NETAJI SUBHAS OPEN UNIVERSITY

Choice Based Credit System (CBCS)

UG

SELF LEARNING MATERIAL

Skill Enhancement Course (SEC)

Botany (HBT)

Plant Diversity and Human Welfare

SE - BT - 21

PREFACE

In a bid to standardize higher education in the country, the University Grants Commission (UGC) has introduced Choice Based Credit System (CBCS) based on five types of courses viz. *core, generic, discipline specific elective, ability and skill enhancement* for graduate students of all programmes at Honours level. This brings in the semester pattern which finds efficacy in sync with credit system, credit transfer, comprehensive continuous assessments and a graded pattern of evaluation. The objective is to offer learners ample flexibility to choose from a wide gamut of courses, as also to provide them lateral mobility between various educational institutions in the country where they can carry their acquired credits. I am happy to note that the university has been recently accredited by National Assessment and Accreditation Council of India (NAAC) with grade "A".

UGC (Open and Distance Learning Programmes and Online Programmes) Regulations, 2020 have mandated compliance with CBCS for U.G. programmes for all the HEIs in this mode. Welcoming this paradigm shift in higher education, Netaji Subhas Open University (NSOU) has resolved to adopt CBCS from the academic session 2021-22 at the Under Graduate Degree Programme level. The present syllabus, framed in the spirit of syllabi recommended by UGC, lays due stress on all aspects envisaged in the curricular framework of the apex body on higher education. It will be imparted to learners over the six semesters of the Programme.

Self Learning Material (SLMs) are the mainstay of Student Support Services (SSS) of an Open University. From a logistic point of view, NSOU has embarked upon CBCS presently with SLMs in English / Bengali. Eventually, the English version SLMs will be translated into Bengali too, for the benefit of learners. As always, all of our teaching faculties contributed in this process. In addition to this we have also requisioned the services of best academics in each domain in preparation of the new SLMs. I am sure they will be of commendable academic support. We look forward to proactive feedback from all stakeholders who will participate in the teaching-learning based on these study materials. It has been a very challenging task well executed, and I congratulate all concerned in the preparation of these SLMs.

I wish the venture a grand success.

Professor (Dr.) Subha Sankar Sarkar
Vice-Chancellor

Netaji Subhas Open University

Under Graduate Degree Programme

Choice Based Credit System (CBCS)

Subject : Honours in Botany (HBT)

Course : Plant Diversity and Human Welfare

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Notification

NETAJI SUBHAS OPEN UNIVERSITY

UG : Botany
(HBT)

Plant Diversity and Human Welfare

SE-BT-21

Unit 1 □ Plant Diversity and its Scope

Structure

1.0 Objectives

- To understand the term biodiversity and its different level and measurement.
- To know the significance of genetic, species, and ecosystem diversity.
- To know the species diversity in India and World.
- To give an idea about different types of ecosystems present in the nature.
- To discuss about the diversity of agricultural crops, their origin, and importance.
- To get a brief idea about the diversity of cultivated plants.
- To know the values and uses of plant and microbial diversity.

1.1 Introduction

Biodiversity is a term encompassing the variety and variability among living organisms, the genetic diversity they contain, the assemblages they form and the ecological complexes in which they occur. It is omnipresent, both on land, air and in water including all organisms, from microscopic bacteria to more complex plants and animals. According to United Nations Convention on Biological diversity (UNEP, 1992), biodiversity means: "*The variability among living organisms from all sources including inter-alia, terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems*". Another definition, which is more concise and clearer, but more challenging, is "*the totality of genes, species and ecosystems in a region*" (WRI, IUCN and UNEP, 1992). Biodiversity is autosustainable and self-regulating, if there are no natural and/or man-made perturbations. It exists

with the support of ecological processes and organic evolutions. There are some major aspects, which make it so important for the human race. It is a valuable natural as well as genetic resource for the survival of mankind, a gradual reduction of which may result in disappearance of economically and medicinally important species.

Biodiversity is directly related to ecosystem and perform not only as a tool for maintaining its health and stability but also ensure optimum utilization of abiotic resources in an ecosystem. Concept of Biodiversity can be subdivided in four levels. **Genetic diversity** (diversity within species); **species** or **taxonomic** or **organismal diversity** (diversity between species); **ecological** or **habitat diversity** (diversity of ecosystems), and **molecular diversity** (diversity of molecules). In measuring the biodiversity, Ecologists and biogeographers divide species richness into **four** major components: **point richness/diversity** (the number of species that can be found at a single point in space), **alpha diversity** (the number of species in a single community, which comes closest to the popular concept of species richness and can be used to compare the number of species in different ecosystem types), **beta diversity** (change in species composition along environment gradients representing intercommunity diversity or between habitat diversity) and **gamma diversity** (the rate at which additional species are encountered as geographical replacements within a habitat type in different localities).

Molecular biodiversity is the richness of molecules found in life. It is distinct from genetic diversity, though both ultimately depend on inheritable DNA. It occurs within one individual, between individuals of the same species, between related species, within and between phyla and ecosystems, and throughout evolution. Without molecular biodiversity evolution cannot occur, either in the origin of a new species, its survival and development, or its eventual extinction (Campbell, 2003).

Genetic diversity can be measured by methods based on DNA and Chromosomes. There are some factors both biotic and abiotic that control the diversity of genetic resources is also a significant part of genetic diversity study. There are a large variety of different ecosystems on earth, which have their own complement of distinctive inter linked species based on the differences in the habitat. Ecosystem diversity can be described for a specific geographical region, or a political entity such as a country, a State or a taluka. Distinctive ecosystems include landscapes such as forests, grasslands, deserts, mountains, etc., as well as aquatic ecosystems such as rivers, lakes, and the sea. Each region also has man-modified areas such as farmland or grazing pastures. Agricultural biodiversity (or agro-biodiversity) includes all the animal, plant and micro-organism species that sustain agricultural ecosystems, and the variety between and within them, and is essential to food and nutrition security. Agrodiversity naturally promotes the topic cultivated plant diversity. Biodiversity has

a huge aesthetic and ethical values. However, there are numerous valuation methods as well as precautionary principles for that valuation. Plant can be used as food, drugs, medicines, fuels, timber, ornamentals, etc. Microbes mainly used in medicine, pharmaceuticals, and dairy industry.

1.2 Plant Diversity and its Scope

The great variety of life on earth has provided for man's needs over thousands of years. This diversity of living creatures forms a support system which has been used by each civilization for its growth and development. Those that used this "bounty of nature" carefully and sustainably survived. Those that overused or misused it disintegrated.

Science has attempted to classify and categorize the variability in nature for over a century. This has led to an understanding of its organization into communities of plants and animals. This information has helped in utilizing the earth's biological wealth for the benefit of humanity and has been integral to the process of 'development'. This includes better health care, better crops and the use of these life forms as raw material for industrial growth which has led to a higher standard of living for the developed world. However, this has also produced the modern consumerist society, which has had a negative effect on the diversity of biological resources upon which it is based. The diversity of life on earth is so great that if we use it sustainably, we can go on developing new products from biodiversity for many generations. This can only happen if we manage biodiversity as a precious resource and prevent the extinction of species.

The following six reasons incidentally explain the scope of this branch of science.

(i) Biodiversity is the unifying driving force, all along much needed, to provide a continuum within the broad field of Biology. The readers are quite aware of the fact that Biology is now fragmented into a large number of disciplines. Although originally done to facilitate understanding the various facets of Biology, this fragmentation has diminished, even eradicated the connections among the different disciplines as well as produced an unhealthy competition among them, leading to underestimation of each other. In most countries, Molecular Biology and Biotechnology have become the most sought-after disciplines of Biology, relegating Morphology and Taxonomy to the lowest level of preference; the latter also hold little or no career incentives. The fact has been obscured that these two groups of disciplines of Biology are equally

necessary and that a close co-operation and interaction among the various disciplines are absolutely important for the welfare of human kind. Such interaction and cooperation are also needed to address all the problems of Biodiversity with greater ease and perfection. Thus, the science of Biodiversity has the potential to unify all fragmented disciplines of Biology and bring together the activities of all scientists professing these disciplines. This is, as a matter of fact, one of the important goals of the International Union of Biological Sciences (IUBS).

(ii) Biodiversity is the backbone for Agriculture, Aquaculture, Animal Husbandry, Forestry and a host of other applied branches of Biology. Hence it stands at the very foundation of development, especially in a rapidly changing world. Population growth has not declined to a desired level. We are not going to simply expand the load on the land presently available, but actually multiply the load. Evidence suggests that the Green Revolution is likely to diminish gradually and stop. Grain and pulse yields have stopped rising as fast as in earlier years. Supplies of fresh water are growing scarce. Human beings currently appropriate 54% of accessible freshwater runoff, but in the next 25 years, the projected increment in demand is more than 70%. Soil quality has already started deteriorating the world over. There is very little unplanted arable land left for further agricultural exploitation. Hence, new varieties of useful plants and new breeds of domesticated animals have to be constantly evolved for increased yield/productivity, desired lifetime, disease resistance etc. Effort to increase the quality and quantity of bioresources is possible only if we have adequate information and knowledge about their wild relatives, which form the genetic source for their further improvement through conventional or biotechnological methods.

(iii) It is well known to all readers that intense globalisation of trade and markets has occurred during the last decade, resulting in very rapid and dramatic changes in land-use patterns and regional developmental activities. Consequently, pronounced deforestation (at the rate of some 14 million hectares each year), alarming desertification and substantial global climatic changes have taken place. About 40 to 50% of the land on Earth has been irreversibly transformed through change in land cover or degradation by human beings. Models based on UN's intermediate population projection mentioned in the paragraph above suggest that an additional one-third of global land cover will be transformed over the next one hundred years. It has now become highly obligatory for mankind to not only check these alarming

changes, but also to reconstruct and restore the changed ecosystems to their original state. Any new change in the existing landscape must be properly planned in order to make it environment-friendly. Such undertakings require a deep understanding of biodiversity in all its aspects.

(iv) The first half of the present century, as in the last half of the previous century, is definitely going to be dominated by Biology. Biodiversity is fast becoming the fundamental requirement on which the new industrial developments and innovations are going to be based. Biodiversity will offer in the coming years, new sources of food, medicine and other human requirements. Therefore, industrial development will become possible only by exploring the great potential of the still unknown biological resources. For this, in-depth knowledge of biodiversity is imperative.

(v) Globalisation of information and communications has markedly increased. Furthermore, a substantial human migration to various parts of the world is anticipated in the next one or two decades. There is also anticipation of substantial movement of plants and animals to different parts of the globe. All these processes will definitely lead to profound changes not only in the existing society and culture, but also in the landscape of different parts of the world. Under these circumstances, the study of biodiversity cannot be treated in isolation from the anticipated human dimension. Thus, biodiversity will become the only purposeful scientific tool with which one can bridge the social and cultural world.

(vi) Biodiversity is the resource on which all human existence depends, i.e., it is the pillar of human development. Consequently, a sustainable exploitation of bioresources should be practised. Sustainable development can be compared to a chair with four legs of similar length and strength. These four legs respectively denote the economic, environmental, social and cultural facets of biodiversity. Unless all the four dimensions of biodiversity are equally strong, sustainable development cannot result. Therefore, biodiversity, is vital for sustainable development.

1.3 Genetic Diversity

Diversity within species is the Genetic diversity. Each member of any animal or plant species differs widely from other individuals in its genetic makeup because of the large number of combinations possible in the genes that give every individual specific characteristic. Thus, for example, each human being is very different from

all others. This genetic variability is essential for a healthy breeding population of a species. If the number of breeding individuals is reduced, the dissimilarity of genetic makeup is reduced and in-breeding occurs. Eventually this can lead to the extinction of the species. The diversity in wild species forms the 'gene pool' from which our crops and domestic animals have been developed over thousands of years.

Genetic diversity, is also referred to as within-species diversity, or intra- or infraspecific diversity. A number of infra-specific categories have often been recognised and most of them also enjoy taxonomic implications without necessarily being defined in genetic terms (UNEP 1995): subspecies, varieties, land races, clines, cultivars, ecotypes, chemotypes, cytotypes, hybrids, polytypes, polyploid complexes, aggregated species, etc. The recognition of these 'taxonomic' categories often poses problems in defining and conceptualizing genetic diversity. It should thus be emphasised that there is no single definition of genetic diversity that can be used for all purposes.

1.3.1 Nature and Origin of Genetic Variations

It is a well-known fact that the blueprints for all living beings are genes and that they consist of discrete segments of deoxyribonucleic acid (DNA). DNA is a linear molecule composed of sequences of four different nucleotide bases: adenine, guanine, thymine and cytosine. These four bases form the four base pairs: adenine-thymine, guanine-cytosine, thymine-adenine and cytosine-guanine. All observed variations are invariably due to variations in the sequences of the four base pairs of the DNA molecule. The number of possible combinations of these base pairs exceeds the number of atoms in the universe. From this, one can imagine the magnitude of variations that can be produced. The combinations of these four base pairs in various permutations result in the Genetic code. The genetic code distributes 64 triplet codons to 20 amino acids, including initiation signals and three termination signals for the construction of protein molecules with specific sequences of amino acids.

