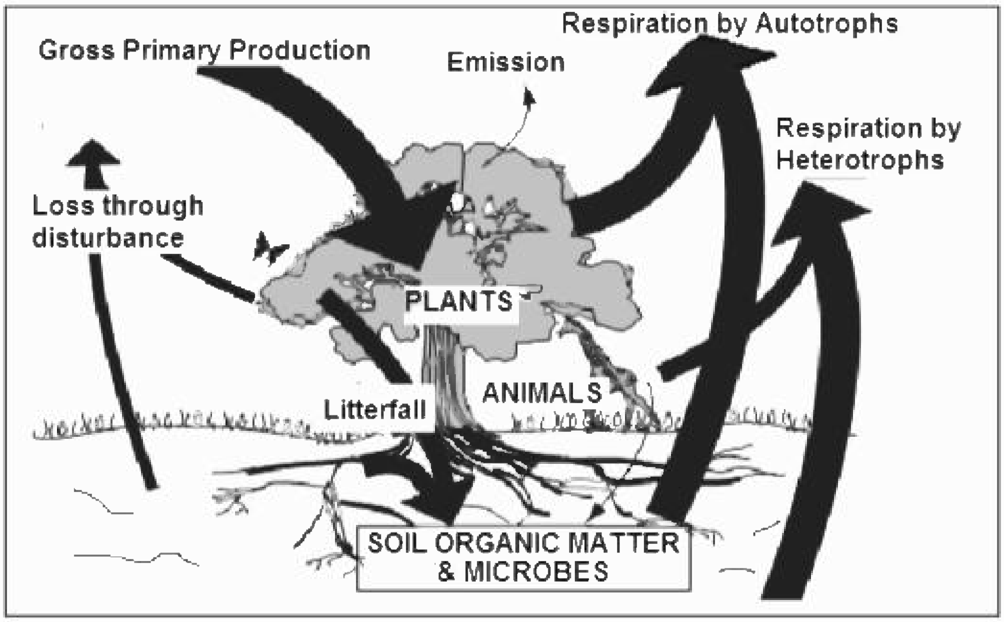

Fig. 1.4: Overview of major carbon fluxes in terrestrial ecosystem

Source: Chapin *et al;* 2002

Dead plant material (litter) and animal residues are gradually decomposed until their original identity is no longer recognizable, at which point they are considered soil organic matter (SOM). Litter consists primarily of compounds that are too large and insoluble to pass through microbial membranes. Microbes therefore secrete exoenzymes (extracellular enzymes) into their environment to initiate breakdown of litter. These exoenzymes convert macromolecules into soluble products that can be absorbed and metabolized by microbes.

The consequences of decomposition are the mineralization of organic matter to inorganic components (CO_2, mineral nutrients, and water) and the transformation of organic matter into complex organic compounds that are recalcitrant (i.e., resistant to further microbial breakdown). In other words, decomposition occurs to meet the energetic and nutritional demands of decomposer organisms, not as a community service for the carbon cycle.

1.4.4 Nutrient Cycling

Nutrient cycling involves the entry of nutrients to ecosystems, their internal transfers between plants and soils, and their loss from ecosystems. Nutrients enter ecosystems through the chemical weathering of rocks, the biological fixation of atmospheric nitrogen, and the deposition of nutrients from the atmosphere in rain, wind-blown particles, or gases. Fertilization is an additional nutrient input in managed ecosystems.

Internal cycling processes include the conversion of nutrients from organic to inorganic forms, chemical reactions that change elements from one ionic form to another, biological uptake by plants and microorganisms, and exchange of nutrients on surfaces within the soil matrix. Nutrients are lost from ecosystems by leaching, tracegas emission, wind and water erosion, fire, and the removal of materials in harvest.

Most of the nitrogen and phosphorus required for plant growth in unmanaged ecosystems is supplied by the decomposition of plant litter and soil organic matter. Inputs and outputs in these ecosystems are a small fraction of the quantity of nutrients that cycle internally, producing relatively closed systems with conservative nutrient cycles. Human activities tend to increase inputs and outputs relative to the internal transfers and make the element cycles more open. There are important differences among elements in their patterns of biogeochemical cycling.

Anthropogenic disturbances such as forest conversion, harvest, and fire increase the proportion of the nutrient pool that is available and therefore vulnerable to loss from the ecosystem. Some of these losses occur by leaching of dissolved elements to groundwater, causing a depletion of soil cations, increase in soil acidity and increases in nutrient inputs to aquatic ecosystems.

Gaseous losses of nitrogen influence the chemical and radiative properties of the atmosphere, causing air pollution and enhancing the greenhouse effect. The combustion of fossil fuels has released large quantities of nitrogen and sulfur oxides to the atmosphere and increased their inputs to ecosystems. Fertilizer use and the cultivation of nitrogen-fixing crops have further increased the fluxes of nitrogen in agricultural ecosystems. Together these human impacts have doubled the natural background rate of nitrogen inputs to the terrestrial biosphere. Changes in the cycling of nutrients therefore dramatically affect the interactions among ecosystems, as well as the carbon cycle and the climate of Earth.

1.5 ECOSYSTEM SERVICES AND HUMAN WELLBEING

It has been widely recognized that ecosystems are the planet's life-support systems. Nature's goods and services are the ultimate foundations of life for the human species and all other living beings. Human biology has a fundamental need for food, water, clean air, shelter and relative climatic constancy. All these resources are directly or indirectly derived from ecosystems or nature. Changes in the flow of these services affect health, livelihoods, income, migration and political affairs of human society which in turn have wide-ranging impacts on human well-being.

Table 1.1: Ecosystem good and services

Ecosystem Goods and Services	
Goods (Provisioning Services)	**Cultural Services**
Food, fiber and fuel	Spiritual and religious values
Genetic resources	Knowledge system
Biochemicals	Education and inspiration
Fresh-water	Recreation and aesthetic value
Regulating Services	**Supporting Services**
Invasion resistance	Primary production
Herbivory	Provision of habitat
Pollination	Nutrient cycling
Seed dispersal	Soil formation and retention
Climate regulation	Production of atmospheric oxygen
Pest regulation	Water cycling
Disease regulation	
Natural hazard protection	
Erosion regulation	
Water purification	

Source: Global Biodiversity Outlook 2 (2006)

Global Biodiversity Outlook 2, a comprehensive report published in 2006 by the Convention on Biological Diversity, proposed systematic accounting of ecosystem goods and services. Parallel to this, the Millennium Ecosystem Assessment (MEA), a project conducted by UN and completed in 2005, assessed the current status of various ecosystem services at the global scale. A total of 24 ecosystem goods and services have been described in these studies which are grouped into four sets: Goods (Provisioning services), Supporting services, Regulating services and Cultural services. These goods and services have been enlisted in the given table 1.1.

1.6 HUMAN INTERVENTION IN ECOSYSTEM

Our biosphere is home to an estimated 5-10 million species of living creatures. Man, however, is the single most dominant species that has been drastically modifying the earth for the last several thousand years, in order to fulfill his needs as well as limitless aspirations. Significant effects of human activities on environment were observed, during the past ten thousand years when man started agriculture. As a result of human actions, the structure and functioning of world's ecosystems have changed more rapidly in the second half of the twentieth century than at any other time in human history. A number of negative impacts on world ecosystem have been documented by numerous scientific studies.

It is becoming increasingly clear that population growth and economic development are leading to rapid changes in our global ecosystems. In recognition of this, the United Nations undertook the Millennium Ecosystem Assessment in order to assess the consequences of ecosystem change as related to human well-being, and establish the scientific basis for actions needed to enhance the conservation and sustainable use of those systems, so that ecosystems can continue to supply the services that underpin all aspects of human well being. This assessment exercise has involved more than 1300 experts worldwide.

As mentioned earlier, the Millennium Ecosystem Assessment examined the state of 24 services, that make a direct contribution to human well-being. The assessment concludes that 15 out of these 24 services are in decline, including provision of fresh water, marine fishery production, the number and quality of places of spiritual and religious value, the ability of the atmosphere to cleanse itself of pollutants, natural hazard regulation, pollination, and the capacity of agricultural ecosystems to provide bio-control of pests.

The findings of this assessment provide the strongest evidence so far of the impact of human actions on the natural world. They show, for example, that over the past 50 years, humans have changed natural ecosystems more rapidly and extensively than in any other comparable period in human history . This transformation of the planet has apparently contributed to substantial net gains in human well-being and economic development but not all regions and groups of people have benefited from this process. In fact, many have been harmed. Moreover, the full costs associated with these gains are only now becoming apparent.

Poverty and hunger have tended to force many rural people to do farming on marginal drought-prone lands with poor soil fertility, and others to move to urban slums. About 1 billion people are affected by land degradation such as that caused by soil erosion, water logging or salinity of irrigated land. Erosion has caused substantial reductions of crop yields in Africa. Diminished human health and well-being tends to increase the immediate dependence on ecosystem services and the resultant additional pressure can damage the ecosystems' capacity to deliver services.

Interestingly, the regions facing the greatest challenges in achieving the Millennium Development Goals, overlap largely with those facing the greatest problems related to the sustainable supply of ecosystem services. Ecosystem changes may occur on such a large scale, as to have a catastrophic effect on human health.

The concept of ecological footprint has been designed to measure the extent of human pressure on the land and seas. Ecological footprint measures the biologically productive area that people use for provision of renewable resources, occupy with infrastructure, or require for absorption of CO_2 wastes. As per Living Planet Report 2010, humanity used nature's services 50% faster than what the Earth could renew in 2007. The report also reveals humanity's Ecological Footprint has more than doubled since 1966. Moreover, with the modest UN projections for population growth, consumption and climate change, by 2030 humanity will need the capacity of two Earths, to absorb carbon dioxide waste and keep up with natural resource consumption of ever growing human population. Now it depends on the people and the nations that how they respond to such an alarming situation. Adopting sustainable development in future course of human endeavor is the only solution and way forward.

1.7 NEED FOR MANAGING ECOSYSTEMS

It has been made clear in the preceding sections that ecosystem services are indispensable to the wellbeing of people everywhere. It is also now widely recognized that adverse changes in ecosystems have a more direct influence on human well-being among poor populations than among wealthy populations. Even wealthy populations cannot be insulated fully from the degradation of ecosystem services. Social adaptations may minimize, displace or postpone the negative impacts of ecosystem disruption, but there are limits to what can be achieved.

To sum up, in order to achieve the goal of sustainable development and to enhance human well-being, ecosystem services need to be conserved by all means. For achieving this target, comprehensive reforms in governance, institutions, laws and policies are required along with personal commitment at the level of individuals to adopt an eco-friendly lifestyle. Reducing the present level of resource consumption, fighting inequalities in resource access and giving top priority for managing essential ecosystem services like provision of clean water and nutritious food are some of the pathways to achieve sustainability.

Check Your Progress 2

Note: a) Use the space given below for your answer.

b) Compare your answers with those given at the end of the unit.

1) What will happen, if decomposition process in ecosystems stops?

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2) Why are ecosystems important for us?

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1.8 LET US SUM UP

- The biotic and abiotic components of nature form an interacting system called 'ecosystem'. Ecosystem is the structural and functional unit of biosphere.
- Ecosystem structure can be described in terms of its components, trophic organization, species composition, stratification, consideration of size and scale etc.
- Major functional aspects of an ecosystem include energy flow, production, decomposition and nutrient cycling.
- Goods and services, provided by ecosystems, are the ultimate foundations of life for the human species and all other living beings.
- Pattern of development in the past 50 years indicates that population growth and economic development are leading to degradation of 60% of ecosystem services.
- Human societies can achieve long term growth sustainability by restructuring their development needs, adjusting their lifestyles and managing more judiciously, and scientifically, world's ecosystems.

1.9 KEY WORDS

Food chain : Linear sequence of who eats whom in ecosystem.

Food web : Many food chains when interwoven together.

Detritus : Dead plants and animals fallen on ground.

Decomposition : Break down of complex organic molecules into simple ones.

Trophic levels : A way of delineating the position of an organism in the food chain.

Ecological pyramid : Graphical representation of ecological parameters.

1.10 REFERENCES AND SUGGESTED FURTHER READINGS

- Chap, F.S., Matson, P.A. and Mooney, H.A. 2002. Principles of Terrestrial Ecosystem Ecology. Springer-Verlag, New York.
- Millennium Ecosystem Assessment 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington DC.
- Odum, E.P. 1959. Fundamentals of Ecology. Saunders, Philadelphia.
- Odum, E.P. and Barrett, G. W. 2005. Fundamentals of Ecology. Brooks Cole.
- Schmitz, O. J. 2007. Ecology and Ecosystem Conservation. Island Press, Washington, DC
- Secretariat of the Convention on Biological Diversity 2006. Global Biodiversity Outlook 2. Montreal.

Relevant Websites:

- www.http://cbd.int [Ecosystem approach]
- www.http://unep.org [Developing an ecosystem approach]
- www.http://wikipedia.org/wiki/ecosystem [What is an ecosystem?]

1.11 KEY TO CHECK YOUR PROGRESS

Check Your Progress 1

1) Your answer must include the following points:
   - Community include assemblage of living being of an area
   - Ecosystem include living community along with abiotic environment
2) Your answer must include the following points:
   - Scale vary as per context
   - Boundaries may overlap making assessment of the size difficult

Check Your Progress 2

1) Your answer must include the following points:
   - Dead organic matter will accumulate
   - Atmospheric CO_2 concentration may fluctuate
2) Your answer must include the following points:
   - Ecosystem provides goods and services
   - Human wellbeing depends on ecosystem services

UNIT 2 BIODIVERSITY: LEVELS, DISTRIBUTION AND USES

Structure

2.0 INTRODUCTION

Biodiversity refers to the variety of life forms on the earth. It is one of the essential components of the nature that makes the earth a habitable place. Now a days, biodiversity is considered as major indicator of ecosystem health and bear immense importance in the context of sustainable development. There is consensus among scientists across the world that a development can be said sustainable, if it conserves the precious biodiversity of the earth. It is therefore important to understand the concept of biodiversity and its implications for the development process.

This unit provids you an insights about human dependency on natural environment to appreciate the key services provided by nature and will help you in understanding concept of biodiversity. Only after understanding how the different life forms including humans are interdependent on each other for survival, you will be in the position to make a good decision about how much space should be given to other life forms in our developmental pursuit.

For getting a firsthand experience of biodiversity, you can visit a nearby forest, sanctuary, lake or similar place with wilderness. There you will get a glimpse of biodiversity and there are chances that you may also realize its relevance of in human life.

