
UNIT 2 BIODIVERSITY: LEVELS, DISTRIBUTION AND USES

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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 provides 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 not with 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.

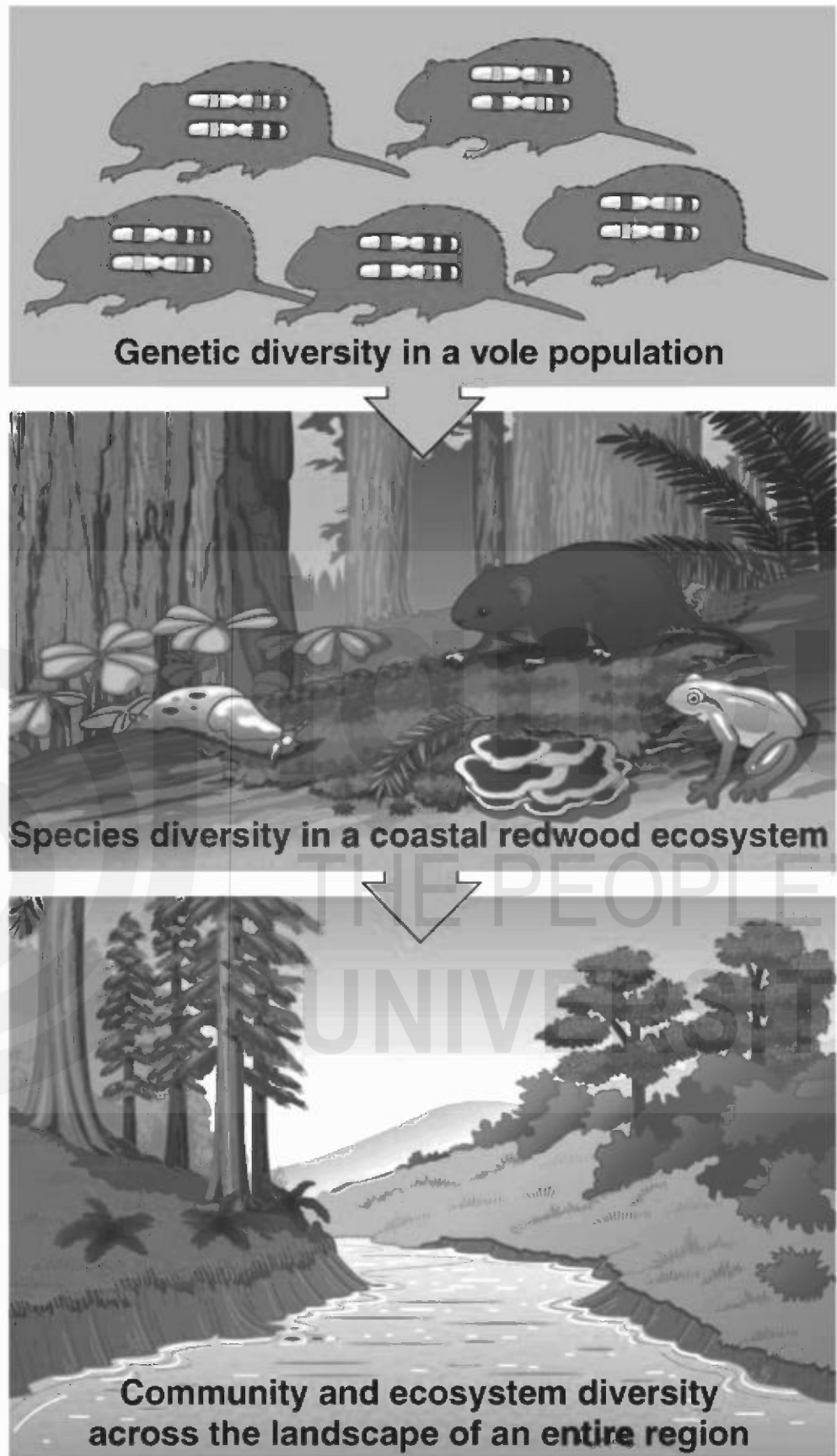


Fig 2.1: Depiction of the three levels of biodiversity

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°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 due 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 for conserving 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 megadiverse 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