1.4 Species Diversity

The number of species of plants and animals that are present in a region constitutes its species diversity. This diversity is seen both in natural ecosystems and in agricultural ecosystems. Some areas are more rich in species than others. Natural undisturbed tropical forests have a much greater species richness than plantations developed by the Forest Department for timber production. A natural forest ecosystem provides a large number of non-wood products that local people depend on such as

fruit, fuel wood, fodder, fiber, gum, resin and medicines. Timber plantations do not provide the large variety of goods that are essential for local consumption. In the long-term the economic sustainable returns from non-wood forest products are said to be greater than the returns from felling a forest for its timber. Thus, the value of a natural forest, with all its species richness is much greater than a plantation. Modern intensive agricultural ecosystems have a relatively lower diversity of crops than traditional agropastoral farming systems where multiple crops were planted.

Historically, species are the fundamental descriptive units of the living world and this is why biodiversity is very commonly, and incorrectly, used as a synonym of species diversity, in particular of ‘‘species richness,’’ which is the number of species in a site or habitat. Discussion of global biodiversity is typically presented in terms of global numbers of species in different taxonomic groups. An estimated 1.8 million species have been described to date; estimates for the total number of species existing on earth at present vary from 5 million to nearly 100 million. A conservative working estimate suggests there might be around 12.5 million (Swingland, 2001).

When considering species numbers alone, life on earth appears to consist mostly of insects and microorganisms. The species level is generally regarded as the most natural one at which to consider whole-organism diversity. While species are also the primary focus of evolutionary mechanisms, and the origination and extinction of species are the principal agents in governing biological diversity. Species cannot be recognized and enumerated by systematists with total precision. The concept of what a species is differs considerably among groups of organisms. It is for this reason, among others, that species diversity alone is not a satisfactory basis on which to define biodiversity.

1.4.1 Species Inventory

An inventory is a formal surveying, sorting, cataloguing, quantifying and mapping of the occurrence of defined elements of biodiversity such as genes, individuals, populations, species, habitats, ecosystems and landscapes at a particular point of time in a defined geographical unit (spatial scales range from nanometres to countries or even continents). Here we are concerned with the inventory of species.

Several considerations influence a good inventory:

(i) The existing knowledge base on which the proposed inventory is to be commenced; the greater the existing knowledge, the better the inventory.

(ii) The level of expertise of personnel and technical capabilities available; the sounder these are, the better the inventory.

(iii) The level of funding; the larger the funding, the better the inventory.

(iv) The purpose and intensity of inventory.

(v) The presence of multiple performers 'contributing to a common network of data administration and analysis' will promote greater success in the inventory.

(vi) Lastly, the level of enthusiasm, dedication and commitment of the personnel and institutions involved in the inventory significantly determine its coverage.

Based on species inventory, one can study biodiversity at the global or national / regional levels for the whole plant kingdom or specific groups of plants. Possible approaches for orienting an inventory are:

(i) survey of major elements;

(ii) identification of keystone species and indicator elements;

(iii) identification of targeted elements, such as threatened species;

(iv) comprehensive assessment of all other important elements, such as Exotic or Alien invasives, Flagship species, and economically useful taxa.

1.4.2 Species Diversity of Microbes and Plants

According to the World Conservation Monitoring Centre (WCMC, 1992), the total number of species described at the global level so far is 1,604,000. However, WCMC has estimated that at the global level there are likely to be 17,980,000 species, i.e. about 14 times more than the presently known species. The increase is likely to be primarily from the tropics and subtropics. However, a more realistic working figure of species at the global level is around 12,250,000 (WCMC, 1992). The most recent figure of the estimated total number of species present in the globe is 1,730,725, (IUCN, 2014). Even the number of plant species has been subjected to substantial revision in recent years, with current estimates being around 307,674 species as opposed to the previously commonly cited figure of 2,50,000 (Heywood and Iriondo, 2003). The estimated number of vertebrates, invertebrates, plants, and animals by IUCN (2014) are presented in Table 1.

A comprehensive catalogue of the known viruses is not yet available. It is evident that about approximately 6000 different viruses are known to date, although a conservative estimate of the possibly existing viruses in the world places the figure at around 400,000-500,000. This means we know only 1% of the viruses. To date, approximately 5000 species of bacteria (including Cyanobacteria) have been discovered and recorded. The conservative estimate of the total number of bacterial species on the Earth is around 400,000.

To date, more than 70,000 species of fungi, including about 13,500-17,000 species of lichens, are known. The conservative figure for fungi existing on the Earth is about 1.5 million while the extreme estimate is 2.7 million; the number of lichen species likely to exist is around 25,000 (Hawksworth, 1991). In a small area such as the British Isles, the currently recorded species of fungi is around 12,000.

So far more than 40,000 algal species have been described and another 360,000 species are believed to exist on the Earth, as Per conservative estimates Algae yet to be described are likely to come from barks and rocks as well as from the marine environment; a good contribution is also expected from the Polar regions. Bryophytes are a diverse group of plants containing several classes. So far 14,000-15,000 species of bryophytes are known, of which about 8000-9000 species (under 425 genera) are mosses and 6000-7500 species liverworts. The number of bryophyte species is likely to increase to about 30,000, if more regions of the world are subjected to serious inventory.

The Pteridophytes are vascular land plants and together with Gymnosperms and Angiosperms dominate the terrestrial environment of the Earth. There are about 15,000 species of Pteridophytes, of which many are native to moist tropical forests. It has been estimated that 12.5% of the world's fern species are found in Papua New Guinea. Most species of Gymnosperms are trees, although a few are shrubs. There are about 500 species of Conifers, 100 species of Cycads and 71 species of Gnetales. The number of species yet to be discovered in Gymnosperms is likely to be very few. Recent estimate suggests that total number of angiosperm species at around 450,000, of which 10-20% are still unknown to science. The 300,000 species of flowering plants are grouped in about 13000 genera under about 416 families depending on the classification system. Orchidaceae with 26,000 species and Asteraceae with about 32,000 species are the largest families among angiosperms. In fact, approximately 30 families account for almost 62% of the known angiosperms; 36 families are unispecific (e.g. Adoxaceae).

Recent estimates for gymnosperms (1000 species), ferns (10,000 species), lycophytes (1300 species), mosses (9000 species), hornworts (200-250 species;), and liverworts (7500) suggest that the global total for all land plants is around 500,000 species. This compares with around 10,000 bird species and 5400 mammals. Indeed, the only taxonomic groups whose diversities are thought to substantially exceed that of land plants are the largely plant dependent fungi (1.5-5.1 m) and beetles (ca. 1.5 m).

Table 1. : Estimated number of described species according to IUCN, 2014.

	Category	Species	Totals
Vertebrate Animals	Mammals	5,513	
	Birds	10,425	
	Reptiles	10,038	
	Amphibians	7,302	
	Fishes	32,900	
	Total Vertebrates		66,178
Invertebrate Animals	Insects	1,000,000	
	Spiders and scorpions	102,248	
	Molluscs	85,000	
	Crustaceans	47,000	
	Corals	2,175	
	Others	68,827	
	Total Invertebrates		1,305,250
Plants	Flowering plants (angiosperms)	268,000	
	Conifers (gymnosperms)	1,052	
	Ferns and horsetails	12,000	
	Mosses	16,236	
	Red and green algae	10,386	
	Lichens	17,000	
Others	Mushrooms	31,496	
	Brown algae	3,127	
	Total Others		51,623
	TOTAL SPECIES		1,730725

1.4.3 Diversity Indices Based on Species

The literature on diversity measurement based on species is huge. Numerous indices and methods are available. Ecologists have estimated biodiversity by three measures:

(i) *species richness*, which is indicated by the total number of species in an area;

(ii) *species abundance*, which is indicated by the total number of individuals of a species in an area;

(iii) species evenness, which represents equitability of species as given by their relative abundance.

Ecologists, in particular those interested in functional aspects of ecosystems, more often use the Shannon-Wiener index, Shannon weaver index, Simpson index, Fisher's alpha log series or modifications of the same, which again are based on species abundance. Each index has its own relative advantages and disadvantages.

1.4.4 Spatial Patterns of Species Diversity

Complex spatial patterns of species biodiversity have often been recognised by dividing species richness into three major components, i.e. to characterise diversity on different scales: alpha richness, beta richness and gamma richness (also often called respectively *alpha diversity, beta diversity* and *gamma diversity*). *Alpha* or point richness refers to the number of species in an area, i.e., within-area diversity. Here we count the number of species using only their presence (and not abundance) in a given area of a given size. *Beta* richness or between-area richness refers to the changes in number of species between sites at local, small and homogeneous areas. Beta richness cannot be expressed in species numbers and can only be represented in terms of the similarity index between species diversity of different areas in the study region or of species turnover rates. Beta diversity is the ratio of gamma diversity of a region to the average alpha diversity of local areas within the region (UNEP 1995). However, various authors have given different definitions for beta diversity. Gamma diversity refers to overall species richness within a large region, at the level of a landscape, i.e., biodiversity characterisation at a regional scale. Gamma diversity, therefore, does not have an upper limit.

1.4.5 Biodiversity Hotspots

Biodiversity conservation effort is closely linked up with the concept and creation of **hotspots.** To define as a hotspot, an area must contain at least 0.5% or 1500 of the world's 300,000 plant species as endemics. A hotspot has got further characteristic which has lost 70% or more of its primary vegetation. Based on floristic richness, Myers (1990) recognized 18 hotspots throughout the world. Later, Myers *et al*. (2000) identified 25 biodiversity hotspots throughout the world. Recently, there are 35 biodiversity hotspots have been revealed as updated and reanalyzed. The 35th hotspot is the **Forests of East Australia (**Williams *et al.*, 2011**)**. Nine leading hot spots have been recognised which contain 30% of all plants, 25% of all species in four vertebrate groups, and 0.75 of earths land surface (Myers *et al.*, 2000). The leading hot spots are richer in endemics than other hot spots. **Hottest hotspots** can be recognised depending on five key factors: numbers of endemics and endemic species/area ratios for both plants and vertebrates, and habitat loss. Some of

them are Madagascar and Indian Ocean Islands, Philippines, Sundaland, Brazils Atlantic Forest, Carribbean, Indo-Burma, Western Ghats and Sri Lanka, and Eastern Arc Mountains and Coastal Forests of Tanzania and Kenya (Myers *et al*., 2000).

1.4.6 Species Diversity in India

India, known for its rich heritage of biological diversity, has so far documented over 91,200 species of animals and 45,500 species of plants in its ten bio-geographic regions. Besides, it is recognized as one of the eight Vavilovian centres of origin and diversity of crop plants, having more than 300 wild ancestors and close relatives of cultivated plants, which are still evolving under natural conditions. India is also a vast repository of Traditional Knowledge (TK) associated with biological resources.

India ranks among the top ten species-rich nations and shows high endemism. India has four global biodiversity hotspots (Himalaya, Indo-Burma, Western Ghats and Sri Lanka, and Sundaland), (Table 1.2). India has over 40 sites, which are known for their high endemism and genetic diversity. The Indian flora is more varied than that of any other country of equal area in the eastern hemisphere, if not on the globe. As a matter of fact, three hotspots from Indian subcontinent are recognized as hottest hotspots.

In terms of plant diversity, India ranks tenth in the world and fourth in Asia. With over 45,500 plant species, India represents nearly 11% of the world's known floral diversity. As elsewhere in the world, many organisms especially in lower groups such as bacteria, fungi, algae, lichens and bryophytes are yet to be described and remote geographical areas are to be comprehensively explored. The richness of Indian plant species as compared to the world is shown in Table 1.1. According to the present estimates, India's contribution to the global biodiversity is around 8% species.

Table 1.1: Number of species in major groups of plants and microorganisms

Plant groups	No. of Species described		% of India to the World
	India	World	
Virus/Bacteria	850	8,050	10.6
Algae	7175	40,000	17.9
Fungi	14,500	72,000	20.1
Lichens	2223	13,500	16.4
Bryophytes	2500	14,500	17.2
Pteridophytes	1,200	10,000	12.0
Gymnosperms	67	650	10.3
Angiosperms	17,527	2,50,000	7.0

Source: Botanical Survey of India, 2009

Table 1.2: Salient features of Hotspots of India.

Vital signs	Himalaya	Indo-Burma	Western Ghats and Sri Lanka	Sundaland
Hotspot original extent (Km^2)	741,706	2,373,057	189,611	1,501,063
Hotspot vegetation remaining (Km^2)	185,427	118,653	43,611	100,571
Endemic plant species	3,160	7,000	3,049	15,000
Endemic threatened birds	8	18	10	43
Endemic threatened mammals	4	25	14	60
Endemic threatened amphibians	4	35	87	59
Extinct species	0	1	20	4
Human Population Density	123	134	261	153

Source: Botanical Survey of India, 2009

1.5 Plant Diversity at the Ecosystem Level

Assessment of biodiversity at the ecosystem level remains highly problematic and very difficult due to the presence of both abiotic and biotic components. There is also a lack of unique definition and classification of ecosystems at the global level and often at regional levels too. Global ecosystem classification has become 'highly subjective like the classification of plants themselves'. Another stumbling block is that ecosystems are essentially dimensionless and lack boundaries.