2.1 OBJECTIVES

After reading this unit, you will be able to:

- describe and discuss the concept of biodiversity;
- discuss the evolution, status and distribution of biodiversity; and
- explain the importance and uses of biodiversity.

2.2 CONCEPT OF BIODIVERSITY

Our Earth is unique not only due to its potential to sustain life but also for the fact that, it provides habitat to millions of life forms. There are over 10 million species that live in this planet. Understanding this diversity of life forms is as fascinating as understanding the basic process of life in biosphere. In fact, in order to appreciate the entire story of evolution of life and human species, it is always desirable to understand the vast diversity of life forms living on the earth.

Biological diversity or biodiversity, is the term given to the variety of life forms on the Earth. "Biodiversity" is often defined as the variety of all forms of life, from genes to species, through to the broad scale of ecosystems. It is the variation of life forms within a given ecosystem, biome, or for the entire earth. The word biodiversity is a contraction of biological diversity which was first used during the National Forum on Biodiversity held in Washington in 1986. The proceedings of the forum were published two years later, under the title Biodiversity, which was later cited as Biodiversity.

The biodiversity, that we see today is the outcome of over 3 billion years of consistent evolution during which millions of species were created and modified by natural processes. Biodiversity is generally expressed in terms of the wide variety of plants, animals and microorganisms. So far, about 1.7 to 1.8 million species has been identified, mostly small creatures such as insects. Scientists reckon that there are actually about 13 million species, though estimates range from 3 to 100 million.

It is, the combination of life forms and their interactions with each other and with the rest of the environment, that has made Earth a uniquely habitable place for humans. Biodiversity provides a large number of goods and services that sustain our lives. This biodiversity in fact forms the web of life of which we are an integral part and upon which we are fully depend. Biodiversity, is often used as a measure of the health of biological systems.

Biodiversity made the headlines throughout most of the last decade, developing into a matter of high concern in most of the countries. This is partly due to the fact, that man is increasingly playing a dominant role in shaping, as well as depleting this natural asset of the earth. In fact biodiversity of the world is depleting at unprecedented alarming rate in the past few decades. Moreover, biodiversity conservation is seen as one of the major component of sustainable development.

2.3 LEVELS OF BIODIVERSITY

Diversity, is a concept that refers to the range of variation or differences among some set of entities. Since biodiversity includes entities with varying degrees of complexity and different time-space scales, it has a hierarchical structure. The hierarchy of biological and ecological systems, covers several levels, starting with the individual and covering increasingly complex forms of groupings of individuals.

As per the definition of biodiversity, given in the Convention on Biological Diversity (Article 2), "biological diversity means the variability among living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic systems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems". Three main levels or components of biodiversity are thus defined as: genetic diversity (within species), species diversity, and ecosystem diversity.

The three levels of biodiversity can be understood through certain examples. Numerous varieties of rice with different traits, varieties of roses with different colours, breeds of cows and buffaloes with different productivity represent genetic diversity. Spectacular differences in form, size and other features among different species, for example cow, buffalo, goat, horse etc., displays another level of biodiversity what is termed as 'Species Diversity'. The third level of biodiversity may be seen in the form of striking differences among large aggregates of habitats of different species occupying large areas with some common distinctive features, called ecosystems, such as forests, deserts, inland waters as well as coastal and marine areas. This third level of biodiversity is termed 'Ecosystem Diversity'.

Table 2.1: Elements of Biodiversity

Ecological Diversity	Genetic Diversity	Organisational Biodiversity
Biomes		Kingdoms
Bioregions		Phyla
Landscapes		Families
Ecosystems		Gemra
Habitats		Species
Niche		Subspecies
Populations		Populations
	Populations	Individuals
	Individuals	
	Chromosomes	
	Genes	
	Nucleotides	

2.3.1 Genetic Diversity

Genetic variation existing within a species is called genetic diversity. For example, it includes different varieties of crops like wheat or rice, as well as different varieties of ornamental plants like roses, or different breeds of cows and buffaloes. Cultivated rice belongs to only two species, yet includes over 120,000 genetically distinct varieties.

Genetic diversity, is manifestation of variation in genetic makeup of a species. Generally individuals belonging to same species have almost similar genetic makeup due to which they crudely look alike. But in many instances individuals of the same species also differ from each other significantly, in terms of genetic makeup. Such genetic variations within species are called as genetic diversity. This gives rise to variations in colors or size or other characters within a particular species.

Variation in genetic makeup within a species is the result of variation in the genetic material present inside the cell, that constitutes bodies of living beings. Chromosomes, DNA, genome, genes and alleles represent different types or levels of genetic materials present in the cell. Chromosomes are thread like structure, which carry genes and they are found in specific number in a particular species. DNA or deoxyribonucleic acid is the building block to make chromosome and it is a large molecule made up by combination of numerous small units or nucleotides. Gene represents the unit area in a chromosome (made by particular combination of nucleotides) which is responsible for carrying a single trait of that individual. Genome represents the complete set of genes of a particular individual of species. Alleles are the different variants of same genes. Genes carry the characteristics of individuals across the generations and also determine the uniqueness of each individual and each species.

A population, is able to respond to natural selection due to its genetic diversity. Species with more genetic diversity can adapt better to the changed environmental conditions. Species with low genetic diversity results into uniformity and thus becomes susceptible to several risks. For example, a cropland with genetically similar crop plants is more likely to suffer loss due to pest or weed attack as compared to that having genetically diverse crops. The genetic diversity within a species often increases with environmental variability. Genetic diversity and species diversity are also interrelated. A community with rich species diversity generally has greater genetic diversity as compared to another community having, only a few species.

2.3.2 Species Diversity

Individual living organisms of any one kind, that freely interbreed among themselves are termed as 'species'. Species are the basic unit of classification, consisting of a population or series of populations of closely related and similar individuals that freely interbreed with one another in natural conditions but notwith members of other species. Thus species, can be viewed as a channel transmitting genetic information in time through the component individuals. Species diversity refers to the variety of species within a region. It includes the full range of species in the region, from microorganisms to multi-cellular plants and animals. Species are distinct units of diversity, each of which have specific role in an ecosystem. It is represented by the incredible variety of different species on the planet.

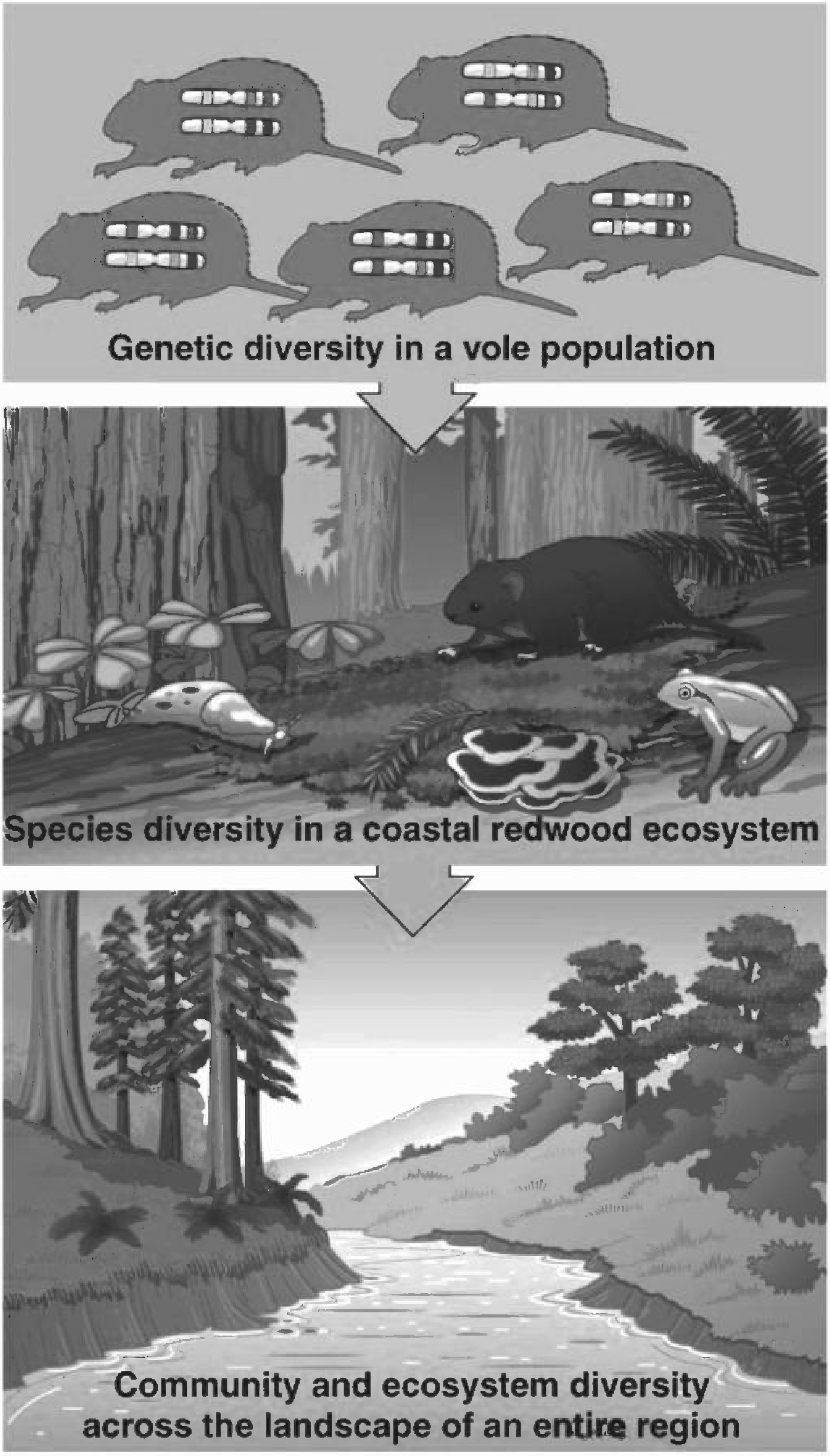

Fig 2.1: Depiction of the three levels of biodiversity

Source: Pearson Education, Inc. publishing as Pearson Benjamin Cummings, 2006

Individuals of same species living in a particular place or environment are collectively called as population. There is usually considerable heritable variation (genetic differences) within and among these populations. There is competition among different groups for food and other resources, leading to a struggle for survival. Some members, who are better adapted to the changes in environment, are able to leave more progeny in successive generations and eventually outnumber, their less adapted relatives. Reproductive isolation (because of inability to mate with other groups or failure to interbreed with them) makes them sufficiently differentiated in due course of time and this leads to evolutionary development of new species, which is better adapted to a new habitat. This natural evolutionary process may take centuries, or even thousands of years. There are, however, some mechanisms that may give rise to new species almost abruptly and suddenly because of numerical and structural changes in genetic material of the species. The process of creation of new species from the existing species is called as 'Speciation'.

Species diversity is considered as the major level of biodiversity on which most scientific, public and political issues focus. However, there are certain drawbacks when focusing on species diversity alone. Firstly, there is still no universal definition of species. The criteria used for describing species also vary between higher taxa and lower taxa.

The species diversity of a region is measured on the basis of two parameters: species richness and evenness or equitability. Species richness refers to the number of species per unit area. The number of species, increases with the area of the site. Generally higher species richness represents greater species diversity. Evenness or equitability indicates the evenness in the distribution of a species. Higher evenness of species means higher species diversity in the region.

2.3.3 Ecosystem Diversity

Ecosystem diversity, refers to the variations in the ecosystems in which species live. This is next higher level of biodiversity in the hierarchy of genetic and species diversity. It includes different ecosystem types such as deserts, forests, wetlands, mountains, lakes, rivers, and agricultural landscapes.

An ecosystem is structural and functional unit of the biosphere. It consists of biotic and abiotic components which interact and exchange material between them with consistent flow of energy across the system. In simple words an ecosystem is a piece of vegetated land or water body where life continues naturally All the living beings, that live in an ecosystem are collectively called community. Diversity within community is also termed as community diversity. Community diversity differs from ecosystem diversity, as the former include diversity of living creatures while the latter includes diversity of living and nonliving components.

An ecosystem is the result of all the biological, climatic, geological and chemical ingredients in a particular area. This total combination of factors, gives rise to certain kinds of plant and animal communities, whose needs can be met by interacting with all the other parts of the system. Variations in these ingredients results into creation of diverse forms of ecosystems that we call ecosystem diversity.

Broadly speaking, the diversity of an ecosystem is dependent on the physical characteristics of the environment, the diversity of species present, and the interactions, that the species have with each other and with the environment. Therefore, the functional complexity of an ecosystem can be expected to increase with the number and taxonomic diversity of the species present, and the vertical and horizontal complexity of the physical environment.

While the physical characteristics of an area, will significantly influence the diversity of the species within a community, the organisms can also modify the physical characteristics of the ecosystem. For example, stony corals are responsible for building the extensive calcareous structures that are the basis for coral reef ecosystems, that can extend thousands of kilometers, e.g. Great Barrier Reef.

There are three perspectives of ecosystem diversity: alpha diversity, beta diversity and gamma diversity.

i) Alpha diversity indicates diversity within the community or ecosystem. It refers to the diversity of organisms sharing the same community or habitat. A combination of species richness and evenness/equitability is used to represent alpha diversity within a community or habitat.

ii) Beta diversity indicates diversity between communities or ecosystems. Species frequently change when habitat or community changes. There are marked differences in species composition of communities along environmental gradients, e.g., altitudinal gradient, moisture gradient etc. The higher heterogeneity in the habitat in the region exhibit higher beta diversity.

iii) Gamma diversity, on the other hand, refers to the diversity of the habitats over the total landscape or geographical area.

The higher diversity at ecosystem level provides stability and higher productivity. In temperate grasslands, it has been observed that landscape with higher community diversity are more stable and productive, even under environmental stress like prolonged dry conditions.

Check Your Progress 1

Note: a) Use the space given below for your answer.

b) Compare your answers with those given at the end of the unit.

1) Elaborate your understanding about the concept of biodiversity.

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2) Differentiate between different levels of biodiversity.

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2.4 EVOLUTION OF BIODIVERSITY

Biodiversity is the result of 3.5 billion years of evolution while formation of the earth took place 4.5 billion years ago. The history of evolution of life and biodiversity on the earth, tells an interesting story of how different life forms evolved during this long journey, how different organisms adapted to changing conditions of the earth and how different forms of life have contributed in shaping the environment of this planet. Here, major milestones of this journey of evolution have been described in a chronological sequence.

Formation of planet earth took place about 4.5 billion years ago when a part of the sun separated from it. Initially boiling at huge temperatures, in time it started to cool, allowing the formation of the atmosphere, then the lithosphere (the solid surface crust) and once the temperature dropped below 100^{0}C, the hydrosphere. At that time, everything was different from present, the oceans were very acidic and the atmosphere consisted mainly of carbon dioxide.