There are a large variety of different ecosystems on earth, which have their own complement of distinctive inter linked species based on the differences in the habitat. Ecosystem diversity can be described for a specific geographical region, or a political entity such as a country, a State or a taluka. Distinctive ecosystems include landscapes such as forests, grasslands, deserts, mountains, etc., as well as aquatic ecosystems such as rivers, lakes, and the sea. Each region also has man-modified areas such as farmland or grazing pastures.

The foregoing difficulties notwithstanding, the main advantage of assessing biodiversity at the ecosystem level is that it is much easier to record and to monitor changes and trends and the effects of human activities on ecosystems than on individual populations of species. In the ecosystem approach, basically biodiversity is considered within areas (alpha diversity) and between areas.

1.5.1 Major Ecosystem Types of the World

As already stated, it is very difficult to design a classification of the world's ecosystems acceptable to all. For the sake of convenience, the following few major ecosystems were discussed regarding their diversity.

Tropical moist forest ecosystems are often equated with rain forests. These forests are found between the Tropic of Cancer and the Tropic of Capricorn. In India, they are found on the southern slopes of the Eastern Himalayas, in south-west India (Western Ghats). The total land area of Earth occupied by this type of forest is 9,350,000 km^2, whereas FAO/UNEP estimated the total area to be 72,007,990 km^2. These forests contain a closed community of essentially, but not exclusively, broadleaf, evergreen trees. These trees occur in two or more strata ('Forests piled upon forests'). Ground vegetation is extensive and vines, lianas and epiphytes abundant. A great variety of microbial populations (viruses, bacteria, fungi and microalgae) as well as of Bryophytes and Pteridophytes is characteristic. Tropical moist forests account for more than 50% and possibly as much as 90% of all known plant species. These forests are also rich in endemics. ln fact, in 14 of the originally proposed 18 areas of the Earth with an unusually high degree of plant endemism (hot spots), Tropical moist forests constitute the major vegetation. These forests contain more than 37,000 endemic plant species, i.e., 15% of all the plant species, in less than 30,000 km^2 or 0.2% of the Earth's land surface. Life-form classes are also extremely diverse in these forests.

In contrast to the Tropical forests, Temperate forests (or woodlands) occur mainly in the Northern Hemisphere. They occur in Europe, eastern Asia, eastern North America, as a narrow band along the Pacific coasts of North and South America, and on the islands of New Zealand and Tasmania. Temperate forests are dominated by deciduous hardwood trees and to a lesser extent by evergreen broadleaf hardwood trees and conifers. Approximately, more than 1200 species of trees are reported in this type of forest, although eastern Asia is the most diverse with the greatest number of species.

Boreal Forest ecosystems are circumpolar biomes covering approximately 13 x 10^6 km^2 as upland entities and 2.6 x 10^6 km^2 in peatland in North America and Eurasia. Boreal forests are generally poor in terms of species richness, but the functional diversity of component species is very high. The biological diversity in Arid and Semiarid ecosystems is rather poor and is influenced by water availability. Precipitation is extremely unpredictable in time and space as well as total amount. These ecosystems comprise drought evading, enduring and resisting taxa. The cold-dominated ecosystems devoid of trees are the Arctic and Alpine ecosystems. They

occupy about 8% of the terrestrial surface of the Earth with 5% in the arctic region and 3% in the alpine. These ecosystems support only about 4% of the Earth's flora, with 1500 species in the arctic zone and 10,000 in the alpine regions.

The most commonly distributed ecosystem forming a natural vegetation on the land surface of the Earth is the Grassland ecosystem. The grassland ecosystem is dominated by grass and grass-like species, although in some areas shrubby and herbaceous elements (often called 'forbs') as well as trees may be present. In the last instance, there are often fewer than 10-15 trees per hectare of grassland.

It is extremely difficult to define a wetland ecosystem as it covers a wide range of inland, coastal and marine habitats. The all-inclusive definition of wetlands is perhaps the one provided by the Ramsar convention, according to which wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salty, including areas of marine water, the depth of which at low tide does not exceed six metres. Wetlands support waterbird, fish, amphibian, reptile and plant species during important life stages by providing roosting, nesting and feeding habitat as well as refuge during extreme weather conditions.

Biodiversity of the marine environment in general and of marine sediments in particular is very poorly known. This is true both in descriptive terms of species richness and distribution along latitudinal and depth gradients, and the ecological and evolutionary processes regulating it. Such ignorance or lack of interest in marine benthos in the coastal system and in pelagic or deep-sea communities of open seas is unwarranted since the marine environment occupies 71% of the Earth's surface (and about 51% of its surface by ocean over 3000 m in depth). However, 49 large marine ecosystems have been recognised in the world, accounting for 20,000 marine plant species and a number of marine viruses and microbes.

Mangroves are intertidal forested wetlands characteristically located in littoral, sheltered and low-lying tropical and subtropical coast. They dominate river deltas, lagoons and estuarine complexes developed from terrigenous sediments. Mangroves are also found on islands. They are highly salt-tolerant and various structural and physiological adaptations have been developed for this characteristic in different taxa of mangroves. Although mangroves have a diverse collection of trees and shrubs, there are exclusive species and non-exclusive species. The former are found only in the mangrove habitat while the latter are not restricted to mangroves. There are about 60 species in 22 genera are exclusive, while 23 species in 16 genera are non-exclusive, whereas 54 species of mangroves are trees. In addition, the mangrove habitat promotes the growth and establishment of a wide variety of other organisms.

Mangroves do not exhibit a uniform appearance. They may vary from extremely closed forests of 40-50 m high trees in parts of South America and Sundarbans in Bangladesh, to open forests with sparsely distributed trees to stunted shrubs of less than 1 m high. The world extent of mangroves covers 240 x 10^3 km^2 area of the world's coastal line. (Krishnamurthy, 2003).

1.6 Agrobiodiversity and Cultivated Plants

Agrobiodiversity is the result of natural selection processes and the careful selection and inventive developments of farmers, herders and fishers over millennia. Agrobiodiversity is a vital sub-set of biodiversity. It is the variety and variability of animals, plants and micro-organisms that are used directly or indirectly for food and agriculture, including crops, livestock, forestry and fisheries. It comprises the diversity of genetic resources (varieties, breeds) and species used for food, fodder, fibre, fuel and pharmaceuticals. It also includes the diversity of non-harvested species that support production (soil micro-organisms, predators, pollinators), and those in the wider environment that support agro-ecosystems (agricultural, pastoral, forest and aquatic) as well as the diversity of the agro-ecosystems.

In contrast with the existence of agrobiodiversity outside agroecosystems, not all biodiversity regularly present within agroecosystems should be regarded as 'agrobiodiversity'. Function will determine this, rather than just presence: agrobiodiversity has an actual or potential impact on agricultural production. Much biodiversity in agroecosystems may have no specific role in agriculture: indeed, it has been estimated that a greater part of terrestrial biodiversity persists in agricultural landscapes. Such landscapes could therefore be a key to global biodiversity conservation. The struggle to maintain biodiversity is going to be won or lost in agricultural systems. Management of agricultural landscapes will be the litmus test of our ability to conserve species, most terrestrial biota will eventually have to coexist with human agriculture. However important, this 'incidental' biodiversity falls outside the definition of 'agrobiodiversity', yet its conservation could be a bonus of sound agroecosystem management.

Many people's food and livelihood security depend on the sustained management of various biological resources that are important for food and agriculture. Agricultural biodiversity, also known as agrobiodiversity or the genetic resources for food and agriculture, includes:

- Harvested crop varieties, livestock breeds, fish species and non-domesticated (wild) resources within field, forest, rangeland including tree products, wild animals hunted for food and in aquatic ecosystems (e.g., wild fish);

- Non-harvested species in production ecosystems that support food provision, including soil micro-biota, pollinators and other insects such as bees, butterflies, earthworms, greenflies; and
- Non-harvested species in the wider environment that support food production ecosystems (agricultural, pastoral, forest and aquatic ecosystems).

Many farmers, especially those in environments where high-yield crop and livestock varieties do not prosper, rely on a wide range of crop and livestock types. This helps them maintain their livelihood in the face of pathogen infestation, uncertain rainfall and fluctuation in the price of cash crops, socio-political disruption and the unpredictable availability of agro-chemicals. So-called minor or underutilized crops, more accurately, companion crops, are frequently found next to the main staple or cash crops. They often grow side by side and their importance is often misjudged. In many cases, from a livelihoods perspective, they are not minor or underutilized as they can play a disproportionately important role in food production systems at the local level. Plants that will grow in infertile or eroded soils, and livestock that will eat degraded vegetation, are often crucial to household nutritional strategies. In addition, rural communities, and the urban markets with which they trade, make great use of these companion crop species.

There are several distinctive features of agrobiodiversity, compared to other components of biodiversity:

- Agrobiodiversity is actively managed by male and female farmers;
- many components of agrobiodiversity would not survive without this human interference; local knowledge and culture are integral parts of agrobiodiversity management;
- many economically important agricultural systems are based on ‘alien’ crop or livestock species introduced from elsewhere (for example, horticultural production systems or Friesian cows in Africa). This creates a high degree of interdependence between countries for the genetic resources on which our food systems are based;
- as regards crop diversity, diversity within species is at least as important as diversity between species;
- because of the degree of human management, conservation of agrobiodiversity in production systems is inherently linked to sustainable use - preservation through establishing protected areas is less relevant; and
- in industrial-type agricultural systems, much crop diversity is now held *ex situ* in gene banks or breeders’ materials rather than on-farm.

1.6.1 The Role of Agrobiodiversity

Experience and research have shown that agrobiodiversity can:

- Increase productivity, food security, and economic returns
- Reduce the pressure of agriculture on fragile areas, forests and endangered species
- Make farming systems more stable, robust, and sustainable
- Contribute to sound pest and disease management
- Conserve soil and increase natural soil fertility and health
- Contribute to sustainable intensification
- Diversify products and income opportunities
- Reduce or spread risks to individuals and nations
- Help maximize effective use of resources and the environment
- Reduce dependency on external inputs
- Improve human nutrition and provide sources of medicines and vitamins, and
- Conserve ecosystem structure and stability of species diversity. (Adapted from Thrupp, 1997).

1.6.2 Importance of Agrobiodiversity

Yet agriculture is the largest global user of biodiversity. Agriculture has selected and added value to wild biodiversity over more than 10,000 years of managing agrobiodiversity. Agriculture has conserved biodiversity on the hoof and as seed and planting materials over this long period. Agriculture extracts value from biodiversity at each harvest or cull, but nurtures the productive and renewable base, Indeed, it is certain that the most immediately valuable part of global biodiversity is the agrobiodiversity on which farming, and in turn, global food security depends.

Agrobiodiversity is irreplaceably important in its own right, as providing most of our food, In the past, agrobiodiversity management has underpinned our civilization, based as this is on the transfer of the surplus production of the agricultural landscape to cities. The management of agrobiodiversity will determine our future, both in cities and the countryside, with particular impact on the unequal distribution of resources between the rich and the poor.

The new approach to conservation in the wild has moved from an emphasis on rare and endangered species to embrace ecosystem function and the importance of ecosystem services. The knowledge base exists for a comparable synthesis in agriculture. Agroecosystems - mediated through agrobiodiversity - have always

provided the essential ecosystem service of food production, and can be designed to deliver a further range of ecosystem services as needs and knowledge change. Present knowledge extends from a greater appreciation of traditional agriculture and the needs of farmers, through classical agricultural research in animal husbandry, genetics, statistics, replicated experiments, plant breeding, agronomy, crop protection, rural sociology, information management and many more, through to biotechnology, Contributors to this book will review our practical knowledge of agrobiodiversity management and attempt to place it in greater prominence in the global debate over biodiversity and sustainable development.

1.6.3 Diversity of cultivated plants

Cultivated plants, broadly, are plants that are planted and grown, rather than emerging naturally as part of the biome where they are found. There are many reviews of useful or edible plants, but the most relevant relationship between human and plants is the active process of cultivation of a plant species by man. The “invention” of agriculture (“neolithic revolution”) has been characterized as a very important event in the evolution of mankind. Agroecosystems, like other types of ecosystems, vary widely in the amount of biodiversity they contain and how that biodiversity is organized among species, among varieties or cultivars within species, and within cultivars. Cultivated plants are well known for having low species diversity when compared with most non-agricultural ecosystems; indeed, the farmer’s intention is to eliminate all but one or a few species from a field if possible. Discrimination based on species is also applied by breeders when they separate the species in an ecosystem into two groups: the ones that they are trying to improve (comprising ‘genotypes’) and all others (which are part of the ‘environment’). In general, knowledge of cultivated plant diversity at the species level is good, but at the cultivar level it is variable: for improved varieties it is patchy but adequate for some crops (rice, maize, wheat), while for landraces it is poor. Therefore, the number of cultivated plant species is of general interest and amounts to about 7,000. Amenity horticulture is a quickly developing area comprising ornamentals and other plants connected with gardening and landscaping. 28,000 plant species have been estimated to belong to this group. Cultivated forest plants are partly included in the first group and mostly in the second group. Thus, the total number of cultivated plants amounts to 35,000 species, i.e., about 14% of the number of higher plant species of the world. A high number of cultivated species is characteristic for commercial ‘‘plant finders’’ (often of less scientific accuracy). However, they provide the possibility to summarize information from commercial plants and seed lists. The plant finder contains 50,000 species and cultivars. In the plant lists of the Royal Horticultural Society (RHS 2006) more than 70,000 species and cultivars, including many notomorphs, i.e., taxa of

hybrid origin. This amalgamation of ornamental (hybrid) species and cultivars is full of taxonomical difficulties.

Centres of origin of cultivated plants are separated from one another by mountain chains, deserts, or expanses of water, i.e., they give rise to independent, isolated agricultural civilisation. Together they occupy about 2.5% of the total land area, minus mountainous regions and desert within each centre. In most cases, a particular genus or species is associated with a single centre, but some crops are associated with two or more centres of diversity. Therefore, Vavilov recognised primary centres of origin where the plant in question takes the most diverse forms and was domesticated for the first time, and secondary centres arising as a result of migration of individual forms from the primary one. For, e.g., the primary centre of Maize origin is in Mexico, whereas China served as the secondary centre of origin of its waxy varieties.

N. I. Vavilov (1935) identified eight independent centres of origin of the major cultivated plants worldwide or, in other words, eight regions of domestication of various plants (Fig. 1.1). These centres include Chinese centre of origin (136), Indian centre of origin (117), Indo-Malay centre (42), Near Eastern centre (38), Mediterranean centre (84), Abyssinian centre (38), South Mexican & Central American centre, South American (Peruvian-Ecuadorian-Bolivian) centre (45). In addition to the main South American centre of origin, Vavilov also recognized two subcentres: The Chiloe centre (4) and Brazilian-Paraguayan centre (13) (Table 1.3). The numbers within the parentheses indicate the number of diversity of cultivated plants in the concerned centre.

Table 1.3: Vavilovian centres of origin of cultivated plants.

Vavilovian centres	Cultivated plants
1. Chinese Centre	Millets, Sorghum, Buck wheat, Soybean, Kidney bean, Yam, Radish, Cannabis, Tea (Total cultivated taxa: 136)
2(a). Indian Centre	Rice, Finger Millet, Pigeon Pea, Green gram, Horse gram, Winged bean, Cluster bean, Amaranthus sp., Brinjal, Bitter gourd, Bottle gourd, Snake gourd, Taro, Mango, Orange, Lemon, Myrobalan, Breadfruit, Tamarind, Sugar-cane, Mustard (Total: 117)
2(b). Indo-Malayan Centre	Coix, Velvet bean, Zinger, Pomelo, Litchi, Banana, Durio, Coconut, Cardamom, Black pepper, Turmeric, Gutta-percha (Total: 55)

3. Inner Asiatic Centre	Peas, Lentils, Chick-pea, Flax, Safflower, Melon, Carrot, Onion, Basil, Pistachio, Pear, Grapevine (Total: 42)
4. Asia Minor	Eincorn type wheat, Soft wheat, Secabe, Cereals, Pea, Alfalfa, Vetch, Sesame, Castor, Figs, Poppy, Pumpkin (Total: 83)
5. Mediterranean Centre	Artichoke, Emmer, Oats, Barley, Lentils, Horse bean, Chick-pea, Flax, Black mustard, Olive, Beetroot, Cabbage, Onions, Cumin, Fennel, Lavender (Total: 84)
6. Abyssinian Centre	Triticum durum, Barley, Finger millet, Lentil, Fenugreek, Niger, Safflower, Sesame, Coriander, Coffee, Bhendi, Pearl millet, Sorghum (Total: 38)
7. South Mexican & Central American centre	Maize, Jack-bean, Squash, Chayote, Pumpkin, Sweet potato, PepperChilli, Upland cotton, Sisal, Papaya, Guava, Cherry, Tomato, Cocoa, Avocado (Total: 49)
8 (a). South American (Peru, Ecuador, Bolivia) centre	Potato, Lupine, Maize, Tomato, Peanut, Tobacco (Total: 45)
8 (b). Chilean centre	Strawberry (Total:4)
8 (c). Brazil-Paraguay centre	Manihot, Peanut, Hevea rubber, Pineapple, Yam, Cassava (Total: 13)

1.7 Values and uses of Biodiversity

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

Ethical and Aesthetic Values

It is also sometimes known as existence value. It involves ethical issues like "*all life must be preserved*". It is based on the concept of "*Live and Let Live*". All forms

of life have the right to exist on earth. Man is only a small part of the Earth's great family of species. Plants and animals have an equal right to live and exist on our planet which is like an inhabited spaceship. We do not know if life as we know it exists elsewhere in the universe. If we want our human race to survive, then we must protect all biodiversity, because biodiversity is valuable.

The ethical value means that we may or may not use a species, but knowing the very fact that this species exists in nature gives us pleasure. We all feel sorry when we learn that "passenger pigeon" or "dodo" is no more on this earth. We are not deriving anything direct from Kangaroo, Zebra or Giraffe, but we all strongly feel that these species should exist in nature. This means, there is an ethical value or existence value attached to each species. Indian civilization has over several generations preserved nature through local traditions. This has been an important part of the ancient philosophy of many of our cultures. We have in our country a large number of sacred groves or 'deorais' preserved by tribal people in several States. These sacred groves around ancient sacred sites and temples act as gene banks of wild plants.

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

Symbols from wild species such as the lion of Hinduism, the elephant of Buddhism and deities such as Lord Ganesh, and the vehicles of several deities that are animals, have been venerated for thousands of years. Valmiki begins his epic story with a couplet on the unfortunate killing of a crane by a hunter. The 'Tulsi' has been placed at our doorsteps for centuries.

Economic value

Biodiversity play an important role in boosting the economy of a country by providing the daily necessary needs for the common peoples. Each species is of potential value to humans. So are healthy ecosystems. The global collection of genes, species, habitats and ecosystems is a resource that provides for human needs now, and is essential for human survival in the future. Humans depend on other species for all of their food and for many medicines and industrial products. Some of the important economic commodities that biodiversity supplies to humankind are:

Food: crops, livestock, forestry, fish, etc.

Medication: Wild plant species have been used for medicinal purposes since before the beginning of recorded history. For example, quinine comes from the cinchona tree (used to treat malaria), digitalis from the foxglove plant (chronic heart trouble), and morphine from the poppy plant (pain relief). Up to 80 per cent of the people in developing countries depend on traditional medicine for primary health care, most of which is derived from plants and some from animal and mineral sources. According to the National Cancer Institute, over 70 % of the promising anti-cancer drugs come from plants in the tropical rainforests. Animals also play a significant role in medicinal research.

Industry: fibers for clothing, wood for shelter and warmth. Biodiversity may be a source of energy (such as biomass). Other industrial products are oils, lubricants, perfumes, fragrances, dyes, paper, waxes, rubber, latexes, resins, poisons, and cork, which can all be derived from various plant species. Supplies from animal origin include wool, silk, fur, leather, lubricants, and waxes. Animals may also be used as a mode of transport.

Tourism and recreation: biodiversity is a source of economical wealth for many areas, such as many parks and forests, where wild nature and animals are a source of beauty and joy for many people. Ecotourism, in particular, is a growing outdoor recreational activity.

Evolutionary value

Biodiversity found on Earth today is the result of 4 billion years of evolution. The original origin of life is not well known to science, though limited evidence suggests that life may already have been well-established only a few 100 million years after the formation of the Earth. Until approximately 600 million years ago, all life consisted of bacteria and similar single-celled organisms. The apparent biodiversity shown in the fossil record suggests that the last few million years include the period of greatest biodiversity in the Earth's history. Modern biodiversity is not much different than biodiversity of 300 million years ago. Estimates of the present global macroscopic species diversity vary from 2 million to 100 million species, with a best estimate of somewhere near 10 million. New species are discovered regularly (on average about three new species of birds each year) and many, though discovered, are not yet classified (an estimate states that about 40% of freshwater fish from South America are not yet classified). Most of the terrestrial diversity is found in tropical forests.

Cultural Value

The natural environment provides for many of the inspirational, aesthetic, spiritual and educational needs of people, of all cultures, now and in the future.

Indian society places great cultural value, such as the Tiger, Peacock, Banyan tree have become national icons. Biodiversity in India, particularly, is important for its religious, spiritual and other cultural uses. Many plants and animals have ritual significance. Among auspicious flowers offered in temples are *Hibiscus* offered to goddess Kali, Akanda (*Caltropis* sp.), and *Datura* flowers to Lord Siva, Palash (*Butea monosperma*) to Goddess Saraswati, Padma flowers (*Nelumbo nucifera*) to Goddess Durga. In some parts of India such as Gujarat, Sami (*Prosopis spicigera*) is used in sacrificial fires. Various plant and animal species are considered sacred on account of their association with different deities. Some bird animal species are termed vahanas or ve-hicles of deities and are hence venerated. Important among these are the bull for Lord Siva, the rat for Lord Ganesh, Peacock for Lord Kartick, Owl for Goddess Laxmi, and the lion for Goddess Durga.

1.7.1 Precautionary Principle

At present, only a relatively small percentage of biodiversity is actively exploited by man and valued. However, there are other elements of biodiversity that may be very important for the different reasons listed below:

(i) They may have values unused or unknown at present, but once discovered anti exploited, could substantially enhance the well-being of humankind, and

(ii) They may become useful at some future time due to changing circumstances.

These reasons support a precautionary approach to maintenance of all biodiversity. Biodiversity elements with actual (yet unknown) or potential use should not be lost simply because we presently do not know their value. Further, it must be understood that biodiversity elements once lost cannot be recreated even with our best technologies. (Krishnamurthy, 2003).

1.7.2 Methodologies for Valuation

Many methods for quantifying the benefits of biodiversity, i.e., for valuation, have been proposed and refined by the growing group of environmental economists. Methods as suggested by UNEP (1995) are given below.

UNEP (1995)

A. Contingent valuation and Ranking

a) Contingent valuation

b) Contingent ranking

B. Revealed preference methods

a) Travel cost method

b) Hedonic travel cost method

c) Random utility method

C. Production function approaches

D. Revealed preference and opportunity cost methods

a) Change in productivity

b) Change in earnings

c) Defensive or preventive expenditures

d) Replacement cost Substitution or proxy Shadow project

e) Compensation costs

f) Benefits transfer

1.7.3 Uses of Plants

Species of plants provide an array of products used by people worldwide. Certain plants can be exploited directly from the wild, while others sustain humanity through cultivation. In spite of vast overall development, plant biodiversity as a global resource largely remains poorly understood, underexploited and poorly documented. Knowledge of plant use from indigenous people has not been translated into wider use largely because of poor documentation of ethnic information. However, plants have been a major source of food, medicine, horticultural and ornamental plants, timber, fibre, dyes and other chemicals, fuel and renewable energy, and a host of other products used in industry and commerce. A general outline of the major uses of plants is provided below.

Food

The most important contribution of plants to humanity is food. In the early years of man's evolution, plants were consumed raw and obtained from the wild; gathering food from the wild continues even today in tribal communities throughout the world. However, with the evolution of civilisation, man began to domesticate plants for food. Of the about 250,000 species of flowering plants, 75,000 species are edible but to date only about 3000 are regarded as a source of food. Of these, around 200 plant species have been domesticated with 15-20 constituting crops of major economic value. Species belonging to Poaceae, Papilionaceae, Brassicaceae, Rosaceae, Apiaceae, Solanaceae, Lamiaceae, Chenopodiaceae, Araceae, Cucurbitaceae and Asteraceae are the major sources of food. The very high probability of global climatic changes is expected to cause large-scale shifts in natural vegetation and agricultural crops. Hence there is urgent need to protect genetic resources of food plants to maintain crop productivity in different climatic conditions. There are several species of useful plants in the tropics alone whose uses could be extended from emergency sustenance

in isolated locations or disaster areas to fully exploitable alternative sources of food. Future prospects are limitless and unforeseeable.

Fodder and Forage

Many species of plants are used as fodder. They are either used directly from the wild, as in pastures and rangelands, or domesticated. Grasses and legumes are the most important fodder sources.

Timber

Wood, the source of timber, is one of the most utilised plant commercial commodities throughout the world. Although predominantly harvested from the wild, monoculture plantations under agro-and social-forestry programmes are increasingly being raised as a source of timber. Wild sources of timber, especially from hardwoods, are predominantly tropical and, in fact, account for a very significant proportion of export earnings for developing countries in the tropics. The USA, some European countries and former USSR provinces account for the major supply of softwoods. Malaysia, Myanmar, Indonesia, Papua New Guinea and Gabon are the most important tropical countries involved in timber trade. Wood is exported as logs, sawn wood or plywood. It is difficult to assess the extent to which timber either for domestic consumption or for export is derived from plantations. Industrial timber plantations of temperate countries predominantly consist of coniferous species. Ghana has 674 tree species of great timber potential but timber is exploited from only 60 species in the past. Peninsular Malaysia has about 3000 tree species, of which over 400 have been a source of good timber for national and international markets.