The first living organisms appeared in the ocean about 3.5-4.0 billion years ago. They were bacteria like organisms, termed as prokaryotes which do not have organelles and nucleus and feed on the organic compounds dissolved in water. About 3 billion years ago, there was not enough food for all of them. Then, some turned towards a better source of energy, plentiful and unending, the solar radiation and started transforming and storing it as chemical energy through photosynthesis. During photosynthesis oxygen was liberated into the earth's atmosphere for the first time. In time, oxygen accumulated in both water and air. About two billion years ago, concentration of oxygen in atmosphere was about 0.3% of its present concentration.

Oxygen, due to its highly reactive nature and tendency to form oxidants proved toxic to biological systems. In the due course of time, most living organisms started using its reactivity to further break down organic compounds and use more of the chemical energy stored, a process called respiration. The more efficient oxygen-burning cells grew faster and in time, started to include other cells within their own membrane, cells that became specialized either in photosynthesis, or respiration. These organisms which have specialized organelles like mitochondria and plastids are called eukaryotes. The first eukaryotic organisms were formed about 1.8 billion years ago.

About 1.1 billion years ago, the simple asexual reproductive strategies were replaced with a more complicated process, sexual reproduction, which is based on DNA repairing mechanisms. Around 600 million years ago, the first metazoans (i.e., multicellular) algae were recorded followed by the first invertebrate metazoans. Then a burst in speciation (i.e., creation of new species from existing species) occurred leading to evolution of first primitive fish and vertebrates (i.e., animals with internal skeletons) about 500 million years ago.

Until about 500 million years ago, life forms existed only in water, which could shield them from UV radiation. Meanwhile, at high altitude in the atmosphere, the oxygen molecule (O_2) started forming ozone molecules (O_3) by absorbing high-energy content of ultraviolet (UV) radiation. In dus course of time, the large quantities of ozone were accumulated in the higher strata of the atmosphere, created a shield against the harmful effects of UV-radiation. As a result of formation of protective ozone layer, organisms started living on land. About 440 million years ago, the first plants, followed by invertebrates and vertebrates, started colonizing the land. Slow fusion of continents into a single land mass (Pangaea) reduced the length of coastline and coastal habitat availability and thus motivated the organisms to move towards terrestrial landmasses. However, not all marine phyla attempted or succeeded in doing so. The most successful group that developed on land, in an enormous variety of similar forms is the insect.

With the course of time plants developed huge skeletons consisting of cellulose and lignin to fight gravity, and had to adapt to the limited water supply by developing a pumping system in their roots. The large amount of organic matter stored in woody structures was mostly unavailable to usual grazers and accumulated in enormous quantities. This organic matter, partly contributed to the formation of soils, and many times it was transformed into coal. In this way, huge amounts of carbon dioxide were pumped from the atmosphere and caused a decrease of the greenhouse effect. At this stage, all the surface of the planet was already covered by different life forms, generating a distinct layer known as biosphere. Biosphere is the part of the earth where living beings are present.

The uppermost solid layer of the earth is called lithosphere and it is broken into several (more than 2 dozens) fragments which are called plates. These plates keep on moving in relation to each other in geological time scale: the phenomenon is known as plate tectonics. About 200 million years ago, plate tectonics accounted for the steep rise in diversity. This was due to fragmentation of the earth caused by the break-up of Pangaea, the only supercontinent existing, into seven continents of present. This formed a variety of terrestrial and aquatic biogeographical barriers that effectively isolated previously connected populations and thus increased the rate of speciation. Moreover, the process also created huge spatial diversity in terms of geographical and climatic parameters which resulted into evolution of rich biodiversity across the globe.

The past 400 million years are marked by periodic, massive losses of diversity known as mass extinction events. During the last several thousand years, humans have drastically modified the environment, severely depleting species diversity. At present there are about 1.7 to 1.8 million species that have been identified, mostly small creatures such as insects. Scientists hold the view that there are 3 to 100 million species.

2.5 PRESENT STATUS OF BIODIVERSITY IN THE WORLD

Biodiversity encompasses all forms of terrestrial and aquatic plants, animals and microorganisms, their genetic material and the ecosystem of which they are part. Quantification or assessment of this enormous diversity is highly difficult task. In past, few attempts to perform an inventory were done before the 18th century. In 1758, the Swedish botanist Linneus first proposed the binary system of classification of living organisms that is still in use, and since then number of species described has steadily increased over time.

Species information is considered as the basic unit of documenting and describing biological diversity. It is extremely difficult to inventory all the species on earth.

This is the reason, why the exact number of species on the earth is unknown. A conservative estimate ranges from 3 to 100 million species. For practical purposes, a total of 12.5 million species has been estimated as the known species. Out of this, only about 1.7 million species have been described till date. This figure suggests that only 13% of species on the earth have yet been described. Furthermore, comprehensive catalogues of all 1.7 million species are not available and are poorly known in biological terms.

New species are regularly discovered (on average between 5–10,000 new species each year, most of them insects) and many, though discovered, are not yet classified (estimates are that nearly 90% of all arthropods are not yet classified).

Table 2.2: Total estimated and known number of species on the earth

Group	Estimated total number of species (in thousands)	Known number of species (in thousands)	% known species
Insects	8,000	950	11.9
Fungi	1,000	70	7
Arachnids	750	75	10
Nematodes	500	15	3
Viruses	500	5	1
Bacteria	400	4	1
Plants	300	250	83.3
Molluscs	200	70	35
Protozoans	200	40	10
Algae	200	40	10
Crustaceans	150	40	26.7
Vertebrates	50	45	90
Total	**12500**	**1700**	**13.6**

The available information, in some cases, is inaccurate and biased. Inaccurate because it contains errors of taxonomic judgment and biased because a detailed and relatively accurate information is available only for some groups. Description of species has dominated by the world of animals and plants, frequently ignoring fungi and micro-organisms. Viruses, bacteria, fungi, insects, algae and nematodes are among the least described species. Due to the fact that we know but a portion of the organisms in the biosphere, we do not have a complete understanding of the workings of our environment. This means, that even before a species has had the chance of being discovered, studied and classified, it may already be extinct.

Worldwide efforts are being made to develop accurate biodiversity database. The availability and accessibility of global biodiversity data and information have been described under several categories, which chiefly include global data, conservation area data, species data, genetic data, biological reference collections etc. Majority of the data are increasingly available in digital form. The available datasets are biased i.e., detailed datasets are available for few parameters while a limited amount of data are available for others. Moreover, available datasets are concentrated in developed countries or in the temperate regions. In general, core data sets are improving, expanding and becoming more easily available. A number of NGO's such as WWF, IUCN, Conservation International, and Wetland International are actively contributing to the generation and maintenance of global biodiversity data and information.

2.6 DISTRIBUTION OF BIODIVERSITY ACROSS THE WORLD

Biodiversity is not distributed evenly on the Earth. In fact flora and fauna diversity depends on climate, altitude, soils and the presence of other species. Most of the terrestrial diversity is found in tropical forests. It often decreases as one approach to polar regions. Even though biodiversity declines from the equator to the poles in terrestrial ecoregions, this may not be the case with marine ecosystems where diversity in higher latitudes sometimes increases. There are certain regions in the world which harbor rich biodiversity. Biodiversity hotspot and mega-biodiversity countries have been indentified on the basis of such criteria.

2.6.1 Biodiversity Hotspots

Biodiversity on the earth is facing severe crisis. Unsustainable consumption in many northern countries and crushing poverty in the tropics are destroying the precious biodiversity of the earth. Extinction is the most serious aspect of the biodiversity crisis as it is irreversible damage. While extinction is a natural process, human impacts have elevated the rate of extinction by possibly several thousand times the natural rate. Mass extinctions of this magnitude have only occurred five times in the history of our planet; the last brought the end of the Dinosaur Age. The present era of biodiversity is referred as sixth mass extinction.

In a world, where conservation budgets are insufficient and a number of species are critically endangered, identifying conservation priorities in terms of geographical coverage becomes crucial. British ecologist, Norman Myers defined the biodiversity hotspot concept in 1988 to address the dilemma that conservationists face: what areas are the most immediately important forconserving biodiversity?

Biodiversity hotspots are bio-geographic region characterized both by exceptional levels of plant endemism and by serious levels of habitat loss. According to Conservation International (CI), to qualify as a hotspot a region must meet two strict criteria:

i) it must contain at least 1,500 species of vascular plants (> 0.5 percent of the world's total) as endemics, and

ii) it has to have lost at least 70 percent of its original natural vegetation. In 1999, 25 biodiversity hotspots were identified. In 2005, there were 34 biodiversity hotspots in the revised list. Over 50 percent of the world's plant species and 42 percent of all terrestrial vertebrate species are endemic to these 34 biodiversity hotspots. Their combined area of remaining habitat covers only 2.3 percent of the earth's land surface. Most of these hotspots fall in tropical region.

2.6.2 Megadiversity Countries

Like biodiversity hotspots, the megadiversity countries were identified in an attempt to prioritize biodiversity conservation efforts around the world. The mega-diverse countries are a group of countries that harbor the majority of the earth's species and are therefore considered extremely biodiverse. The World Conservation Monitoring Centre, an agency of the United Nations Environment Programme, has identified 17 megadiverse countries, most located in the tropics. In alphabetical order, these 17 countries are: Australia, Brazil, China, Colombia, Congo, Ecuador, India, Indonesia, Madagascar, Malaysia, Mexico, Papua New Guinea, Peru, Philippines, South Africa, United States and Venezuela. These countries are given priority in allocation of international grants for running conservation programmes.

2.7 USES AND IMPORTANCE OF BIODIVERSITY

Biodiversity is immensely important for sustaining life on the earth. The vast array of interactions among the various components of biodiversity makes the planet habitable for all species, including humans. All life forms here exist in a highly interdependent pattern, where all creatures are linked to each other through complex ecological interrelations. For example, animals are dependent on green plants for supply of oxygen and food while plants often need services of animals in pollination and scattering of seeds. Both plants and animals depend on microorganisms for breakdown of dead organic material while the latter depend on plants and animals for food. Such interdependence can be observed at different levels of biodiversity.

Biodiversity is essential for proper functioning of ecological systems of the earth. In fact biodiversity forms the basis of numerous ecosystem services. These ecosystem services not only cater the basic material needs for survival, but also underpin other aspects of a good life, including health, security, good social relations and freedom of choice. These natural services are so varied as to be almost infinite, that it would be extremely costly or impossible to replace them. For example, it would be impractical to replace, to any extent, services such as food production by agrobiodiversity, or pollination performed by insects and birds. Time after time, we have rushed back to nature's cupboard for cures to illnesses or for infusions of tough genes from wild plants to save our crops from pest outbreaks. Biological resources are in fact the pillars upon which, we have built our civilizations and from where we derive our all our basic needs.

Goods and services provided by biodiversity are numerous in number and there are several ways in which they can be studied. The Millennium Ecosystem Assessment, undertaken under CBD framework, identified 24 ecosystem services that are directly or indirectly related to biodiversity and that make a direct contribution to human well-being. The Assessment was intended to examine the changing status of these services so as to devise conservation strategy for future. These 24 goods and services can be described in four categories: goods, cultural services, regulating services and supporting services. Besides these there are some unknown benefits from biodiversity. In the following sections each category is described in fair detail.

2.7.1 Goods or Provisioning Services

Goods or provisioning services include (i) Food, fiber and fuel, (ii) Genetic resources, (iii) Biochemicals, and (iv) Fresh water. These are the basic day to day requirements of human society that are derived from nature as material resource or goods. These goods are either directly used by human society or converted into some useful commodity for commercial use. The extent to which biodiversity supports human society, varies from urban areas to rural areas, and community to community. In urban setting, biodiversity provides wide range of industrial materials including building materials, fibers, dyes, pharmaceuticals, cosmetics and oil. Biodiversity is closely linked to livelihood options in rural areas where people largely depend on agriculture and associated occupations. Tribal communities and forest dwellers are particularly dependent on biodiversity for food, medicine and most of the needs of life. The importance of biodiversity to issues of resource security (food, fiber, fuelwood, timber, paper, medicinal resources and fresh water etc.) are increasingly being recognized as universal.

Humans use at least 40,000 species of plants and animals. People around the world depend on these species for their food, shelter, clothing and energy requirement. Food is obtained from various food crops and animal species. Fiber for clothes, is also derived from both plant and animal species. For energy, forests provide fuel wood while fossil fuels are also derived from fossilized biodiversity of the past.

Genetic resources are particularly relevant for food sector. There are several thousand species of edible plants, but only 20 kinds of plants are cultivated to produce about 80% of world's food. The three major crops wheat, rice and maize contribute about two third of total food production. There is enormous untapped potential for increasing the range of food products suitable for human consumption.

The reservoir of genetic traits present in wild varieties and traditionally grown landraces is extremely important in improving crop performance. Important crops, such as the potato, banana and coffee, are often derived from only a few genetic strains. Improvements in crop species over the last two centuries have been largely due to harnessing genes from wild varieties and species. Interbreeding crops strains with different beneficial traits, has resulted in more than doubling crop production in the last 50 years as a result of the Green Revolution.

Biochemicals derived from biological resources have immense uses in pharmaceutical and cosmetics industries. A significant proportion of drugs are derived, directly or indirectly, from compounds found in plants, animals, and microorganisms. About 80% of the world population depends on medicines from nature (used in either modern or traditional medical practice) for primary healthcare. For example the wonder drug Penicillin is derived from a fungus called *Penicillium*. Quinine, the cure for malaria, is obtained from the bark of *Cinchona* tree. Similarly *Aloe vera*, herbaceous plant species, has wider application for making cosmetics for skin.

One of the key health issues associated with biodiversity is that of drug discovery and the availability of medicinal resources. Only a tiny proportion of the total diversity of wild species has been investigated for medical potential. There are many more plant species whose medicinal value has not yet been explored.

Through the field of bionics, considerable advancement has occurred which would not have occurred without rich biodiversity.

Biodiversity play key role in ensuring availability of fresh water. This is largely due to the fact that the purification processes taking place in water bodies are facilitated by living organism including bacteria, algae and macroflora. These organisms not only consume organic impurities from the water but also remove toxic heavy metals from it. Applications of these processes have been made for bioremediation of polluted water. Moreover, forest in general is known for maintaining soil moisture and thereby ensuring consistent water availability in the landscape. Some tree species like *Quercus* are particularly known for retaining soil moisture in Himalayan region.