Because of continual exploitation and lack of adequate replantation, most timber tree species of tropical countries are now threatened; habitat loss, forest fragmentation, improper and inadequate management, etc. have also contributed to this threat. More than 80 tree species of timber value are already listed as endangered all over the world.

Rattans and Canes

Rattans and canes constitute the most important resources exported from tropical countries. Most of the 600 or so species, all belonging to Arecaceae (palms), are native to South and Southeast Asia and the vast majority are endemics. The Philippines, China, Indonesia, India, Sri Lanka and Thailand are the most important rattan exporting countries. Rattans and canes are used for cane furniture, mats, baskets, fish traps, dyes, medicines etc. Rattans and canes are obtained almost exclusively from wild sources, although 10oh of the supply comes from plantations in Central and South Kalimantan. They are mainly obtained from species of *Calamus* (15 species of this genus are more important sources).

Medicinal Plants

Plants are very important in health care. In less developed/ developing countries, 80% of the people still rely only on traditional medicines obtained from local plants and 85% of traditional medicine involves the use of plant extracts. Further, since adequate hospital facilities and allopathic doctors are absent in much of the tropics, any destruction of tropical forests would concomitantly destroy the primary healthcare network involving local plants and traditional doctors. Some 200 chemicals extracted in pure form from *circa* 90 plant species are used in medicine throughout the world, i.e., about half of the world's medicinal compounds are still derived or obtained from plant sources. Many of these chemicals cannot be synthesised. Therefore, medicinal plants are of great significance to both developed and developing countries.

At present only a very small percentage of the world's plants contributes on a global scale to health care. There is clearly a great range of higher plants from which to draw and there is also a great repository of traditional knowledge in the various cultures/societies of people using medicinal plants. WHO has listed over 21,000 plant species worldwide which are reportedly of medicinal value. More than 2500 species of plants are used in the Ayurveda, Siddha, Unani and other traditional health care systems.

Natural plant diversity might be increasingly valued for the 'blueprints' it provides for new synthetic drugs, in spite of an increasing technology to design and manufacture synthetic drugs. The potential annual market value in OECD countries of the species of medicinal plants likely to vanish before the year 2050 is US $60 million. This figure is about 0.15% of the amount spent on plant-based medicines. It represents a benefit foregone rather than an actual loss. It is, however, only a market value and does not include other components of the total economic worth of the drugs, such as the cost to a society deprived of them and the benefits of good health. Therefore, the total economic value could be 5 to 50-fold higher.

Medicinal plants, especially those used in traditional medicine, are still largely harvested from the wild and relatively few cultivated. Cultivation has been attempted only for the last 25 years and a number of medicinal plants have reportedly lost/ become poor in medicinal properties upon cultivation. Yet species such as *Papaver somniferum, Cinchona officinalis, Mentha piperita, Ocimum sanctum, Digitalis purpurea, Gentiana lutea, Valeriana mexicana, Vinca rosea* and others have been effectively domesticated.

Because of constant exploitation, a number of medicinal taxa have become threatened in various parts of the world. Such taxa include species of *Dioscorea, Ephedra, Solanum, Rauvolfia, Parkia,* and others.

Ornamentals

Ornamentals are domesticated wild plants and like food plants have a long history. In China, lilies have been cultivated for more than 2000 years and similarly in Rome, roses, violets, anemones, narcissi and lavender have a long history of cultivation. The number of ornamental and decorative plants under cultivation far exceeds the number of food plants. In the UK alone, *circa* 3000 species are ornamentals.

Ornamentals are important commercially and contribute significantly to international trade in countries such as the Netherlands, USA and Japan. Both whole plants and cut organs such as flowers and leaves, twigs have ornamental value. Among whole plants of importance, the most important are orchids, succulents (cacti and euphorbias), cycads, insectivorous plants, bulbous species etc. Cut flowers of orchids, tulips, lilies, narcissi, violets, roses, anemones etc. are very important. More than 5000 species of orchids and their hybrids were recorded in the trade statistics of CITES during 1983-1989, a figure that must have increased substantially by now. Thailand, Malaysia and India account for major trade in tropical orchids. Although a number of these orchids are artificially propagated *in vivo* and *in vitro*, exploitation from natural habitats is still enormous, threatening endangerment of many orchid species. In japan already 70 taxa of orchids have been entered in Red data lists.

The average international trade in cacti per annum is approximately 14 million plants as per CITES statistics, obviously a gross underestimate. One nursery in the Netherlands alone produces over 18 million cacti annually, the USA between 10-50 million, while Mexico exports around 50,000 every year.

Other Uses

Plants have several other uses but only the most important are mentioned here. A number of species yield fibres of great value for cloth and other industrial purposes. Cotton, linen, jute, sisal, hemp, coconut, etc. are some of the fibres obtained. A number of fibre plants have been domesticated (cotton, linen, jute etc.) but fibres from wild taxa are still widely obtained, especially in tribal and rural areas.

Plants offer a good source of fuel, either as wood (firewood) or its transformed product, charcoal. Plant biomass from any source can also be converted into fuel. In fact, plants are very efficient sources of renewable energy.

Natural rubber, latex, gums, resins, dyes, essential oils and beverages are some of the other products of commercial value obtained from plants.

1.7.4 Uses of Microbes

There are many relationships between humans and microbes and they affect us on many levels of our existence. We are hosts to many prokaryotic and eukaryotic

symbionts in addition to being victims of bacterial and protozoan pathogens. Humans have also—long before the existence of microbes was recognized—utilized microbial processes and learned to prevent some adverse effects of microbial activities. Thus, microbiological technologies which have been in use since prehistoric times include a variety of fermented foods involving lactic acid bacteria, propionic acid fermenters, and the production of vinegar from ethanol. In addition to their gastronomic qualifications, these techniques have served to prevent or control undesirable or even dangerous microbial spoilage of food, which is also the purpose of salting, smoking, or acidifying food. It has also been suggested that the use of spices and drinking of wine, rather than water, also served to control pathogenic microbes. A list of some some microorganisms used in food and beverage preparation has been listed in Table 1.4. A quite different use of microbes is acid mine leaching, which was also in use long before the underlying mechanism was understood. Circulating water through crushed copper ore leads to acid conditions and dissolution of the ore; metallic Cu can then subsequently be recovered from the leachate by chemical methods. The underlying mechanism is that a consortium of acidophilic, chemoautotrophic bacteria (including *Thiobacillus ferrooxidans*) oxidize both the reduced S and the reduced Fe of pyrite (FeS_2), which is omnipresent in many ores. The resulting sulfuric acid in turn dissolves the ore.

Biological sewage treatment serves primarily to mineralize organic material. Various types of sewage treatment are in use, depending, among other factors, on the scale of the plant; most systems involve aerobic and anaerobic microbial processes. An important aspect is the flocculation of bacteria, a process which is enhanced by the presence of protozoa. Removal of nitrate by microbial denitrification is another important function of biological sewage treatment, whereas phosphate is primarily removed by chemical precipitation. Mainly in smaller plants, anaerobic mineralization can be exploited to produce methane, which can be collected and subsequently used for heating. In recent times, mass production of certain species of bacteria for the production of enzymes and antibiotics has played an important industrial role. Recently, genetically engineered bacteria that express human protein genes (e.g., insulin and other hormones) have been used in the pharmaceutical industry. Microbial diseases, of which there are many, represent the most direct encounter between humans and microbes. Through recorded history such diseases have played an important role for human populations, most dramatically illustrated, perhaps, by the recurrent plague epidemics in Europe from medieval times to approximately 1700; however, many other bacterial diseases, such as cholera, tuberculosis, leprosy, and typhoid fever, and protozoal diseases such malaria were also important. In North America, Europe, and in some other parts of the world serious bacterial and protozoal diseases have, especially after World War II, largely been brought under

control due to the combined effects of hygienic measures, vector control (mosquitoes and rats), immunization programs, and antibiotics and other forms of chemotherapy. However, globally, tuberculosis and malaria remain among the most frequent causes of death. Many bacterial and protozoal diseases of livestock also remain economically significant. Evolving resistance to antibiotics and other types of chemotherapy in agents of disease in man and animals may represent an increasing problem and indicate that our interactions with pathogenic microorganisms is not a closed chapter in human history.

Table 1.4: List of some microorganisms used in food and beverage preparation

Name of Microorganisms	type	food and beverages
Acetobacter aceti	bacterium	chocolate, vinegar
Aspergillus acidus, A. oryzae	fungus	tea, liquor sake
Bacillus cereus, B. coagulans, B. licheniformis	bacterium	Chocolate, dairy products
Brachybacterium alimentarium	bacterium	cheese
Candida colliculosa	fungus	cheese
Enterococcus faecium	bacterium	soy sauce, vegetable pickle
Lactobacillus acetotolerans, L. acidophilus, L. fermentum, L. fermentum, L. gasseri, L. paracasei, L. plantarum	bacterium	fruit, bread, vegetables, yogurt, dairy, meatcheese
Lactococcus lactis,	bacterium	dairy buttermilk
Leuconostoc mesenteroides, L. citreum	bacterium	vegetables, wine, fish
Mucor hiemalis	fungus	soy bean
Penicillium camemberti, P. commune, P. roqueforti	fungus	Cheese, medicines, antibiotic
Saccharomyces cerevisiae	fungus	beer, bread, cider, cheese, chocolate, wine
Staphylococcus succinus, S. vitulinus, S. warneri	bacterium	dairy, meat, cheese, meat

1.8 Summary

Since life originated on earth nearly 3.8 billion years ago, there had been enormous diversification of life forms on earth. Biodiversity refers to the sum total

of diversity that exists at all levels of biological organisation. Of particular importance is the diversity at genetic, species and ecosystem levels and conservation efforts are aimed at protecting diversity at all these levels. As our knowledge of the world's species is incomplete, our primary task is to make inventories and to catalogue species in several parts of the world and in several ecosystems. How to carry out this inventory is a topic of great discussion these days. Some have recommended the initiation of an intense global survey whereby all species believed to exist on the Earth are catalogued; an analysis and classification of all species should follow the survey. The other important task that needs immediate attention is the creation of a synoptic or global master database for the presently known species in all groups, including synonymy. From this master database, the currently accepted name for each species, authorities and synonyms could be obtained and ascertained.

Earth's rich biodiversity is vital for the very survival of mankind. The reasons for conserving biodiversity are narrowly utilitarian, broadly utilitarian and ethical. Besides the direct benefits (food, fibre, firewood, pharmaceuticals, etc.), there are many indirect benefits we receive through ecosystem services such as pollination, pest control, climate moderation and flood control. We also have a moral responsibility to take good care of earth's biodiversity and pass it on in good order to our next generation.

1.9 Questions and Answers

A. Multiple Choice Questions:

1. The totality of gene, species and ecosystem of a region is known as –

a. Phytogeography

b. Biotechnology

c. Biodiversity

d. Biogeography

Answer- c. Biodiversity

2. The number of species that can be found at a single point in space –

a. alpha diversity

b. point richness/diversity

c. beta diversity

d. gamma diversity

Answer- b. point richness/diversity

3. Genetic diversity can be measured –

a. in terms of the diversity of genes that an individual possesses.

b. in terms of amount of DNA per cell.

c. in terms of chromosomal structure, size, shape and number.

d. all of the above.

Answer- d. all of the above.

4. WCMC full form:

a. World Conservation Monitoring Committee

b. World Conservation Management Center

c. World Conservation Monitoring Center

d. World Conservation Management Committee

Answer- c. World Conservation Monitoring Center

5. How many centres N. I. Vavilov identified as the Centres of Origin of the major cultivated plants worldwide?

a. 7

b. 8

c. 9

d. 10

Answer- b. 8

6. Southern slopes of Eastern Himalaya shows:

a. Tropical moist forest

b. Temperate forest

c. Boreal forest

d. Mangrove forest

Answer- a. Tropical moist forest

B. Short answer type questions:

1. Define biodiversity.

Answer- 1.0

2. What is molecular diversity.

Answer- 1.0

3. Define alpha, beta, and gamma diversity.

Answer- 1.0

4. What is species diversity?

Answer- 1.4

5. What is the difference between species richness and species evenness?

Answer- 1.4.3

6. Define species abundance.

Answer- 1.4.3

7. How many Hotspots are there in Indian subcontinent.

Answer- 1.4.6

8. What is centres of diversity? How many centres Vavilov have recognized as the origin of cultivated plant? Write their names.

Answer- 1.6.3

9. What do you mean by cultivated plants? Give example.

Answer- 1.6.3

10. Name two microbes used in dairy products.

Answer- 1.7.3

C. Long answer type questions:

1.Write the scope of plant diversity.