2.7.2 Cultural Services

Cultural services include (i) Spiritual and religious values, (ii) Knowledge system, (iii) Education and inspiration, and (iv) Recreation and aesthetic values. Biodiversity is valuable not only because it provides useful items like food, wood or medicine but also for the fact that it provide nonmaterial benefits to mankind. Philosophically it could be argued that biodiversity has intrinsic aesthetic and spiritual value to mankind.

Biodiversity is related to spiritual and religious belief system in many societies worldwide. Many cultural groups view themselves as an integral part of the natural world and show respect for other living organisms. Plants and animal species are considered to be the symbol of national pride and cultural heritage. For example, *Ocimum sanctum* (Tulsi), *Ficus religiosa* (Pipal), many birds, animals and even snakes are considered sacred and worshipped in majority of Indian villages and towns.

Biodiversity is also a great source of knowledge. While exploring pattern of biodiversity across the globe, scientists indirectly discovered many secrets of nature including the process of evolution of life on the earth. Thus a huge amount of scientific information is available just on account of rich biodiversity we have.

Contribution of biodiversity for education and inspiration is also remarkable. History bears testimony that biodiversity has inspired musicians, painters, sculptors, writers and other artists all over the world. The biodiversity of these countries has directly or indirectly influenced and boosted creativity of these people.

Biodiversity provide great deal of fun and recreation. People around the world derive these values through leisure activities such as ecotourism, mountaineering, wildlife and birdwatching etc. Popular activities such as pet keeping, gardening, caring for aquariums and collecting butterflies are all strongly dependent on biodiversity. Thousands of species are being involved in such pursuits.

2.7.3 Ecological Services: Supporting and Regulating Services

As per Millennium Ecosystem Assessment these services have been categorized into two sets: Supporting services and regulating services.

Supporting services include (i) Primary production, (ii) Provision of habitat, (iii) Nutrient cycling, (iv) Soil formation and retention, (v) Production of atmospheric oxygen, and (vi) Water cycling. These are the basic ecosystem services which support life in the biosphere. In other words these are the processes or attributes which supply the basic needs of life viz., oxygen, water, food and shelter.

Regulating services include (i) Invasion resistance, (ii) Herbivory, (iii) Pollination, (iv) Seed dispersal, (v) Climate regulation, (vi) Pest regulation, (vii) Disease regulation, (viii) Natural hazard protection, (ix) Erosion regulation, and (x) Water purification. These are the functions, which play regulatory role for various ecological processes including supporting services. In simple words, these regulate or determine nature, intensity or magnitude of various ecological processes which are essential for supporting life.

Both the sets of ecosystem services are often not readily visible but these are essential for sustenance of life. For example, biodiversity is directly involved in water purification, recycling nutrients and providing fertile soils. It also plays a part in regulating the chemistry of our atmosphere and water supply. Experiments with controlled environments have shown that humans cannot easily build ecosystems to support human needs; for example insect pollination cannot be mimicked by human-made construction, and that activity alone represents tens of billions of dollars in ecosystem services per annum to humankind.

The stability of ecosystems is also related to biodiversity, with higher biodiversity producing greater stability over time, reducing the chance that ecosystem services will be disrupted as a result of disturbances such as extreme weather events or human exploitation.

Check Your Progress 2

Note: a) Use the space given below for your answer.

b) Compare your answers with those given at the end of the unit.

1) Explain how agriculture depends on biodiversity?

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2) Describe any two supporting ecological services associated to biodiversity.

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2.8 LET US SUM UP

- Biodiversity include diversity of genes, species and ecosystem.
- Biodiversity on the earth is an outcome of about 3.5 billion years of evolution.
- There are about 1.7 to 1.8 million known species in the world which are only 13% of the total estimated species.
- Distribution of biodiversity is highly uneven: tropical ecoregions are the richest areas in terms of biodiversity.
- Among different taxa, insects represent the highest species diversity.
- Biodiversity provides us goods and play several cultural and ecological services which are highly relevant for human.

2.9 KEY WORDS

Biosphere : The part of the earth that sustains life.

Evolution : The geological process of development of life on the earth.

Tropics : The region between the line of Capricorn and line of Cancer.

Species : Organism with similar genetic make-up and which can interbreed.

Ecosystem : A piece of vegetated land or water-body where life can continue without external support.

Community : All the living beings which live in a same ecosystem or habitat.

2.10 REFERENCES AND SUGGESTED FURTHER READINGS

- Cogălniceanu, Dan 2007. Biodiversity. Kessel Publishing House, Germany.
- Millennium Ecosystem Assessment 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington DC.
- O'Riordan, Tim and Stoll-Kleemann, Susanne 2002. Biodiversity, Sustainability and Human Communities: Protecting beyond the Protected. Cambridge University Press.
- Secretariat of the Convention on Biological Diversity 2006. Global Biodiversity Outlook 2. Montreal.
- Wilson, E.O. 1988. Biodiversity. National Academy Press. Washington, DC.

Relevant websites :

- http://www.biodiversityhotspots.org (Biodiversity Hotspots of the world)
- http://www.cbd.int/abs/(Conservation of Biodiversity)
- http://wikipedia.org/wiki/biodiversity [What is Biodiversity?]

2.11 KEY TO CHECK YOUR PROGRESS

Check Your Progress 1

1) Your answer must include the following points:
   - Variety of life forms
   - Three levels of diversity
2) Your answer must include the following points:
   - Genetic variations within a species
   - Diversity at the level of species, concept of species
   - Diversity across the ecosystems

Check Your Progress 2

1) Your answer must include the following points:
   - Genes from the wild relatives for producing disease resistant varieties
   - Pollination by insects
2) Your answer must include the following points:
   - Biomass production by plants
   - Oxygen production by photosynthesis

UNIT 3 LOSS OF BIODIVERSITY

Structure

3.0 INTRODUCTION

Biodiversity is the variety of living organisms on the earth. Biodiversity plays critical role in maintaining life on the earth and provides precious biological resources to humanity. Ironically, overexploitation and imprudent use by man are leading to loss of biodiversity on an alarming rate. As a result of biodiversity loss, productivity of most of the ecosystems of the world is declining and the supply of various goods and services provided by nature is getting hindered. The loss of biodiversity is perceived as potential threat to long term sustainability of life supporting system of the earth.

While Unit-2 of the present Block introduced you to the concept of biodiversity, the present Unit gives a comprehensive account of biodiversity loss. In fact, it is unprecedented rate of biodiversity loss that drew attention of the world community towards biodiversity. This unit highlights different human activities which are causing biodiversity loss. Knowledge of such activities will be helpful to formulate a development process that cares the precious biodiversity of the earth while fulfilling human needs.

3.1 OBJECTIVES

After reading this unit, you will be able to:

- describe the magnitude and pattern of biodiversity loss;

- identify the factors responsible for biodiversity loss; and
- explain the consequences of biodiversity loss.

3.2 BIODIVERSITY LOSS: AN OVERVIEW

As discussed in the previous unit of this, block biodiversity is the variety of living organisms on the earth. It includes diversity within species or between species and of ecosystems. Biodiversity plays critical role in maintaining life supporting system of the earth. We knwo new that globally, so far 1.75 million species have been identified against the estimates ranging from 3 to 100 million.

Biodiversity provides precious biological resources to humanity and these are vital to our economic and social development. But as a result of overexploitation and improper use by man, biodiversity of the earth is depleting on an alarming rate. Loss of biodiversity due to human activities occurred more rapidly in the past 50 years than at any time in human history. We are currently responsible for the sixth major extinction event in the history of the Earth.

The services provided by healthy, biodiverse ecosystems are the foundation for human well-being. As a result of biodiversity loss, productivity of most of the ecosystems of the world is declining. It has hampered the supply of various goods and services provided by nature. You already knew that as per a report of the Millennium Ecosystem Assessment, out of the 24 ecosystem services 15 are in decline. These include the provision of fresh water, marine fishery production, the number and quality of places of spiritual and religious value, the ability of the atmosphere to cleanse itself of pollutants, natural hazard regulation, pollination, and the capacity of agricultural ecosystems to provide pest control. These are the services of the nature which are critically important for our wellbeing and can not be supplied or reconstructed by human made devices.

Biodiversity loss is increasingly being recognized as a potential threat of global scale towards our long term survival and wellbeing on the earth. This calls for global and national actions for checking the current pattern of biodiversity loss. Biodiversity loss as a global issue gained importance at the 1992 Earth Summit in Rio de Janeiro, Brazil where world leaders agreed on a comprehensive strategy for "sustainable development". One of the key agreements adopted at Rio was the 'Convention on Biological Diversity' (CBD), which was signed by vast majority of the world's Governments showing commitments for maintaining earth's biological diversity.

In order to quantify the magnitude of biodiversity loss and consequent changes in ecosystem services, the Millennium Ecosystem Assessment project was launched by UN in 2000. The International Union for Conservation of Nature and Natural Resources (IUCN) publishes and regularly updates a Red List which is a comprehensive inventory of plant and animal species that are threatened or facing the risk of extinction. We know till now that the Millennium Ecosystem Assessment, completed in 2005 by more than 1360 scientists working in 95 countries and they found that changes in biodiversity its due to human activities were occurring more rapidly in the past 50 years than at any time in human history.

Since the Stone Age, species loss has accelerated above the prior rate, driven by human activity. The exact rate is uncertain, but it has been estimated that species are now being lost at a rate approximately 100 to 10,000 times as fast as indicated by the fossil records. One of the major factors leading to this decline is that land is increasingly being transformed from wilderness into agricultural, grazing, mining and urban areas for human use. During the last century, significant decreases in biodiversity have been observed. Studies show that 30% of all natural species can be extinct by 2050. About one eighth of the known plant species are already threatened with extinction. Some estimates put the loss at up to 140,000 species per year (based on Species-area theory).

Declines in the numbers of animals such as tigers, lions, bears, elephants, pandas, whales, and various species of birds, have drawn world attention to the problem of species at risk. Species have been disappearing at 50-100 times the natural rate, and this is predicted to rise dramatically. Based on current trends, an estimated 34,000 plant and 5,200 animal species including one in eight of the world's bird species face extinction.

While the loss of individual species catches our attention, it is the fragmentation, degradation, and loss of forests, wetlands, coral reefs, and other ecosystems that poses the gravest threat to biological diversity. Forests are home to much of the known terrestrial biodiversity, but about 45 per cent of the Earth's original forests are gone, cleared mostly during the past century. Despite some regrowth, the world's total forests are still shrinking rapidly, particularly in the tropics. Up to 10 per cent of coral reefs among the richest ecosystems, have been destroyed, and one third of the remainder face collapse over the next 10 to 20 years. Coastal mangroves, a vital nursery habitat for countless species, are also vulnerable, with half already gone.

3.3 ASSESSMENT OF BIODIVERSITY LOSS

Convention on Biological Diversity, established a number of indicators for the assessment of biodiversity loss. Species population trend indices are valuable tools for monitoring and communicating biodiversity change at global, and regional National scales, or within bio-geographic units. They can also be applied to taxonomic groups (e.g., birds), habitat dependent species (e.g., waterfowl) or species with particular ecological characteristics (e.g., migratory species). Trends in abundance and distribution of selected species are indicators of ecosystem quality. Other indicators such as connectivity and fragmentation of ecosystems are also relevant in providing information about the quality of ecosystems. Following the indicators mentioned, Global Biodiversity Outlook 2 demonstrates a number of patterns of biodiversity loss. Some of them are described in the following paragraphs.

Deforestation, mainly through conversion of forests to agricultural land, continues at an alarmingly high rate. The loss of primary forest since 2000 has been estimated at 6 million hectares annually. Coastal and marine ecosystems have been heavily impacted by human activities, with degradation leading to a reduced coverage of kelp forests, sea grasses and corals. (in the Caribbean, average hard coral cover declined from about 50% to 10% in the last three decades. Some 35% of mangroves have been lost in the last two decades in countries. Trends of some 3,000 wild populations of species show a consistent decline in average species abundance of about 40% between 1970 and 2000; inland water species declined by 50%, while marine and terrestrial species both declined by around 30%. Studies of amphibians, African mammals, birds in agricultural lands, British butterflies, Caribbean and Indo-Pacific corals, and commonly harvested fish species show declines in the majority of species assessed.

More species are becoming threatened with extinction. The status of bird species show a continuing deterioration across all biomes over the last two decades and preliminary findings for other major groups, such as amphibians and mammals, indicate that the situation is equally bad for these groups. Between 12% and 52% of species within well-studied higher taxa are threatened with extinction.

Forests and other natural habitats are increasingly fragmented, affecting their ability to maintain biodiversity and deliver ecosystem goods and services. Within the 292 large river systems assessed, for instance, only 12% of riverbasin area was unaffected by dambased impacts. The intensification of fishing has led to the decline in large high-value fishes, such as tuna, cod, sea bass and swordfish, which are high up in the food chain.

According to the report in the North Atlantic, the number of large fish has declined by two-thirds in the last 50 years. The threats to biodiversity are generally increasing. Humans contribute more reactive nitrogen to ecosystems globally than do all natural processes combined. The rate and risk of alien species introductions have increased significantly in the recent past, and will continue to rise as a result of increased travel, trade and tourism.

Overall, unsustainable consumption continues, as indicated by our growing global ecological footprint. The global demand for resources now exceeds the biological capacity of the Earth to renew these resources by some 20%.

On the positive side, the number and area of protected areas is increasing, although most eco-regions fall well short of the target to protect 10% of their surface. Marine ecosystems in particular are poorly represented, with approximately 0.6% of the ocean's surface area and about 1.4% of the coastal shelf areas protected.

3.4 LOSS OF AGROBIODIVERSITY

For thousands of years we have been developing a vast array of domesticated plants and animals important for food and several other human uses. This subset of biodiversity is popularly called as agrobiodiversity. It is defined as 'the subset of biodiversity that is directly relevant to agriculture' and includes crops and livestock species along with many other organisms such as soil fauna, weeds, pests and predators. Agrobiodiversity provides the foundation for food production for the huge world population and it cannot be substituted by any human made technology in long term.

From the human perspective, genetic diversity is of particular importance in cultivated and domesticated species. Numerous genetic varieties of relatively small number of species are used in this way including a few dozen domesticated animals, a few hundred crop plants (if ornamental plants are excluded), and a few dozen major plantation timber species. Genetic variations are important for maintaining high yields, fitness, disease resistance and resilience to changing environmental conditions.