Answer- 1.2

2. What is genetic diversity? Write the origin and nature of genetic variations.

Answer- 1.3 & 1.3.0

3. What do you mean by species inventory? What are the considerations for a good inventory?

Answer- 1.4.0

4. How species richness is distributed globally?

Answer- 1.4.2

5. Write a short note on species diversity in India.

Answer- 1.4.6

6. What is ecosystem diversity? Write briefly about the major ecosystem types of the world.

Answer- 1.5 & 1.5.1

7. Explain Agrobiodiversity. What are the distinctive features of Agrobiodiversity compared to the other components of biodiversity?

Answer- 1.6

8. What are the role of Agrobiodiversity in our society?

Answer- 1.6.1

9. Write the values of biodiversity. What are the methodologies for valuation of biodiversity?

Answer- 1.7 & 1.7.1

10. What is biodiversity hotspots? Write a short note on Biodiversity hotspots in India.

Answer- 1.4.5 & 1.4.6

1.10 References and Further Readings

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Unit 2 □ Loss of Biodiversity

Structure

2.0 Objectives

- To know the reasons for the loss of species, genetic, ecosystem, and agrobiodiversity.
- Provide information about the IUCN threat categories and current census of threatened species.
- To understand the current scenario of biodiversity loss.
- To know about the organizations IUCN, UNEP, UNESCO, WWF, NBPGR associated with biodiversity management.
- To know about the international and national laws of biodiversity.
- Provide information about significant international conventions.
- To know about the libraries, periodicals, and databases associated with biodiversity management.

2.1 Introduction

We already know that biodiversity can be expressed in terms of the different levels of biological organisation such as genes, species, ecosystems and landscapes. All these four forms of biodiversity can be subjected to loss, although the most easily recognisable form of loss is that of species. Since, the different forms of diversity are intimately related to one another, biodiversity loss at any one level will lead to loss at other levels too.

2.2 Loss of Genetic Diversity

It must be evident to the readers that the uncontrolled loss of species is almost always sure to be accompanied by the loss of genetic diversity. When a species is lost, all genetic information carried by that species is also lost. Species lossis usually preceded by fragmentation of its contiguous populations to result in many small, isolated populations. Genetic diversity present in the whole contiguous population is also fragmented and slowly lost when the fragmented populations are also lost. Genetic diversity is usually analysed at the population level. Hence loss of genetic diversity is also studied in populations. The annual losses of populations are around 0.8%, which is equivalent to about 1800 populations every hour (Hughes *et al.*, 1997). Genetic diversity is important for fitness and adaptive changes; loss of genetic diversity, therefore, becomes a serious matter for concern as it will affect the suitability and evolutionary adaptability of a species.

2.2.0 Factors Causing Loss of Genetic Diversity

Reduction in genetic diversity within populations of species may be caused by four factors: Founder effects, Demographic bottlenecks, Genetic drift and Inbreeding depression.

Founder Effects : Founder effects occur when only a few individuals (called ‘founders’) of an originally larger population establish a new population. The genetic constitution of the newly established population will depend on the genetics of its founders. If the founders are not true representatives of the larger parent population in terms of their genetic constitution, or if only a few founders are involved in establishing a newpopulation, then the newly established population is a biased (in terms of genetic diversity) representation of the original larger gene pool (of the parent population of founders) from which it came; thus it may have lower overall genetic diversity.

Demographic Bottlenecks : When a larger population suddenly experiences a severe, temporary reduction in size for whatever reasons, a demographic bottleneck result. The outcome of such a bottleneck is that the genetic diversity of all subsequent generations is contained in the few individuals (of the original population) that survive the bottleneck and reproduce. Expectedly, some genetic diversity will be lost in this process.

Genetic Drift : This represents a random change in gene (or allele) frequencies in small populations. In mathematical terms, it represents a chronic bottleneck that results in repeated erosion of heterozygosity (i.e., increase in homozygosity), loss of variability and eventual loss of genes or alleles; rare alleles are very often lost. A reduction in diversity of allelic combinations is also apparent in subsequent generations. Genetic drift is believed to be a key factor in the loss of genetic diversity and therefore is important in conservation also.

Inbreeding Depression : Inbreeding can be defined as mating of individuals related by common ancestry. There is greater probability of inbreeding occurring in smaller populations. The most important consequence of inbreeding is inbreeding depression which may be defined as a 'decrease in the mean of a character upon inbreeding' (Lande, 1996). Inbreeding depression causes decrease in growth rate, reduction in vigour and fertility, decreased survival rate, physical deformities etc.; all these individually or in combination will be evident in any component of fitness, under a specific environment. The other important genetic outcome of inbreeding is a reduction in heterozygosity and an increase in homozygosity.

2.3 Loss of Species Diversity

The loss of species is a natural process. We know from fossil and historical data that all species have a definite life span. We also know those forces that led to loss of species as well as those that allowed certain species to survive. The fossil data suggest that as much as a quarter of Earth's species become extinct each million years. The actual reasons for this loss are not known. The explanations offered thus far range from interspecific competitions, climatic changes, accumulation of deleterious genes, result of inbreedingor extra-terrestrial impacts such as those of asteroids. Well over 95% of all species that have evolved on this Earth thus far have become extinct. We also know that extinct species outnumber living ones by a factor of perhaps a thousand to one. (Krishnamurthy, 2003).

A species is said to have become extinct when all its individuals are lost without producing progeny. Such a loss of species is called *true extinction*. There have also been *pseudo extinctions*, wherein a species disappears when its lineage is transformed over evolutionary time or divides into two or more separate lineages. Extinctions of

the true type generally occur when a natural or manmade environmental change or challenge exceeds the adaptive capacity of the individuals of a species, and there is no safe place to which the species can retreat. Species extinction without the intervention of man is often called *background extinction* (Raup 1978). The background extinction rate, on average, is calculated to be 4 million years for each species (Raup, 1991). This may appear to be an incredibly long time to humans but is remarkably short with reference to the nearly 4000 million years of history of life on the Earth.

In Earth the history of life has been interrupted by mass extinctions. A *mass extinction* can be defined as an exceptional loss in biodiversity that is substantial in size and global in extent; it should also affect a broad range of taxonomic groups over very short periods of geologic time (Jablonski, 1986). Those mass extinctions can be of shorter periods or of long durations of several million years. Eight extinctions have been identified and grouped into five major mass extinctions (Raup and Sepkoski, 1982):

(i)	Ashgillian	end Ordovician
(ii)	Givetian	
(iii)	Frasnian and	late Devonian
(iv)	Famennian	
(v)	Guadalupian	
(vi)	Dzhulfian	end Permian
(vii)	Norian	end Triassic
(viii)	Maastrichtian	end Cretaceous

Most species extinctions have been due to these mass extinctions. For example, during the mass extinction of the Permian-Triassic boundary 96% of all Earth's species at that time reportedly perished.

2.3.1 Species Extinction

It was earlier remarked that species extinction is a natural process and that during history of the Earth several mass extinction events took place. Natural extinctions are distinct from those triggered by human intervention. Extinctions caused directly or indirectly by human beings are occurring at a rate that far exceeds any estimates of background extinction rates (i.e., 4 million years); the human induced extinction rate may be 1000 to 10000 times greater than the average background extinction rate. Species extinctions are occurring today at very high rates on both local and global

scales and that we are now in the opening phase of another mass extinction, triggered by human intervention alone. The present mass extinction, if it remains unchecked, will purportedly rival and even conceivably surpass in extent any of the previous great mass extinction episodes (Given, 1996).

2.3.2 Processes responsible for Species Extinction

Two types of processes are fundamentally responsible for species extinction:

(i) Deterministic processes or causeand effect relationships: Examples: glaciation, deforestation, habitat fragmentation, etc. In these processes, some essential components of ecosystems are removed while others, lethal to the ecosystem, are added. Deterministic events are either readily observed or easily detected.

(ii) Stochastic processes or chance events: Four types of stochastic Processes are distinguished (Shaffer 1987).

(a) Demographic uncertainty: This resulted from the effect of random events on the survival and reproduction of individuals in a finite population. In a small population of, less than 100 individuals, demographic uncertainty can be seen. For *Astrocaryum mexicanum* a population size of at least 50 individuals is needed, so that the probability of its survival become greater than 95%. The greater the population size of a species, the better its chance of survival.

(b) Environmental uncertainty: This is due to unpredictable environmental events such as sudden changes in weather, food supply, disease incidence, extent of competitors, predators, and parasites etc. Unlike in demographic uncertainty, there is no critical population size that once reached guarantees a high level of long-term security from environmental uncertainty.

(c) Natural catastrophes: These are extreme cases of environmental uncertainty, e.g. floods, hurricanes, fire, drought etc. These catastrophes are usually short in duration but massive in impact.

(d) Genetic uncertainty: This refers to random changes in the genome, mutations, etc. The already described founder effects, genetic drift, inbreeding depression, etc. are also included under genetic uncertainty.

Deterministic and stochastic processes may either act independently or in combination. In the latter case, their effects compound each other.

2.3.3 IUCN Threat Categories

The IUCN Red List Categories are intended to be an easily and widely understood system for classifying species at high risk of global extinction (Fig. 2.0).The general aim of the system is to provide an explicit, objective framework for the classification of the broadest range of species according to their extinction risk. However, while the Red List may focus attention in those taxa at the highest risk, it is not the sole means of setting priorities for conservation measures for their protection.

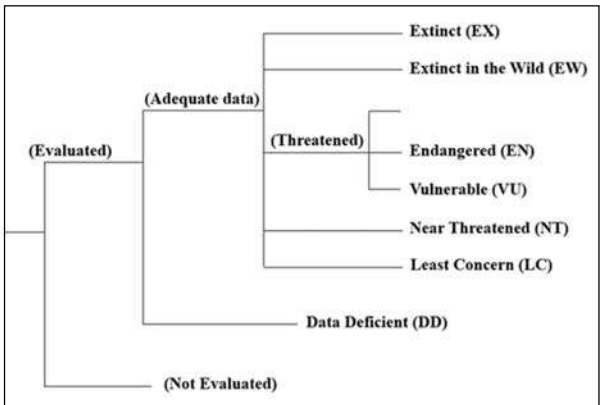

Fig. 2.0: IUCN Threat Categories

Extinct (EX): A taxon is Extinct when there is no reasonable doubt that the last individual has died.

Extinct in the Wild (EW): A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range.

Threatened:

Critically Endangered (CR): A taxon is critically Endengered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered, and it is therefore considered to be facing an extremely high risk of extinction (50% in 5 years) in the wild.

Endangered (EN): A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered, and it is therefore considered to be facing a very high risk of extinction (20% in 20 years) in the wild.

Vulnerable (VU): A taxon is Vulnerable (VU) when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (VU), and it is therefore considered to be facing a high risk of extinction (10% in 100 years) in the wild.

Rare (R): Taxa with small populations that are not endangered or vulnerable at present but are at risk are included under this category.

Not-Threatened:

Near Threatened (NT): A taxon is Near Threatened (NT) when it has been evaluated against the criteria but dose not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely qualify for a threatened category in the near future.

Least Concern (LC): A taxon is Least Concern when it has been evaluated against the criteria and dose not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

Data Deficient (DD): A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and / or population status.

Not Evaluated (NE): A taxon is Not Evaluated when it has been initially proposed but not discussed and not yet been evaluated against the criteria for any reason, including uncertainty about taxonomic or wild status.

2.3.4 Census of Threatened Species

Table 2.0: Global figures for the 2019-3 IUCN Red List of Threatened Species:

Total Species assessed	112, 432 (116, 177 by 2020)
Total threatened species	30, 178 (31, 030 by 2020)
Extinct	877
Extinct in the Wild	73
Critically Endangered	6, 413
Endangered	10, 629
Vulnerable	13, 136
Near Threatened	6, 826
Lower Risk	192
Least Concern	57, 931
Data Deficient	16, 355

Table 2.1 Number of plant species evaluated in relation to the overall number of described species, and numbers of threatened species (IUCN Red List version 2020-1).

	Estimated Number of described species	**Number of species evaluated by 2020**	**% of described species evaluated by 2020**	**Number of threatened species by 2020**
PLANTS				
Mosses	21, 925	281	1.3%	164
Ferns and Allies	11, 800	656	6%	261
Gymnosperms	1, 113	1, 015	91%	402
Flowering Plants	369, 000	38, 445	10%	15, 624
Green Algae	11, 620	13	0.1%	0
Red Algae	7, 298	58	0.8%	9
Subtotal	**422, 756**	**40, 468**	**10%**	**16, 460**
FUNGI & PROTISTS				
Lichens	17, 000	30	0.2%	27
Mushrooms, etc.	120, 000	255	0.2%	141
Brown Algae	4, 275	15	0.4%	6
Subtotal	**141, 275**	**300**	**0.2%**	**174**

2.4 Loss of Ecosystem Diversity

Loss of Ecosystem Diversity may be considered - the ultimate cause for loss of both species and genetic diversities. This has been sufficiently indicated by fossil data as well as information presently available. Both deterministic and stochastic processes, described as responsible for species extinctions, are also responsible for loss of ecosystem diversity. This section delineates the threat factors affecting ecosystems in general as well as the magnitude of loss estimated for the major ecosystems of the world and the major causes for such a loss.