Unfortunately the rich treasure house of agrobiodiversity is shrinking as modern commercial agriculture focuses on relatively few crop varieties, which in turn is making the agriculture vulnerable to ecological risks. About 30% of breeds of the main farm animal species are currently at high risk of extinction. At present human well-being, particularly food security, depends on a small group of crops and domestic animals; failure of one individual crop can have far-reaching consequences. Loss of genetic diversity through the disappearance of locally adapted varieties and landraces of crops and livestock breeds is widely reported but difficult to quantify. It has been estimated that one third of the 6,500 recognized domesticated animal breeds are currently threatened with extinction.

Beyond cultivated systems, over-exploitation of wild harvested species, including several marine fish species, has led to decline of population size and distribution and as a consequence has contributed to the loss of genetic diversity. Selective trophy hunting of game and selective removal of valuable timber trees can change the genetic profile of the remaining populations. More generally, loss of genetic diversity is associated with the decline in population abundance and distribution that result from habitat destruction and fragmentation.

Detailed description about status, loss, conservation and various issues associated to agrobiodiversity is given in another block of this Course (Block 4 - Agrobiodiversity, Natural).

3.5 THE IUCN RED LIST OF THREATENED SPECIES

As discussed in the previous units about red list of threatened species we knew that the International Union for Conservation of Nature and Natural Resources (IUCN) has published the IUCN Red List ofThreatened species. We have learned that the IUCN Red List is a catalogue of taxa that are facing the risk of extinction. Founded in 1948, the IUCN Red List is the world's most comprehensive inventory of plant and animal species that provide up to date information about the species that are threatened.

A series of Regional Red Lists are produced by countries or organizations, which assess the risk of extinction to species within a political management unit. The Red List also provides information to international agreements such as the Convention on Biological Diversity and the Convention on International Trade in Endangered species of Wild Flora and Fauna.

The IUCN Red List is set upon precise criteria to evaluate the extinction risk of thousands of species and subspecies. These criteria are relevant to all species and all regions of the world. The aim of IUCN red list is to convey the urgency of conservation issues to the public and policy makers, as well as help the international community to try to reduce species extinction.

Major species assessors include Bird Life International, the Institute of Zoology (the research division of the Zoological Society of London), the World Conservation Monitoring Centre, and many Specialist Groups within the IUCN Species Survival Commission (SSC). Collectively, assessments by these organizations and groups account for nearly half the species on the Red List.

The IUCN aims to have the category of every species reevaluated every 5 years if possible, or at least every ten years. This is done in a peer reviewed manner through IUCN Species Survival Commission (SSC) Specialist Groups, which are Red List Authorities responsible for a species, group of species or specific geographic area, or in the case of Bird Life International, an entire class (Aves).

According to the IUCN Red List of Threatened Species, between 12% and 52% of species within well studied higher taxa are threatened with extinction. Threatened species occur across all taxonomic groups and in all parts of the world. Over the past few hundred years, it is estimated that humans have increased species extinction rates by as much as 1,000 times the background rates typical over Earth's history.

On the basis of Red List data, a Red List Index can be calculated for different taxonomic groups or geographic regions to show trends in the proportion of species expected to remain extant in the near future without additional conservation interventions. The index is based on the number of species present in each Red List category, and on the number that change categories over time (i.e., between assessments), as a result of genuine improvement or deterioration in status. This index shows a continuing deterioration in the status of bird species, which have been completely assessed for the IUCN Red List four times over the last two decades, across all biomes.

The Red List Index is highly representative, being based on assessments of a high proportion of species in a taxonomic group across the world, but it shows a coarse level of resolution because of the width of the Red List categories. Some of the Red List criteria are based on absolute population size or range size, while others are based on rates of decline in these values or combinations of absolute size and rates of decline.

3.6 VARIOUS CATEGORIES OF IUCN RED LIST SPECIES

On the basis of information or data of abundance of different species, the IUCN Red Lists describes them in terms of the following categories:

Table 3.1: IUCN Red Lists Category

S.No.	Red List Category	Definition/Description
1.	Extinct	A taxon is Extinct when there is no reasonable doubt that the last individual has died.
2.	Extinct in Wild	A taxon is Extinct in Wild when exhaustive surveys have failed to record an individual.
3.	Critically Endangered	A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future.
4.	Endangered	A taxon is Endangered when it is not Critically Endangered but is facing an extremely high risk of extinction in the wild in the near future.
5.	Vulnerable	A taxon is vulnerable when it is not Critically Endangered or Endangered but is facing high risk of extinction in the wild in the medium term future.
6.	Lower risk	A taxon is Lower risk when it has been evaluated and does not satisfy the criteria for Critically Endangered, Endangered, or Vulnerable.
7.	Data deficient	A taxon is data deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction.
8.	Not evaluated	A taxon is Not Evaluated when it has not yet been assessed.

Few examples of endangered animal and plant species of India, mentioned in the IUCN Red List are:

Table 3.2: Few examples of endangered animal and plant species of India

S.No.	Taxon	Examples
1.	Reptiles	Phyton, Tortoise, Sea turtle
2.	Birds	Great Indian Bustard, Pelican, Peacock, Spotted owl
3.	Carnivorous Mammals	Indian wolf, Red Panda, Tiger, Leopard, Indian lion, Red fox, Golden Cat
4.	Primates	Nilgiri langur, Capped monkey, Golden monkey
5.	Other Mammals	Black rhinoceros, Black buck
6.	Plants	Many species of orchids, Rhododendrons, Sarpagandha, Sandal wood tree, Pitcher plant

3.7 EXTINCTION OF THE SPECIES

The most serious aspect of the loss of biodiversity is the extinction of the species. Once a species is eliminated, the unique information contained in its DNA and the special contribution of characters that it possesses is unlikely to be repeated again. Once species gone extinct, its chances for further evolution are lost.

A species is considered extinct when no member of the species remains alive any where in the world. If individuals of a species remains alive only in the human controlled conditions, the species is said be extinct in the wild. In both these situations, the species would be considered globally extinct. A species is considered to be ecological extinct, if it persists at such reduced numbers that its effects on the other species in its community are negligible.

Species become extinct through three types of extinction processes: natural extinction, mass extinction and anthropogenic extinction. Natural Extinction is the extinction of species slowly from the earth due to change in environmental conditions. Species have disappeared and new ones have evolved to take their place over the long geological history of the earth. Mass Extinction refers to the extinction of large number of species due to catastrophe like earthquake, falling meteors, volcano-eruption, advent of glacial age etc. For example, extinction of dinosaurs about 65 million years ago was triggered by similar catastrophic events. Anthropogenic Extinction refers to the disappearance of the species due to human activities. Species disappear chiefly due to habitat destruction, degradation and fragmentation or human induced introduction of exotic species. For example, extinction of bird species Dodo was largely due to human activities.

While loss of species has always occurred as a natural phenomenon, the pace of extinction has accelerated dramatically as a result of human activity. Ecosystems are being fragmented or eliminated, and innumerable species are in decline or already extinct. We are creating the greatest extinction crisis since the natural disaster that wiped out the dinosaurs 65 million years ago. These extinctions are irreversible and pose a threat to our own well-being since, we are dependent on biodiversity for food, medicines and other biological resources.

Check Your Progress 1

Note: a) Use the space given below for your answer.

b) Compare your answers with those given at the end of the unit.

1) What is the purpose of Red List of IUCN?

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2) Why is the extinction of species a serious issue?

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3.8 FACTORS LEADING TO BIODIVERSITY LOSS

There are a number of reasons or factors that are responsible for fast depleting biodiversity of the planet. Potential threats to species includes fragmentation of habitats, declines in size and quality of habitat, introduction of exotic species, uncontrolled exploitation or hunting of certain species, pollution and nutrient loading largely due to industrial development etc.

Fragmentation raises the extinction risk because isolated sub populations can go extinct one by one, without being repopulated. Stochastic declines in small sub populations make it more likely that they will go extinct and the situation is further worsen by the reduction of genetic variability in sub populations resulting from isolation. Species with already restricted ranges are particularly vulnerable to these threats.

For the terrestrial species, the declines in size and quality of habitat principally arise from conversion of forests and grasslands to agriculture, conversion of natural forests to monoculture plantations, and conversion of natural areas to urban settlement. These changes are largely induced by increasing demand for agricultural production, grazing of animals, wood cutting for fuel and timber, and accommodating increasing human population.

Invasive alien species can transform the structure and species composition of ecosystems by repressing or excluding native species because invasive species are often one of a whole suite of factors affecting particular sites or ecosystems. Introduction of exotic species by man also results in habitat degradation and thereby leading to loss of native species. Prominent examples are the spread of the Peruvian thorny tree *Prosopis juliflora* in the dry parts of northern India where it replaces native species such as *Acacia nilotica* (babool), and the spread of the South American flowering bush *Lantana camara* in the sub-Himalayan belt.

For aquatic and semi-aquatic species, the declines in habitat quality are due to diversion of ground and surface water, resulting in the drying up of streams and other water bodies, from siltation, and pollution from pesticides and other chemicals. Freshwater fish are also threatened by the introduction of exotic species which may be predators or competitors.

Deliberate overexploitation or hunting by human beings poses serious threat to a number of species. Black rhinos are disappearing from Africa, because their horns are in demand for the manufacture of ceremonial daggers for Middle Eastern puberty rites; elephants are threatened by the great economic value of ivory; spotted cats are at risk because their hides are in demand by furriers; and whales are rare because, among other things, they can be converted into pet food. Hunting of poaching of these animals have taken the population of these animals to the brink of extinction.

Global atmospheric changes, such as ozone layer depletion and climate change, also add to the stress which may cause biodiversity loss. A thinner ozone layer lets more ultraviolet-B radiation reach the Earth's surface where it damages living tissue. Global warming is already changing habitats and the distribution of species. Scientists warn that even a one-degree increase in the average global temperature, if it comes rapidly, will push many species over the brink.

It is clear from the above description that direct drivers for changing scenario of biodiversity are chiefly habitat alteration, land-use change, intensification of agriculture, species introduction, overexploitation, pollution, nutrient loading and climate change. These are further determined by a number of indirect drivers which include demographic, economic, socio-political pressure. For example increasing demographic or population pressure leading farmers to intensify their agriculture production by focusing on growing only few crop species. This has resulted in severe decline in agrobiodiversity of the world.

3.9 MAN WILDLIFE CONFLICT

Many species become endangered or extinct if their population size gets reduced below a particular threshold. Man wildlife conflict is a significant factor that is responsible for shrinking population size of some of the mammal species like tiger, elephant, bear, wild boar, porcupine, monkeys etc. Many times these animals enter in the agricultural areas, villages or human settlements and cause danger to human life and create a lot of damage to agriculture, livestock and property. In turn people kill these animals for the sake of their security. This creates conflicting situations between man and wild animal. Reports of man - animal conflicts and resultant casualities often appear in newspapers.

The main causes of human – wildlife conflicts are as follows:

- Destruction of habitats of wild animals compels them to move outside the forest and attack the fields and sometimes even humans.
- Conflict between man and animals arise when, man encroaches into the forest areas, because it is an issue of survival of both.
- When a wild animal gets injured or becomes weak, it develops a tendency to attack man. The female of many wild animals often attack humans, when they feel that their new borns are in danger. A tiger/tigress becomes man-eater, if she tastes human flesh once. In the process of tracing and killing such animal many innocent tiger may be killed.
- When there is the shortage of food for wild animals in wildlife sanctuaries and national parks, the animals move out of the sanctuaries and national parks in search of food and cause huge damage to the crop fields of surrounding areas. The farmers get revengeful and kill the wild animals.
- When there is the disruption in the migratory routes of wild animals due to development of human settlements, the migratory animals attack these settlements.
- Often the government does not pay sufficient compensation for the damage caused by the wild animals to the farmer's crop. The agonized farmers start killing the wild animals.

3.10 WHY BIODIVERSITY LOSS IS A CONCERN?

Human society completely depends on ecological system for some of the fundamental need of life including constant supply of oxygen, water and food. For proper functioning of ecosystems, biodiversity is critically important. The loss of biodiversity often reduces the productivity of ecosystems, thereby shrinking nature's basket of goods and services, from which we constantly draw. The loss of biodiversity threatens our food supplies, opportunities for recreation and tourism, and sources of wood, medicines and energy. Loss of biodiversity destabilizes ecosystems, and weakens their ability to deal with natural disasters such as floods, droughts, and hurricanes, and with human caused stresses, such as pollution and climate change.

Biodiversity loss disrupts ecosystem functions, making ecosystems more vulnerable to shocks and disturbances, less resilient, and less able to supply humans with needed services. For example, wherever protective wetland habitats have been lost or degraded, the damage to coastal communities from floods and storms increased dramatically since the natural protection offered by these ecosystems against wave action, tidal surge, and water run-off from land is compromised. Recent natural disasters underline this reality.

The consequences of biodiversity loss and ecosystem disruption are often harshest for the rural poor, who depend most immediately upon local ecosystem services for their livelihoods and who are often the least able to access or afford substitutes when these become degraded. In daily life, rural households depend, to varying degrees, on farming, fishing, hunting and the harvest of wild products to help meet their subsistence and cash needs while complementing this environmental income with outside sources of earnings, such as wage labour. In fact, the Millennium Ecosystem Assessment has confirmed that biodiversity loss poses a significant barrier to meeting the needs of the world's poorest, as set out in the United Nations Millennium Development Goals. The loss of biodiversity is also increasingly recognized as a significant risk factor in business development and a threat to long term economic sustainability of a nation.

The reduction in biodiversity also hurts us in other ways. Our cultural identity is deeply rooted in our biological environment. History bears testimony that biodiversity has inspired musicians, painters, sculptors, writers and other artists all over the world. The biodiversity has directly or indirectly influenced and boosted creativity of people. Plants and animals are often used as symbols, preserved in flags, sculptures, and other images that define us and our societies. We draw inspiration just from looking at nature's beauty and power. Biodiversity is also a great source of knowledge. While exploring pattern of biodiversity across the globe, scientists indirectly discovered many secrets of nature including the process of evolution of life on the earth. Loss of biodiversity implies that these precious benefits to the humanity will also be lost.

Quite apart from nature's immediate usefulness to humankind, there are important additional reasons to care about the loss of biodiversity. An argument that is often cited is that every life form has an intrinsic right to exist. Species alive today are thousands to millions of years old and have each travelled unique evolutionary paths, never to be repeated, in order to reach their present form. It is unethical to drive other forms of life to extinction, and thereby deprive present and future generations of options for their survival and development. In fact we must recognize the right of future generations to inherit, as we have, a planet thriving with life, and that continues to afford opportunities to reap the economic, cultural and spiritual benefits of nature.