2.4.1 Factors Affecting Ecosystem Degradation and Loss

The various mechanisms involved in the loss of ecosystem diversity fall into five major categories: overkill, habitat destruction, impacts of introduced animals and weeds that later become invasive, pollution, and secondary losses.

Overkill denotes the uncontrolled organised collection (for scientific and industrial purposes) and killing of plants.

Habitat destruction can be brought about by an array of organised land conversion causes, such as agriculture, housing, construction of roads and dams, industrial development, gravel and sand quarrying, wetland draining and filling, slash-and-burn (shifting) cultivation, tourism etc. *Desertification* can also be responsible for habitat destruction.

Introduced animals, pests and invasive weeds cause impacts on ecosystems by displacing local taxa and by affecting community structure, biogeochemistry, fire regimes, erosion, geomorphology, hydrological cycle, etc. Water table changes, trampling and overgrazing by animals, herbivory by smaller animals, unwanted competition between the introduced organisms and native ones, diseases and predation and disappearance of symbionts, pollinators and dispersers are other changes introduced directly or, indirectly by exotic invasive organisms.

Pollution can be caused by a number of factors, mostly human-generated. Land, water and air may all become polluted, markedly affecting the ecosystem components.

Secondary losses maybe induced by a combination of two or more of the aforesaid factors.

The most significant phenomenon for ecosystem loss is *fragmentation*. it is the most serious causes for erosion of biodiversity. *Fragmentation* may be defined as an unnatural separation of extensive areas of habitats into spatially segregated fragments that are too limited to maintain their different species for an infinite future. This phenomenon was observed as early as 1855 when de Candolle noticed that the break-up of a landmass into smaller units would necessarily lead to the extinction or local extermination of one or more species (Browne, 1983). Based on the operational mode of forces, fragmentation can be divided into five categories: Regressive, Enveloping, Divisive, Intrusive, and Encroaching.

Fragmentation of larger habitat leads to an artificially created terrestrial islands. Such fragments experience microclimatic effects, i.e. air temperature, light, markedly different from those that existed in the large tracks of habitats before fragmentation. Fragmentation promotes the migration and colonisation of alien species and such colonisation is often substantial and continuous, profoundly affecting the survival of native species. There is considerable evidence that the number of species in a

fragmented habitat will decrease over time, although the probable rates at which it will happen are variable. In fact, actual data on rain forests show that forest fragment have lower species richness and fewer populations compared with continuous undisturbed forests.

2.5 Loss of Agrobiodiversity

Agrobiodiversity is very often equated with richness in crop varieties, i.e., the more the number of varieties within a crop species, the greater the agrobiodiversity of that crop species. Agrobiodiversity richness is also the economic unit of benefit valuation. With loss of agrobiodiversity, narrowing of species richness has occurred on a global level. Of the 400, 000 and more plant species reported, by conservative estimates, for the Earth, only *circa* 300, 000 have been documented. Of the latter, just 10% are edible (i.e., 30, 000 species) and among these 30, 000 species, 7000 are either cultivated or collected by humans for food, feed or other agricultural purposes at one time or another, with just 200 constituting major domesticates. Of these, only 30 are of supreme importance and among these just four constitute primary staple foods, namely rice (26%), wheat (23%), maize (7%) and potato (3%). These four crops alone account for approximately 25-28% of all 6.2 million *ex situ* stored crop accessions (WIEWS 1996). Furthermore, most of the money spent on genetic resources activities is expended on these four crops.

Besides the narrowing down of species richness, a decrease in varietal diversity in agrobiodiversity has also been noted. As 75% of the area under rice cultivation which once accommodated 30, 000 rice varieties, is today sown with only 10 varieties.

It must be understood that every newbreeding activity adversely narrows the genetic base of the source variety. On the other hand, incorporating new and favourable traits by introducing genes, broadens the genetic base of the variety. Loss of genetically coded information from the agricultural field is on the increase due to the rapid disappearance of traditional varieties and land races.

2.6 Projected Scenario for Biodiversity Loss

Global biodiversity loss is taking place at an unprecedented rate as a complex response to several human-induced changes. The magnitude of this loss is so great

and so strongly linked to ecosystem processes and society's use of biodiversity resources that it is now considered an important global change in its own right.There are, however, currently very few projected scenarios for biodiversity change in 10 terrestrial biomes and in freshwater ecosystems for the year 2100. Sala *et al.* (2000) identified the five important determinants of changes in biodiversity at the global scale: changes in land use, atmospheric CO_2 concentration, nitrogen deposition and acid rain, climate, and biotic exchanges (i.e. deliberate or accidental introduction of organisms into an ecosystem). Next, they calculated the expected change of these drivers in each biome followed by estimation of the impact in each biome that a unit change in each driver exerts on biodiversity. They found that for terrestrial biomes, land-use changes would probably have the largest effect, followed by changes in climate, nitrogen deposition, biotic exchanges and elevated CO_2 concentration. Biotic exchange is much more important for a freshwater ecosystem. Mediterranean and grassland ecosystems are likely to experience the greatest losses in biodiversity. Changes in Northern Temperate ecosystems are likely to be the least because major land-use changes have already occurred there (Sala *et al.*, 2000).

2.7 Summary

The causes and mechanisms of biodiversity loss and impoverishment have been detailed in this chapter. However, in concluding attention is drawn to the six fundamental and complex causes often noticed within our policies, laws and management arrangements by various governments and people (UNEP, 1995; WRI/ IUCN/UNEP 1992):

a) High rates of human population growth and biodiversity consumption;
b) Greater and greater specialisation of traded products of agriculture/forestry leading to a very narrow spectrum of used products;
c) Failure of economic systems and policies to adequately value biodiversity resources;
d) Inequity in ownership and access to bioresources, including the benefits from their use and conservation;
e) Inadequate knowledge and inefficient use of biodiversity information; and
f) Poor or misused legal and institutional systems that promote an unsustainable use of biodiversity.

2.8 Management of Plant Biodiversity

There is an ever-growing demand for bioresources by humankind. It is fully realised now that these growing demands can no longer be met by tapping the still unexploited bioresources or by trade-offs between goods and services. Any nation can increase food supply by converting forestlands to agriculture but in doing so it restricts the supply of goods and services rendered by forests which are of equal or greater importance. The projected climatic changes also worsen the act of balancing supply and demand of bioresources. It is worth noting that the governments of the world's various nations had already made an important, but unnoticed, commitment to nature (including biodiversity) conservation and management through the World Charter for Nature, adopted by the General Assembly of the United Nations in 1982. This Charter recognises that humanity is part of nature, that every form of life is unique and warrants respect, and that continued benefits from nature depend upon the management and maintenance of essential ecological processes. In other words, the goal of biodiversity management is to strike the optimal balance between biodiversity conservation, 'advancing human sustainable living' and benefit sharing.

Successful management depends on two things:

(i) The social, political, economic and cultural contexts within which management objectives are pursued should be properly understood by policy-makers and managers.

(ii) Proper tools and methods should be selected to attain the aforesaid objectives.

An integrated, predictive and adaptive approach to biodiversity management requires three basic types of information:

(i) reliable site-specific baseline information on all aspects of biodiversity.

(ii) knowledge on how the value generation (in term of goods and services) in specific ecosystems will respond to changing environments.

(iii) integrated regional models that incorporate the biophysical, economic and technological changes.

The scientific community must immediately take steps to mobilise all its knowledge in a manner that can increase awareness, provide information capacity building at local, regional and national levels and informed policy changes that will better manage the Earth's biodiversity.

2.9 Organizations associated with Biodiversity Management

Biodiversity management can be brought about effectively through committed organisations at the national and international levels (both governmental and non-governmental) which frame policies and methodologies for execution. They also collect/collate vital data, store them and distribute them to the needy. In addition, multilateral and national treatises, conventions and legal systems help in the effective management of biodiversity. Biodiversity information and knowledge are made available to anyone interested through well-organised databases. Biodiversity management requires skills in interdisciplinary areas such as Biology, Economics, Anthropology, Engineering, Forestry, Agriculture, Oceanography, Sociology, Management Science, Geography, Geology, Computerisation etc.

2.9.0 IUCN

IUCN stands for *International Union for Conservation of Nature and Natural Resources*. It is a membership Union uniquely composed of both government and civil society organisations. It provides public, private and non-governmental organisations with the knowledge and tools that enable human progress, economic development and nature conservation to take place together. Created in 1948, IUCN has evolved into the world's largest and most diverse environmental network. It harnesses the experience, resources and reach of its more than 1, 300 Member organisations and the input of 14, 500 experts.

IUCN is the global authority on the status of the natural world and the measures needed to safeguard it. Its experts are organised into six Commissions dedicated to species survival, environmental law, protected areas, social and economic policy, ecosystem management, and education and communication. IUCN provides a neutral forum in which governments, non-governmental organisations, scientists, businesses, local communities, indigenous peoples' groups, faith-based organisations and others can work together to forge and implement solutions to environmental challenges.

IUCN's expertise and extensive network provide a solid foundation for a large and diverse portfolio of conservation projects around the world. Combining the latest science with the traditional knowledge of local communities, these projects work to reverse habitat loss, restore ecosystems and improve people's well-being. In the

IUCN Programme for 2017–2020 conserving nature and biodiversity is linked to sustainable development and poverty reduction. The IUCN Programme 2017–2020 identifies three priority areas:

(i) Valuing and conserving nature.

(ii) Promoting and supporting effective and equitable governance of natural resources.

(iii) Deploying Nature Based Solutions to address societal challenges including climate change, food security and economic and social development.

IUCN congresses have produced several key international environmental agreements including the Convention on Biological Diversity (CBD), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the World Heritage Convention, and the Ramsar Convention on Wetlands. IUCN continues to support these conventions as they grow stronger and evolve so that they can respond to emerging challenges. IUCN's Member organisations are represented by the IUCN Council – the governing body. Headquartered in Switzerland, the IUCN Secretariat comprises around 900 staff in more than 60 countries. (IUCN, 2018).

2.9.1 UNEP

UNEP stands for *United Nations Environment Programme*. It is a UN agency engaged in the coordination of intergovernmental measures for monitoring and protecting the environment, achieving sustainable development and resolving biodiversity issues. it has threefold mandate:

(i) to create awareness on global environmental problems.

(ii) to build consensus on actions addressed towards these problems.

(iii) to Promote and support such action programmes.

UNEP was formed subsequent to the UN Human Environment Conference at Stockholm in 1972, initially with an Executive Body of 50 members and a voluntary UNEP fund to finance the projects of the UNEP. For co-ordinating all activities of UNEP, an Environmental Co-ordination Board was created. As a member of the United Nations Development Group, UNEP aims to help the world meet the 17 Sustainable Development Goals, a "blueprint to achieve a better and more sustainable future for all".

The Sustainable Development Goals are:

1. No Poverty
2. Zero Hunger
3. Good Health and Well-being
4. Quality Education
5. Gender Equality
6. Clean Water and Sanitation
7. Affordable and Clean Energy
8. Decent Work and Economic Growth
9. Industry, Innovation, and Infrastructure
10. Reducing Inequality
11. Sustainable Cities and Communities
12. Responsible Consumption and Production
13. Climate Action
14. Life Below Water
15. Life on Land
16. Peace, Justice, and Strong Institutions
17. Partnerships for the Goals

Over the last thirty years, UNEP has increasingly focused on climate change, helping create or implement environmental treaties and institutions, such as the UN Framework Convention on Climate Change. In 1988, it joined the World Meteorological Organization to establish the Intergovernmental Panel on Climate Change (IPCC), a leading authority on the science of climate change and options for adaptation and mitigation. UNEP is also one of several "Implementing Agencies" for the Global Environment Facility (GEF), the Multilateral Fund for the Implementation of the Montreal Protocol, and the International Cyanide Management Code.UNEP has taken up the following major activities:

(i) biodiversity country studies

(ii) global biodiversity assessment (GBA) projects

(iii) biodiversity data management (BDM) projects for capacity building in developing countries and improved in-country networking of biodiversity information

UNEP operates the Earth Watch Programme and funds publication of the magazine *Earthscan*. It has held/supported several conferences, workshops and meetings. UNEP has produced several seminal publications/documents in addition to Global Biodiversity Assessment (published by CambridgeUniversity Press, 1995). These have brought into focus the pertinent issues of biodiversity conservation and its sustainable use. UNEP is headquartered in Nairobi, Kenya.

UNEP in India

- United Nations Environment Programme established a country presence in New Delhi, India on 16 May, 2016. UNEP's high-level missions in February, March, June and October, 2018 have forged a legacy of environmental leadership: from hosting the biggest and most consequential World Environment Day ever in June 2018, when India boldly pledged to go single-use plastic free by 2022, to conferring of the Champions of the Earth Award on Prime Minister Narendra Modi for his environmental leadership.
- UNEP India in partnership with governments, private sector, UN agencies, civil society, communities, citizens, research and academic institutions and other organizations is working towards raising awareness and stimulating action on critical environmental issues that contribute to the Sustainable Development Goals.
- India makes an annual financial contribution (US$ 100, 000) to the General-Purpose Funds of UN Environment and to several Multilateral Environment Agreements. UNEP has been involved in a number of projects in India including the Tree Planting Programme and the Ganga Action Plan.