3.11 BIODIVERSITY LOSS: COMMON PERCEPTION VS. REALITY

Depleting status of biodiversity is one of the major global concerns calling for immediate attention from the world community. It is generally observed that public sympathy seems more easily aroused over the plight of furry, cuddly, or spectacular animals. On the basis of knowledge gained over last 2-3 decades, it can be said that biodiversity loss is much more extensive than this commonly held perception. The time has come to focus public attention on a number of more obscure and (to most people) unpleasant truths, such as the following:

- The primary cause of the decay of organic diversity is not direct human exploitation, but the habitat destruction that inevitably results from the expansion of human populations and human activities.
- Organisms have provided humanity with the very basis of civilization in the form of crops, domestic animals, a wide variety of industrial products, and many important medicines. Nonetheless, the most important anthropocentric reason for preserving diversity is the role that microorganisms, plants, and animals play in providing free ecosystem services, without which society in its present form could not persist.
- The loss of genetically distinct populations within species is, at the moment, at least as important a problem as the loss of entire species. Once a species is reduced to a remnant, its ability to benefit humanity ordinarily declines greatly, and its total extinction in the relatively near future becomes much more likely. By the time an organism is recognized as endangered, it is often too late to save it.
- Extrapolation of current trends, in the reduction of diversity implies a downfall for civilization within the next 100 years comparable to a nuclear winter.

Arresting the loss of diversity will be extremely difficult. The traditional “just set aside a preserve” approach is almost certain to be inadequate because of factors such as human population growth, pollution and climate change induced by human beings. A quasi-religious transformation leading to the appreciation of diversity for its own sake, apart from the obvious direct benefits to humanity, may be required to save other organisms and ourselves.

3.12 BIODIVERSITY LOSS AND MILLENNIUM DEVELOPMENT GOALS (MDGS)

The Millennium Development Goals were agreed upon at the United Nations Millennium Summit in 2000. Under each goal, specific targets for 2015 were established. The eight goals declared under MDG are: Eradicating extreme poverty and hunger; Achieving universal primary education; Promoting gender equality and empowering women; Reducing child mortality; Improving maternal health; Combating HIV/AIDS, malaria and other diseases; Ensuring environmental sustainability; and Developing a global partnership for development.

For achieving these goals the nations have to face a number of challenges. As per the Millennium Ecosystem Assessment, the current scenario of biodiversity loss poses a significant barrier to meeting the MDGs. Although policy-makers have generally focused narrowly on the contribution of biodiversity conservation and sustainable use to the achievement of Goal 7 ("Ensure environmental sustainability"), the wider role of ecosystem services in supporting livelihoods and human well-being reveals biodiversity to be the foundation for all development, and hence for meeting each of the Millennium Development Goals.

Studies of food security and nutrition, for instance, have shown the importance of agricultural biodiversity to the elimination of hunger and malnutrition. In terms of human health, biodiversity also has a recognized role in controlling vector-based diseases and providing the natural sources of many traditional medicines and modern pharmaceutical drugs.

The potential challenge in achieving MDGs lies in the fact that a number of the actions that could be implemented most quickly to promote economic growth and reduce hunger and poverty (e.g., intensification of agriculture or infrastructure developments) are harmful to biodiversity, at least in the short- to medium-term, and could undermine the sustainability of any development gains. Recognizing the trade-offs and synergies that exist between poverty alleviation and biodiversity conservation, sustainable use of biological resources becomes essential for achieving many of these goals.

Check Your Progress 2

Note: a) Use the space given below for your answer.

b) Compare your answers with those given at the end of the unit.

1) What are the major factors leading to biodiversity loss?

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2) How is human wellbeing affected by biodiversity loss?.

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3.13 LET US SUM UP

- Biodiversity of the earth is depleting on an alarming rate particularly in the last 50 years.
- As per a report of the Millennium Ecosystem Assessment, out of the 24 ecosystem services 15 are in decline.
- The IUCN Red List is the world's most comprehensive inventory of plant and animal species that provide up-to-date information about the species that are threatened.
- Potential threats to biodiversity include fragmentation of habitats, declines in size and quality of habitat, introduction of exotic species and uncontrolled exploitation or hunting of certain species.
- The loss of biodiversity threatens our food supplies, opportunities for recreation and tourism, and sources of wood, medicines and energy.
- The current scenario of biodiversity loss poses a significant barrier to meeting the Millennium Development Goals.

3.14 KEY WORDS

Ecosystem Services	:	Various direct and indirect services provided by nature, e.g., producing food.
Agrobiodiversity	:	Biodiversity that is relevant for agriculture.
Habitat	:	Natural place of living of a species.
Exotic species	:	Species that originated outside a particular region.
Species introduction	:	Growing some new or exotic species in some area.
Extinction	:	When no more members of a species remain alive on the planet.

3.15 REFERENCES AND SUGGESTED FURTHER READINGS

- Cogãlniceanu, Dan 2007. Biodiversity. Kessel Publishing House, Germany.
- Millennium Ecosystem Assessment 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington DC.
- O'Riordan, Tim and Stoll-Kleemann, Susanne 2002. Biodiversity, Sustainability and Human Communities: Protecting beyond the Protected. Cambridge University Press.
- Secretariat of the Convention on Biological Diversity (2006). Global Biodiversity Outlook 2. Montreal.
- Wilson, E.O. 1988. Biodiversity. National Academy Press. Washington, DC.

Relevant websites :

- http://www.biodiversityhotspots.org (Biodiversity Hotspots of the world)
- http://www.cbd.int/abs/(Conservation of Biodiversity)
- http://wikipedia.org/wiki/biodiversity [What is Biodiversity?]

3.16 KEY TO CHECK YOUR PROGRESS

Check Your Progress 1

1) Your answer must include the following points:
   - To enlist the species facing threat of extinction
   - To draw attention of world community for the conservation of these species
2) Your answer must include the following points:
   - Once species is lost, genetic information contained in DNA is lost
   - Loss is irreversible
   - Loss of species may result in loss of some ecosystem function

Check Your Progress 2

1) Your answer must include the following points:
   - Destruction, fragmentation and degradation of habitat
   - Introduction of exotic species
2) Your answer must include the following points:
   - Human wellbeing depends on ecosystem services
   - Loss of biodiversity results into disturbance in ecosystem functions
   - Direct and indirect benefits of biodiversity are lost

UNIT 4 BIODIVERSITY CONSERVATION

Structure

4.0 INTRODUCTION

There is growing recognition that biodiversity is a global asset of tremendous values to the present and future generations. Biodiversity is critically important for proper functioning of ecosystems and the services provided by healthy and bio-diverse ecosystems are the foundation for human well-being and survival of all the creatures of the earth. Ironically, overexploitation and imprudent use by man are leading to depletion of biodiversity on an alarming rate. This calls for global and national attention to save biodiversity from further decline and to adopt various conservation practices. Conservation of biodiversity means using biodiversity in sustainable manner so that it may benefit the present generation while maintaining its potential to meet the needs and aspirations of the future generations.

While Unit-2 of the present Block introduced you to the concept of biodiversity, and Unit-3 gave detailed account of biodiversity depletion, the present unit aims at providing you adequate information about biodiversity conservation. The Unit first discusses the concept and approaches of biodiversity conservation. It then explores various programmes and policy framework for biodiversity conservation at international level. It then describes these programmes and policy framework in the context of India.

4.1 OBJECTIVES

After reading this unit, you will be able to:

- explain the concept of biodiversity conservation;
- describe different approaches of biodiversity conservation; and
- discuss different National and International programmes for conserving biodiversity.

4.2 NEED TO CONSERVE BIODIVERSITY

We know from previous units that biodiversity is the variety of living or ganisms on the earth. It includes diversity within species, between species and of eco-systems. Unfortunately, as a result of overexploitation and imprudent use by man, biodiversity of the earth is depleting on an alarming rate. We have learned that the loss of biodiversity due to human activities occurred more rapidly in the past 50 years than at any time in human history. As a result of biodiversity loss, productivity of most of the ecosystems is declining and the supply of various goods and services provided by nature is getting hampered. This calls for global and National attention to save biodiversity from further decline and to adopt various conservation practices.

Conservation of biodiversity aims at conserving diversity at all the levels including genetic, species and ecosystems. It also includes promoting sustainable use of all its components, including plants, animals and microorganisms. Protecting natural habitats from degradation and fragmentation is an important part of biodiversity conservation programmes. It also provides for fair and equitable sharing of benefits arising from the use of bioresources and associated traditional knowledge.

Worldwide a number of International, regional and National level programmes are being carried out to ensure conservation of biodiversity and to check its further depletion. 'Convention on Biological Diversity' (CBD), one of the key agreements adopted at Earth Summit 1992, chiefly aims at conserving rich biodiversity of the planet. As of now, 193 countries are party to the CBD. India, which is known for its rich heritage of biodiversity, has been a signatory to the Convention since 1994, and is one of the countries that have enacted comprehensive legislation to achieve the objectives of the convention. In India, biodiversity conservation is observed as a part of cultural practices for long and it is also linked to livelihood generation for millions of people especially for those living in rural areas.

4.3 DIFFERENT APPROACHES TO BIODIVERSITY CONSERVATION

Conservation of biodiversity means 'the management of human use of biosphere so that it may give maximum benefit to the present generation, while maintaining its potential to meet the needs and aspirations of the future generations'. Since biodiversity includes living communities and their attributes, understanding of basic principles of biology and ecology is crucial for the management or conservation of biodiversity. Conservation biology as a discipline evolved for the purpose. Conservation biology matured in the mid 20th century as ecologists, naturalists, and other scientists began to collectively research and address issues pertaining to global declines in biodiversity. Conservation biology includes principles, guidelines, and tools for the purpose of protecting biodiversity.

Conservation biology is crisis oriented and multidisciplinary subject, that includes biology, ecology, social organization, education and many other disciplines. The conservation ethic advocates management of natural resources for the purpose of sustaining biodiversity in species, ecosystems, the evolutionary process, and human culture and society. In response to the extinction crisis, the research of conservation biologists is being organized into strategic plans that include principles, guidelines, and tools for the purpose of protecting biodiversity.

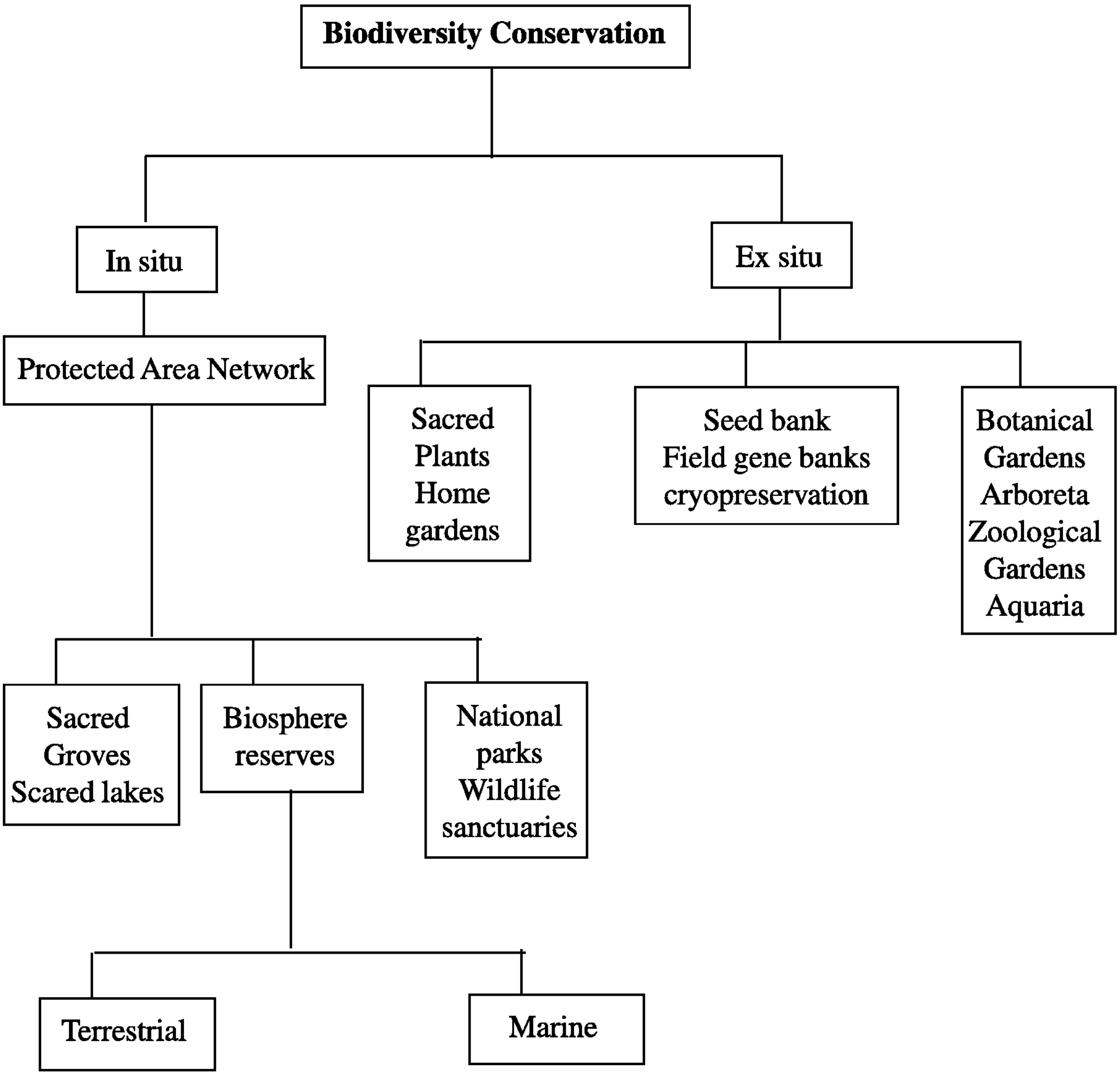

Fig.4.1: Biodiversity Conservation strategies

There are two basic strategies of biodiversity conservation: *in situ* (on site) and *ex situ* (off site). *In situ conservation* refers to the conservation of biological diversity in their natural habitats through protection of total ecosystem. *Ex situ conservation* refers to the conservation of biodiversity at place away from their natural habitat. It has been realized, that preserving habitat (*in situ* conservation) and reintroducing eliminated indigenous species is more effective to conserve biodiversity in general. Once the preservation of the remaining native species in an area is assured, reintroduction can be attempted. Missing species can be identified from databases such as the Encyclopedia of life and the Global Biodiversity Information Facility.

Preventing entry of invasive alien species and managing them, in situations of their unintentional or accidental introduction, help in preserving native biodiversity and their natural habitats. Exotic species that have become a pest can be identified taxonomically (e.g. with Digital Automated Identification System (DAISY), the barcode of life. Eradication is practical only against large groups of individuals due to the economic cost. Other measures contributing to the preservation of biodiversity include: the reduction of pesticide use and/or a switching to organic pesticides. Biodiversity banking is another approach which involves placing a monetary value on biodiversity so that its values are realized in economic terms. One example is the Australian Native Vegetation Management Framework.

4.4 *IN SITU* CONSERVATION STRATEGIES

It refers to the conservation of biological diversity in their natural habitats through protection of total ecosystem. The areas which provide protection to the biological diversity include: Protected areas, Biosphere reserves, Sacred forests and Sacred lakes.

1) **Protected areas.** These are areas of land and /or sea especially dedicated to the protection and maintenance of biodiversity and managed through legal or other effective means. National Parks and Wildlife Sanctuaries are the examples of protected areas.

   The protected areas provide following benefits.

   i) Maintains viable populations of all native species and sub species

   ii) Maintain the number and distribution of communities and habitats and conserve the genetic diversity of all the present species.

   iii) Prevent man made introduction of exotic species

   a) **National Parks:** A National Parks is an area which is strictly reserved for the welfare of wildlife and where activities such as forestry, grazing or cultivation are not allowed. The earliest National parks, the Yellowstone in USA and Royal near Sydney, Australia, were chosen of their scenic beauty and recreational values. The Jim Corbett National Park near Nainital, was first National Park established in India.

   b) **Sanctuaries:** A sanctuary is an area, which is reserved for the conservation of animals only. Operations such as harvesting of timber, collection of minor forest products and private ownership rights are allowed provided they do not affect the animals adversely.

2) **Biosphere reserves:** The man and biosphere (MAB) programme of UNESCO formulated the concept of biosphere reserves in 1975, which deals with the conservation of ecosystems and genetic resources contained therein. The

Biosphere reserves are the special category of protected areas of land / or coastal environments, wherein people are an integral component of the system.

A Biosphere Reserve consists of three zone- Core, buffer and transition zones.

i) Core or natural zone. It comprises an undisturbed and legally protected ecosystem.

ii) Buffer zone: It surrounds the core area, and is managed to accommodate a greater variety of resource use strategies, and research and educational activities.

iii) Transition zone: It is the outermost part of Biosphere Reserve. It serves as an area of active cooperation between reserve management and the local people, wherein activities like settlements, cropping, forestry and recreation and other economic uses continue in the harmony with conservation goals.

The Biosphere performs following three main roles.

i) Conservation: It ensure the conservation of landscapes, Ecosystems, species and genetic resources.

ii) Development: It promotes culturally, socially and ecologically sustainable development.

iii) Scientific research, monitoring and education: It provide support for research monitoring, education and information exchange related to local, national and global issues of conservation and development.

3) **Sacred forest and sacred lakes:** There has been a traditional practice in India and other Asian countries to maintain scared forests and lakes to protect biodiversity. The sacred forest is protected by the tribal communities due to religious sanctity accorded to these forests. Many of states of our country such as Karnataka, Maharastra, Kerala, Meghalaya etc. possess scared forests. These are serving as protective centres for a number of rare, endangered and endemic taxa. Similarly aquatic flora and fauna is also protected in scared water bodies. For instance Khecheopalri lake in Sikkim has been declared scared by the people to save aquatic life for degradation.

4) **On-farm conservation of agricultural biodiversity:** Agrobiodiversity refers to the variety and variability of living organisms that contribute to food production systems and associated activities. In the past five decades, intensification and the homogenization of agroecosystems have led to significant losses in agrobiodiversity, including the loss of crop and livestock species, genetic diversity, as well as crop-associated biodiversity. Need of conserving agrobiodiversity is being perceived as urgent priority at national and international levels. *In situ* on farm conservation of agrobiodiversity is the major approach towards this end. It encourages sustenance of rich biodiversity in the agricultural farms. Although agrobiodiversity has severely declined in most of the modern agricultural farms, there are communities that still practice traditional agriculture in which they grow great variety of

crops. Such communities are largely confined to hilly regions, tribal areas and remote areas in India. In the last two decades, farmers in certain states have also adopted methods of organic farming in which they have paid attention to conserve agrobiodiversity. *In situ* on farm conservation of agrobiodiversity also contributes in improving the livelihoods of farmers particularly in resource poor areas.

4.5 *EX SITU* CONSERVATION STRATEGIES

Ex situ refers to the conservation of biodiversity at place away from their natural habitat. For *ex situ* conservation of biodiversity, germplasm banks or gene banks are established. These include botanical garden, zoos, genetic resources centres, seed, tissue cuture and DNA banks. Seed gene banks are the easiest way to store germplasm at ultra low temperature (i.e., at a temperature of -196°C in liquid nitrogen) is called cryopreservation. By cryopreservation the germplasm can be stored for a long period of time. Gene banks are collections of specimens and genetic material. Some banks intend to reintroduce banked species to the ecosystem (e.g. via tree nurseries).

As compared to *in situ* conservation, *ex situ* conservation requires lesser geographical area to establish but more sophisticated management. Botanical gardens and zoos are the most common places for the conservation of biodiversity. All over the world, there are more than 1500 botanical garden which contains more than 80,000 species of plants. Many of these botanical gardens have seed banks, tissue culture facilities and other *ex situ* technologies.

Ex situ conservation of biodiversity is significant due to the following two major reasons:

i) The conservation of wild varieties of plant or crops and culture of microorganism provides a source of genetic materials.

ii) Plants and animals conserved in botanical garden, zoos and aquaria can be used to restore degraded land, reintroduce into species into the wildlife and restock depleted populations.

Check Your Progress 1

Note: a) Use the space given below for your answer.

b) Compare your answers with those given at the end of the unit.

1) What is the need to conserve biodiversity?

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2) How do protected areas help in conserving biodiversity?

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4.6 INTERNATIONAL EFFORTS TO CONSERVE BIODIVERSITY

For the last 2-3 decades, biodiversity depletion is perceived as a potential challenge to human wellbeing all over the world. As a response to this, efforts to conserve biodiversity have been observed at varying scale. International conferences particularly Stockholm Conference and Earth Summit played key role to evolve institutional or policy measures to conserve biodiversity. In the following sections, these efforts have been mentioned in details.

4.6.1 Emergence of Global Concern for Biodiversity Conservation

Global concern about environmental destruction and loss of species and ecosystems were first time expressed in the early seventies. In 1972, the United Nations Conference on the Human Environment in Stockholm resolved to establish the United Nations Environment Programme (UNEP). Governments signed a number of regional and international agreements to tackle specific issues, such as protecting wetlands and regulating the international trade in endangered species. These agreements, along with controls on toxic chemicals and pollution, helped to slow the rate of destruction. For instance, an international ban and restrictions on the taking and selling of certain animals and plants have helped to reduce over-harvesting and poaching. In addition, many endangered species were protected in zoos and botanical gardens, and key ecosystems were preserved.

Later, it was realized that the long-term viability of species and ecosystems depends on their being free to evolve in natural conditions. This means, that humans have to learn how to use biological resources in a way that minimizes their depletion and allow them to lead their live in their natural habitat. By the early eighties, scientists and policymakers across the world started working on the challenge to find economic policies that motivate conservation and sustainable use by creating financial incentives for those who would otherwise over-use or damage the resource. This required a comprehensive vision for world development supported by adequate policy framework.

In 1987, the World Commission on Environment and Development (the Brundtland Commission) in its landmark report, 'Our Common Future', gave a mandate that humanity has the ability to make development sustainable by ensuring, that it meets needs of the present without compromising the ability of future generations to meet their own needs. It called for a new era of environmentally sound economic development.

4.6.2 Convention on Biological Diversity (CBD)

In 1992, the largest ever meeting of world leaders took place at the United Nations Conference on Environment and Development in Rio de Janeiro, Brazil which is popularly known as "Earth Summit". Two historic agreements were signed at the, conference: the Convention on Climate Change, and the Convention on Biological Diversity. Convention on Biological Diversity (CBD) is the first global agreement on the conservation and sustainable use of biological diversity. CBD gained rapid and widespread acceptance. Over 150 governments signed the document at the Rio conference, and since then more than 193 countries have ratified the agreement.

The Convention on Biological Diversity has three main objectives or goals:

- Conservation of biodiversity,
- Sustainable use of the components of biodiversity, and
- Sharing the benefits arising from the commercial and other utilization of genetic resources in a fair and equitable way.

The Convention addresses all aspects relating to biodiversity. The institutional framework for CBD's implementation is provided by the Conference of the Parties (COP). The COP is the governing body of CBD which keeps under review implementation of the Convention, and steers its development. COP is the supreme decision making body which has the authority to adopt protocols under the Convention. It also has the authority to amend the Convention itself.

The Convention is comprehensive in its goals, and deals with an issue so vital to humanity's future, that it stands as a landmark in International law. It recognizes for the first time, that the conservation of biological diversity is "a common concern of humankind" and is an integral part of the development process. The agreement covers all ecosystems, species, and genetic resources. It links traditional conservation efforts to the economic goal of using biological resources sustainably. It sets principles for the fair and equitable sharing of the benefits arising from the use of genetic resources, notably those destined for commercial use. It also covers the rapidly expanding field of biotechnology, addressing technology development and transfer, benefit-sharing and biosafety. Importantly, the Convention is legally binding; countries that join it are obliged to implement its provisions.

The Convention reminds decision makers that natural resources are not infinite and sets out a new philosophy for the 21st century, that of sustainable use. While past conservation efforts were aimed at protecting particular species and habitats, the Convention recognizes that ecosystems, species and genes must be used for the benefit of humans. However, this should be done in a way and at a rate that does not lead to the long-term decline of biological diversity.

The Convention also offers decision makers guidance based on the precautionary principle that where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat. The Convention acknowledges, that substantial investments are required to conserve biological diversity. It argues, however, that conservation will bring us significant environmental, economic and social benefits in return.

4.6.3 Other Global Conventions Related to Biodiversity Conservation

Apart from CBD there are few other International conventions that directly or indirectly contribute towards conservation of biodiversity and ecosystems at the global or regional scale. Four major conventions have been introduced in the following paragraphs.

Convention on Migratory Species (CMS): It aims to protect those species of wild animals, that migrate across or outside national boundaries. This includes conservation of terrestrial, marine and avian species over the whole of their migratory range. The convention was concluded in 1979 and came into force on 1 November 1983. As of December 1999, 68 states have ratified the convention.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES): It is an international treaty drawn up in 1973 to protect wildlife against overexploitation and to prevent International trade from threatening species with extinction. The treaty entered into force on 1 July, 1975 and now has a membership of 146 countries.

Ramsar Convention on Wetlands of International Importance: The Convention, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. There are presently 117 Contracting Parties to the Convention.

The World Heritage Convention Concerning the Protection of the World Cultural and Natural Heritage (the World Heritage Convention): It was adopted by the General Conference of UNESCO in 1972. As of October 1999, more than 158 countries have signed the convention. This is one of the most universal international legal instruments for the protection of the cultural diversity and natural heritage.

4.6.4 Identification of Biodiversity Hotspots and Mega-Biodiversity Countries

Biodiversity is not distributed evenly on the Earth. There are certain regions in the world which harbor rich biodiversity. Biodiversity hotspot and mega-biodiversity countries have been indentified on the basis of such criteria. Identification of these pockets of rich biodiversity helps in focusing conservation efforts to protect maximum biodiversity of the world.

As discussed earlier biodiversity hotspot are bio-geographic region characterized both by exceptional levels of plant endemism and by serious levels of habitat loss. These biodiversity hotspots were first identified in 1988 by Dr. Norman Myers. We have learned from the previous units that according to Conservation International (CI), to qualify as a hotspot a region must meet two strict criteria: it must contain at least 1,500 species of vascular plants (> 0.5 percent of the world's total) as endemics, and it has to have lost at least 70 percent of its original habitat. In 2005, CI described 34 regions in the revised hotspot list. Most of these hotspots fall in tropical region. India has four out of thirty four global biodiversity hotspots, which is an indicator of high degree of endemism (of species) in India. They are – Eastern Himalayas, Western Ghats, North East India and the Andaman and Nicobar Islands.

The mega-diverse countries are a group of countries that harbor the majority of the Earth's species and are therefore considered extremely biodiverse. The World Conservation Monitoring Centre, an agency of the United Nations Environment Programme, has identified 17 megadiverse countries, most located in the tropics. In 2002, a separate organization, Like-Minded Megadiverse Countries, was formed in Mexico, consisting of countries rich in biological diversity and associated traditional knowledge. In alphabetical order, these 17 countries are: Australia, Brazil, China, Colombia, Congo, Ecuador, India, Indonesia, Madagascar, Malaysia, Mexico, Papua New Guinea, Peru, Philippines, South Africa, United States and Venezuela.

4.7 BIODIVERSITY CONSERVATION IN INDIA

India is known for its rich heritage of biodiversity. India is one of the 17 mega-diverse countries in the world. With only 2.4% of the world's area, India accounts for 7-8% of the world's recorded plant (about 45,000, of which approximately 15,000 are of known medicinal value) and animal species (about 91,000). India's ten biogeographic zones possess an exemplary diversity of ecological habitats like alpine forests, grasslands, wetlands, coastal and marine ecosystems, and desert ecosystems.

India has four out of thirty four global biodiversity hotspots, which is an indicator of high degree of endemism (of species) in India. They are – Eastern Himalayas, Western Ghats, North East India and the Andaman and Nicobar Islands. About 5,150 plant species and 1,837 animal species are endemic to India. India's biodiversity includes wild relatives of agricultural crops and domesticated animals. India has 16 major types and 251 subtypes of forests. The large mosaic of distinct agro-ecosystems has contributed to diverse cropping pattern and systems across the country.

Biodiversity conservation is practiced in India since times immemorial. In the last 4-5 decades, however a number of institutional measures have been taken for the purpose. Creation of protected areas, biosphere reserves, gene banks etc. are some of the examples of such efforts. Various conservation programs and policies of India are discussed in fair details in the following sections.

4.7.1 Biodiversity Conservation Programmes in India

India proudly upholds the tradition of nature conservation. In 252 BC, the Emperor Asoka established Protected Areas (PAs) for mammals, birds, fish and forests through a proclamation. Jim Corbett National Park covering an area of 325 sq. Km. came into being as the India's first and world's third National Park in 1936. India has currently 4.79% of total geograpc hiarea under an elaborate network of PAs, which includes 99 National Parks, 513 wildlife sanctuaries, 43 conservation reserves, 4 community reserves and 3 Biodiversity Heritage sites.

India has a National Wildlife Action Plan, which envisages 10% of the geographical area of the country under PA coverage. This is significant, keeping in view that India holds 18% of world's human population and also 18% of the world's livestock population in an area, which is only 2.4% of the world's geographical area. Under the Man and Biosphere (MAB) Programme out of 16 biospheres in India (70,000 sq. km.), seven are already in UNESCO World Network of Biosphere Reserves (World total 503).

India has a National Wetland Conservation Programme covering 125 wetlands including 25 Ramsar sites under the Ramsar Convention. India accounts for about 5% of the world's mangroves (including Sunderbans delta the largest mangrove forest in the world) and partners with IUCN's Mangroves for future programme and has established a National Institute of the Mangrove Research at Kolkata. Coral reefs in India occupy an extent of 2375 sq. km. (including the Andaman Islands, which have rich coral diversity and a National Coral Reef Research Centre at Port Blair).

India has a National Lake Conservation Plan covering 42 lakes, which aims at rejuvenation in terms of improvement on water quality and biodiversity. India has a National River Conservation Plan under implementation in 160 cities covering 34 rivers. NGRBA (National Ganga River Basin Authority) is responsible for conserving and sustainable use of the biodiversity of the river Ganges.

Conservation and sustainable use of biodiversity have been an integral part of Indian ethos. Sacred groves are thick patches of natural Forests conserved by the local communities as part of sociocultural practices. The Sacred Grove Information System holds information on 3000 such groves in the country out of an estimated 100,000 to 150,000.

Several species specific projects are being implemented for flagship animal species such as Tiger (National Animal), Elephant (National Heritage Animal), Rhinoceros, Gharial, Hangul and snow leopard, birds such as Vulture, Great Indian Bustard, and plants such as Orchids, Rhododendron and citrus.

4.7.2 Important National Parks, Sanctuaries and Gene Banks of India

Some important National Parks of India with a mention of major species being conserved:

- Kaziranga National Park, Assam for Rhinoceros, Elephant, Python etc.
- Sundarbans (Tiger Reserve), West Bengal for Tiger, Crocodile, Deer etc.
- Hazaribagh National Park, Hazaribagh, Jharkhand for Tiger, Sambhar, Nilgai etc
- Corbett National Park, Nainital, Uttranchal for Tiger, Panther, Chital, Cobra etc.
- Gir National Park, Gujrat for Lion, Chinkara, Langur, Panther etc.
- Kanha National Park, Madhya Pradesh for Tiger, Panther, Chital, Blue bull etc.
- Tandoba National Park, Maharastra for Tiger, Bear, deer, Crocodile etc.

- Bandipur National Park, Karnataka for Elephant, Tiger, Leopard, Green Pigeon etc.
- Desert National Park, Rajasthan for Great Indian bustard, Black buck, Chinkara etc.

Some important Sanctuaries of India with a mention of major species being conserved:

- Annamalai Sanctuary, Tamilnadu – Elephant, Tiger, Panther, Spotted deer etc.
- Sultanpur Lake Bird Sanctuary, Gugaon, Haryana – Sarus, Duck, Green pigeon etc.
- Nagarjuna Sagar Sanctuary, Guntur, A.P. – Tiger, Panther, Chital, Nilgai etc.
- Periyar Sanctuary, Kerala – Elephants, Leopard, Black Langur etc.
- Chilka Lake Bird Sanctuary,Orissa – Water fowls, Duck, Cranes etc.
- Manas Wildlife Sanctuary Assam – Rhino, Sambhar etc.

Major gene banks in India are:

- NBPGR (National Bureau of Plant Genetic Resources) at New Delhi
- NBFGR (National Bureau of Fishery Genetic Resources) at Lucknow
- NDRI (National Dairy Research Institute), Karnal, Haryana
- IMTECH (Institute of Microbial Technology), Chandigarh
- NBAIM (National Bureau of Agriculturraly Important Microorganisms), Mau, Utter Pradesh

4.7.3 Policy and Institutional Framework for Biodiversity Conservation

Environment protection is enshrined in the Constitution of India [Article 48A and Article 51A (g)]. Wide ranging policies, programmes and projects are in place, which directly or indirectly serve to protect, conserve and sustainably use the country's biological resources. These include the Forest (Conservation) Act, Wildlife (Protection) Act, Biological Diversity Act, National Green Tribunal Act, National Biodiversity Action Plan, National Forest Policy, National Wildlife Action Plan, National Forestry Action Programme, National Environment Policy and National Action Plan on Climate Change.

India is committed to conservation of biodiversity. This is not only because of India's international obligations as a signatory to the Convention on Biological Diversity, but because India believes that protecting our biodiversity is a critical national priority as it is linked to local livelihoods of millions of people in the country. Sustainable use of our biodiversity, therefore, has both ecological and economic value. It is with this objective that India has enacted Biological Diversity Act, 2002 and set up a National Biodiversity Authority (NBA) in 2003, with an explicit mandate of promoting conservation of biological resources and associated knowledge as well as facilitating access to them in a sustainable manner.

Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, enacted in 2006, is a tool to provide occupational and habitational rights to the people, thus, incentivising conservation and sustainable use of biological resources by providing access to livelihood enhancing resources to people. National Biotechnology Development Strategy, 2007, calls for promotion of mass use of technologies for sustainable utilisation of bioresources. National Biodiversity Action Plan of 2008 developed in consultation with various stakeholders and by taking cognizance of legislative and policy framework is a dynamic matrix for mainstreaming biodiversity concerns in the country.

India has large number of scientific personnel and important network of scientific institutions in public, private and NGOs sectors. The important institutions/ organisations include Botanical Survey of India, Zoological Survey of India, Wildlife Institutes, Fishery Survey of India, Forest Survey of India, ICFRE, ICAR, CSIR, DBT, DST, DRDO etc. National Bureaus on plants, animals, fish, insects, microbes and forest genetic resources are specifically mandated for management of genetic resources. All India Coordinated Project on Taxonomy and network projects on honeybee and pollinators and ornithology are also in place for capacity building and research.

India has put in place a number of initiatives for promoting conservation of biodiversity, such as, provision of national gene fund, national biodiversity fund, awards etc. Pressure from habitat loss and degradation has been reduced by the system of environment clearances based on Environmental Impact Assessment (EIA), Coastal Regulation Zone (CRZ), National Afforestation and Eco-development Board (NAEB), National Action Programme to Combat Desertification and Green India Mission.

4.7.4 India as a Signatory to the Convention on Biological Diversity (CBD)

India has been a signatory to the Convention since 18th February, 1994, and is one of the first countries to have enacted an appropriate comprehensive legislation to achieve the objectives of the convention. As of now, 193 countries are party to the CBD. India has to hosted COP-11 in 2012. The COP-11 was very significant as it the 10th anniversary of Johannesburg World Summit on Sustainable Development, 20th anniversary of the Rio Earth Summit and 40th anniversary of Stockholm Conference. During 2010, several activities have been organized in India to mark the celebration of International Year of Biodiversity.

As a signatory to the CBD, the Biological Diversity Act, 2002, passed on December 11, 2002 came into force on February 5, 2003, followed by the formation of it Rules in 2004. The Biological Diversity Act of, 2002, provides necessary statutory and administrative mechanism at the National, State and Local body levels to realize the objectives of the Act and CBD. A three tiered system of regulation is envisaged under the Biological Diversity Act, which consists of the National Biodiversity Authority (NBA) at the apex level, Biodiversity Boards (SBBs) at State level and Biodiversity Management Committees (BMCs) at local level.

The headquarter of NBA is at Chennai and the main functions include regulating activities, advising the Government of India on biodiversity matters, grant for access to biodiversity and associated knowledge and to take necessary measures to protect the biological diversity of the country. The main functions of the State Biodiversity Boards are to regulate requests for utilization of biological resources by Indian nationals and to assist the State Government in notification of areas of biodiversity importance as Biodiversity Heritage Sites and framing rules for their management and conservation. At the local level, Biodiversity Management Committees perform the function of documenting People's Biodiversity Registers and implement biodiversity conservation programmes.

To ensure the fair and equitable sharing of benefits arising out of the use of genetic resources, India has taken significant legislative measures and also integrated these principles in various policies and programmes. The Protection of Plant Varieties and Farmer's Rights Act, 2001 and Rules, 2003 deal primarily with the protection of plant breeders rights over the new varieties developed. The second and third amendments to the Patent Act, 1970 provide for mandatory disclosure in the patent application, of the source and geographical origin of the biological material used in the invention. National Innovation Foundation (NIF), an autonomous society established in 2000 for recognizing, respecting and rewarding innovations and outstanding traditional knowledge at grass root level.

4.7.5 Protection of Traditional Knowledge about Biodiversity

India has rich traditional knowledge about medicinal values of plants and natural products which have been used by people here since times immemorial. This knowledge has generally been passed down by word of mouth from generation to generation. A part of this knowledge has been described in ancient classical and other literature which is often rarely accessible to the common person.

Documentation of this existing knowledge, available in public domain, on various traditional systems of medicine has become imperative to safeguard the sovereignty of this traditional knowledge and to protect it from being misappropriated in the form of patents on non-original innovations, and which has been a matter of national concern. India fought successfully for the revocation of turmeric and basmati patents granted by United States Patent and Trademark Office (USPTO) and neem patent granted by European Patent Office (EPO).

In 1999, the Department of Ayurveda, Yoga & Naturopathy, Unani, Siddha and Homoeopathy (AYUSH) and Council of Scientific and Industrial Research (CSIR) constituted an interdisciplinary Task Force, for creating an approach paper on establishing a Traditional Knowledge Digital Library (TKDL). TKDL is an effective deterrent to bio piracy. TKDL is a maiden Indian effort and is a proprietary and original database. TKDL is available in English, Japanese, French, German and Spanish. Today, India through TKDL is capable of protecting about 0.224 million medical formulations. TKDL is proving to be an effective deterrent against biopiracy.

India has also set up a global bio piracy watch system under TKDL in respect of patent applications related to Indian System of Medicines misappropriation and biopiracy are the issues of great concern for the developing countries and this agenda is being pursued at multilateral flora such as CBD, TRIPS Council and WIPO, and a global Traditional Knowledge protection system is expected to be established soon. The Biological Diversity Act, 2007 provides for documentation of coded and oral traditional knowledge associated with bioresources in the form of People's Biodiversity Register, to ensure effective management, promotion and sustainable uses.

4.8 MAJOR CHALLENGES IN MEETING GOALS OF BIODIVERSITY CONSERVATION

Major challenges in meeting goals of biodiversity conservation are briefly summarized as below:

- Regulating the large scale deforestation and land use changes while meeting the growing demands of expansion of agriculture, roads, railway tracks, mining, factories, powerhouses, river dams and urban residential schemes among many others.
- Meeting the increasing demand for biological resources caused by population growth and increased consumption.
- Controlling the increasing pollution levels and global warming.
- Increasing our capacity to document and understand biodiversity, its value, and threats to it.
- Building adequate expertise and experience in biodiversity planning.
- Improving policies, legislation, guidelines, and fiscal measures for regulating the use of biodiversity.
- Adopting incentives to promote more sustainable forms of biodiversity use.
- Promoting trade rules and practices that foster sustainable use of biodiversity.
- Strengthening coordination within governments, and between governments and stakeholders.
- Securing adequate financial resources for conservation and sustainable use, from both national and international sources.
- Making better use of technology.
- Building political support for the changes necessary to ensure biodiversity conservation and sustainable use.
- Improving education and public awareness about the value of biodiversity.

Check Your Progress 2

Note: a) Use the space given below for your answer.

b) Compare your answers with those given at the end of the unit.

1) What are the major goals of CBD?

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2) Has India taken some initiative to protect biodiversity?

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4.9 LET US SUM UP

- Biodiversity of the earth is depleting on an alarming rate and this calls for conservation efforts from the world community.
- Conservation of biodiversity means using biodiversity in sustainable manner so that present and future generations can fulfill their needs.
- *In situ* conservation approach includes Protected areas (like National parks and sanctuaries), biosphere reserves, Nature reserves, sacred grooves, on-farm conservation of agricultural biodiversity etc.
- *Ex situ* conservation approach includes botanical garden, zoological parks, seed-banks, tissue culture etc.
- At international level, Conference on Biological Diversity (CBD) provides the most comprehensive policy framework for the sustainable use of biodiversity.
- A number of policy and programmes for biodiversity conservation are running in India which is one of the signatory to CBD.

4.10 KEY WORDS

Ecosystem Services : Various direct and indirect services provided by nature, e.g., producing food.

Conservation : Conservation of biodiversity means using biodiversity in sustainable manner so that present and future generations can fulfill their needs.

***In situ* conservation** : Conservation of biological diversity in their natural habitats.

***Ex situ* conservation** : Conservation of biodiversity at place away from their natural habitat.

Endemism : The extent to which species of any area are confined to that area in their distribution.

Extinction : It is a phenomenon when all the members of a particular species disappear from the world due to natural or human induced reasons. Once a species is extinct, the unique information contained in its DNA is lost forever.

4.11 REFERENCES AND SUGGESTED FURTHER READINGS

- Cogălniceanu, Dan 2007. Biodiversity. Kessel Publishing House, Germany.
- Millennium Ecosystem Assessment 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington DC.
- O'Riordan, Tim and Stoll-Kleemann, Susanne 2002. Biodiversity, Sustainability and Human Communities: Protecting beyond the Protected. Cambridge University Press.
- Secretariat of the Convention on Biological Diversity 2006. Global Biodiversity Outlook 2. Montreal.
- Wilson, E.O. 1988. Biodiversity. National Academy Press. Washingot, DC.

Relevant Websites:

- http://www.biodiversityhotspots.org (Biodiversity Hotspots of the world)
- http://www.cbd.int/abs/(Conservation of Biodiversity)
- http://wikipedia.org/wiki/biodiversity [What is Biodiversity?]

4.12 KEY TO CHECK YOUR PROGRESS

Check Your Progress 1

1) Your answer must include the following points:
   - To save species from extinction and threats to their survival
   - To maintain ecosystem services provided by biodiversity
2) Your answer must include the following points:
   - Maintaining viable population of native species and sub-species
   - Protecting natural habitats of all species to promote their conservation
   - Managing threats imposed by invasive alien species

Check Your Progress 2

1) Your answer must include the following points:
   - Conservation and management of biodiversity
   - Sustainable use of the components of biodiversity
   - Sharing the benefits arising from the use of bioresources (and associated traditional knowledge) in a fair and equitable manner as provided under the national legislation

2) Your answer must include the following points:
   - India's national obligations as a signatory to CBD
   - Legal protection to biodiversity in India
   - Establishment of protected areas and biosphere reserves
   - Conservation practices in India since historical times