2.9.2 UNESCO

UNESCO stands for *United Nations Educational, Scientific and Cultural Organisation*. It was established in 1945 as a UN Agency. In 1948 it funded for the establishment of the IUCN. UNESCO has also assisted in the creation and operation of networks such as the MIRCENS (Microbial Research Centres), Biosphere Reserves and, other protected areas, and marine research stations. MIRCENs are the outcome of a joint effort by UNESCO, UNEP and the International Cell Research Organisation. Activities of MIRCENs typically include collection, maintenance, testing and distribution of microbes, and training of personnel.

The International Man and Biosphere Programme (MAB) was initiated by UNESCO in the early 1960s, took its final shape in 1968, and was actually launched in 1977. One hundred and ten countries co-ordinate in the MAB. Several UNESCO-MAB documents have already been prepared, wherein the objectives of the network of Biosphere Reserves, the characteristics which the Reserve must display and the action plans of these Reserves are detailed. Subsequently several MAB networks were established. These include the EuroMAB, USMAB, MAB-CYTED (Ibero-American Programme), CBRN-MAB (Chinese network) and MAB-GEF (Central European network).

UNESCO has also identified World Heritage Sites and listed them. A World Heritage Fund was created and is being managedby UNESCO's World Heritage Committee; the annual budget for this fund is 2 million US dollars.

UNESCO, with the help of IUCN, was instrumental in the preparation of the draft for the Rio summit and convention. It, along with the International Union of Biological Sciences, launched in 1991 the famous co-operative scientific programme on biodiversity called DIVERSITAS for studying the origin, maintenance, loss etc. of biodiversity. The headquarters for UNESCO is in Paris.

2.9.3 WWF

WWF stands for *Worldwide Fund for Nature and Natural Resources*. It was established in 1961 and is headquartered in Gland, Switzerland. WWF International has several affiliated national units. The Indian unit was established in 1969 at the time of the XII General Assembly of the IUCN, held in New Delhi. The WWF International is controlled by, Board of International Trustees, while the national units are managed by separate national teams. For example, the Indian unit has a Board of 8 trustees, with its headquarters in Mumbai. It has a network of 18 State and Divisional Units. WWF has initiated several specific conservation programmes in more than 24 countries, with importance given to endangered fauna and flora. The logo of WWF is the Giant Panda, as designedby Gerald Watterson.

WWF-India has three mission to stop the degradation of the planet's natural environment and build a future in which humans live in harmony with nature, by:

- Conserving the world's biological diversity
- Ensuring that the use of renewable natural resources is sustainable
- Promoting the reduction of pollution and wasteful consumption

In order to conserve India's ecological security, WWF-India has adopted the following steps:

- Ensuring conservation of the country's biodiversity, major ecosystems and critical landscapes.
- Minimizing wasteful consumption and promotion of sustainable and judicious use of natural resources by all sectors of society.
- Promoting the active involvement of rural and traditional communities in the sustainable management and conservation of natural resources.
- Working towards reduction in the impact of climate change.
- Minimizing pollution, reducing the use of toxic chemicals and ensuring improved management of toxic waste.
- Enhancing active participation of all sections of society in nature conservation and environmental protection through environmental education, awareness and capacity-building.
- Ensuring that environmental principles are integrated into development planning, policy and practices.
- Promoting environmental governance through legislation, policy and advocacy.

2.9.4 NBPGR

In India initially centralized plant introduction agency was established in 1946 at Indian Council of Agricultural Research (ICAR), New Delhi. This unit was further expanded in 1956 as "Plant Introduction and Exploration Organization" in the Botany Division of Indian Agricultural Research Institute (IARI) and it was further expanded in 1961, as an independent "Division of Plant Introduction". In August 1976, on the recommendation of the Government of India, this division upgraded to an independent institute as "National Bureau of Plant Introduction" and was renamed as "*National Bureau of Plant Genetic Resources* (NBPGR)" in January 1977. NBPGR is the nodal agency for activities and services related to plant genetic resources. It was established with the mandate to plan, conduct, promote, and coordinate all activities, including collection, conservation, exchange, quarantine, evaluation, documentation, and utilization of plant genetic resources.

The establishment of the Bureau coincided with the advent of the Green Revolution and was in response to the realization of perceived effects of the Green Revolution on agrobiodiversity. Further, it was in accordance with the international developments in the form of establishment of the International Board for Plant Genetic Resources (IBPGR), Rome, in 1974 (now renamed as International Plant Genetic Resources Institute). The NBPGR played a pivotal role in the improvement of various crop plants and diversification and development of agriculture in India through germplasm introduction from various institutes/organizations located in foreign countries and germplasm collection from within the country and abroad and conservation thereof.

The National Bureau of Plant Genetic Resources (NBPGR) has its headquarters at New Delhi, located at latitude of 280 35' N, longitude of 70018' E and an altitude of 226 m above mean sea level. The Bureau draws guidelines from the Crop Science Division of ICAR, Institute Management Committee, Research Advisory Committee, Institute Research Council and Germplasm Advisory Committees.

The Bureau has five Divisions, three units and an experimental farm at its Headquarters in New Delhi and has 4 Divisions, 3 units, 2 cells. There are 10 Regional Stations located in different phyto-geographical zones of the country. These includes:

(i) Shimla (Himachal Pradesh)
(ii) Jodhpur (Rajasthan)
(iii) Thrissur (Kerala)
(iv) Akola (Maharashtra)
(v) Shillong (Meghalaya)
(vi) Bhowali (Uttarakhand)
(vii) Cuttack (Orissa)
(viii) Hyderabad (Andhra Pradesh)
(ix) Ranchi (Jharkhand)
(x) Srinagar (Jammu & Kashmir)

Different activities of NBPGR: Different activities of NBPGR include:

1. Introduction and supplement of the required germplasm from other countries.
2. To explore and collection of valuable germplasm.
3. Maintaining proper inspection and quarantine measures.

4. Testing, multiplication and proper maintenance of germplasm.
5. Publication of exchange and collection list.
6. Maintenance of the record of introduced plants.
7. To supply the germplasm to scientists or any institution on written request.
8. Improvement of medicinal and aromatic plants.

2.10 Biodiversity Legislation and Conventions

Primitive man, even from the hunter-gatherer stage, was highly dependent on the various elements of biodiversity; he had developed an unwritten code for the sustainable use of biodiversity. Such codes exist even today in several tribal pockets throughout the world. During the evolution of human society and civilisation, these unwritten codes were replaced by legislation. Only a few decades ago, however, environmental law emerged as a distinct branch of law in order to regulate the activities of man towards the biotic and abiotic components of the environment.

Throughout the world, biodiversity laws started as specialised sub-branches of agriculture and/or forestry laws; initially they dealt specifically with regulation of the exploitation of wild species and the establishment of protected areas. Only slowly did they evolve as specialised biodiversity laws extended into laws pertaining to planning and land-use legislation. From the initial regulatory and punitive status, biodiversity laws are now increasingly developing to provide framework for the establishment of procedures and institutions destined to facilitate and encourage biodiversity conservation and management programmes, to make biodiversity into a public service and to promote better public awareness of biodiversity.

2.10.0 International Biodiversity Laws

International laws have two dimensions: public and private. In the public dimension, international laws govern the activities and relationships between nations, although the principle of state sovereignty dominates them. Consequently, nations are not strictly bound by such international laws; their consent is very essential while approving or enchanting such laws. With refence to the private dimension, it can be mentioned that private law operates within the context of the public law, and controls the activities and relationships of individuals and non-governmental organisations.

It is evident from the foregoing that treatise have become the backbone of international laws. Treatise are contracts providing for benefits to both the contracting nations and, therefore, if one nation fails to comply with its treaty commitments, the other can retaliate by refusing to discharge its own obligations. Very recent developments in International Laws have resulted in treatise laying down general rules that the contracting nations should absolutely commit themselves to, failing which they self-defeat themselves.

Steps towards implementation of the treatise:

(i) Establishment of appropriate institutions, such as Conferences of Nations and Secretariat to review implementation of the contents of the treatise, encourage and promote co-operation between the nations, and provide a forum where in cases of non-compliance are discussed and solutions reached.

(ii) Underscore the obligation of contracting nations to provide periodic reports on the actions taken by each nation in implementing the contents of the treatise.

(iii) Empower the conference or Secretariat to adopt specific recommendations relating to the treaty and,

(iv) Allow admission of non-governmental organisations as observes at meetings of the Conference.

There are four sources of international laws:

(i) international conventions,

(ii) international custom,

(iii) general principles of law and,

(iv) judiciary decisions and teachings of the most highly qualified publicists such as the International Court of Justice Statute 1948 (UNEP, 1995).

2.10.1 Biological Diversity Act of India

The Biological Diversity Act (BDA) was formulated after India became signatory to the CBD. The draft legislation was developed through an intensive consultation process involving all stakeholders such as the Central Government, State Governments, institutions of local self-government, scientific and technical institutions, experts, non-governmental institutions, industry, etc. The act was passed by the Parliament in December 2002. The objectives of the act are ‘to provide for conservation of biological diversity, sustainable use of its components and equitable sharing of the benefits

arising out of the use of biological resources and for matters connected therewith or incidental thereto'.

Salient Provisions: Some of the salient provisions made in the BDA for regulation of access to biological diversity, its conservation and sustainable use are:

(i) Conservation and sustainable use of biological diversity.

(ii) Conservation and development of areas important from the standpoint of biological diversity by declaring them as biological diversity heritage sites.

(iii) Protection and rehabilitation of threatened species.

(iv) To respect and protect knowledge of local communities related to biodiversity.

(v) Regulation of access to biological resources of the country with the purpose of securing equitable share in benefits arising out of the natural resources and its associated knowledge.

(vi) To secure sharing of benefits with local people as conservers of biological resources and holders of knowledge and information related to the use of biological resources.

(vii) Involvement of institutions of self-government in the broad scheme of the implementation of the act through constitution of committees.

The Act envisages a three-tier structure to regulate access to the biological resources, comprising of

- National Biodiversity Authority (NBA),
- State Biodiversity Boards (SBB) and
- Biodiversity Management Committees (BMC) at the local level

The **National Biodiversity Authority** (NBA) was established in 2003 to implement India's Biological Diversity Act (2002). The NBA is a Statutory, Autonomous Body and it performs facilitative, regulatory and advisory function for the Government of India on issues of conservation, sustainable use of biological resources and fair and equitablesharing of benefits arising out of the use of biological resources.

The **State Biodiversity Boards** (SBBs) focus on advising the State Governments, subject to any guidelines issued by the Central Government, on matters relating to the conservation of biodiversity, sustainable use of itscomponents and equitable sharing of the benefits arising out of the utilization of biological resources. The SSBs also

regulate, by granting of approvals or otherwise requests for commercial utilization or bio-surveyand bio-utilization of any biological resource by Indians.

The local level **Biodiversity Management Committees** (BMCs) are responsible for promoting conservation, sustainable use and documentation of biological diversity including preservation of habitats, conservation of landraces, folk varieties and cultivars, domesticated stocks and breeds of animals and microorganisms and chronicling of knowledge relating to biological diversity. Since its establishment, NBA has supported creation of SBBs in 26 States and, facilitated establishment of around 32, 796 BMCs. One of the key mandate of BMCs is to prepare Biodiversity Register, which documents the elements of biodiversity in the areas, and issues pertaining toits sustainable utilization and befit sharing; the traditional knowledge associated with it.

2.10.2 Convention on Biological Diversity

Also called the Rio or Earth Summit, the *Convention on Biological Diversity* (CBD) is a major landmark in biodiversity management, regulation and utilisation. This convention was the result of very intense political interest in biodiversity and several years of intense bio diplomacy. Preparations for CBD were initiated by UNEP in 1987 with the formation of an Ad hoc Working Group of Experts met in 1988, followed by a meeting in 1991 of the Intergovernmental Negotiating Committee for a CBD. The CBD was adopted during the Earth Summit (UNCED) in Rio de Janeiro, Brazil in 1992. The CBD was launched in June 1992, along with establishment of the Global Environmental Facility (GEF). The Convention came into force on 29th December 1993. This was followed by the first meeting of the contracting countries in the Bahamas, Nov-Dec, 1994. By February 1995, 168 countries had signed this Convention, while by April 1995, 188 countries had ratified its tenets, and currently has 193 countries as Parties.

Reaffirming sovereign rights of nations over their biological resources, the Convention has set three main objectives: (i) conservation of biological diversity; (ii) sustainable use of biodiversity; and (iii) rational sharing of the benefits derived from the domestic and wild plants. The first two objectives are straight forward while the third one was effective barrier to the biotechnology products of developed or industrialised countries. The CBD was aimed at reaching an agreement among all contracting countries since there was (and still is) serious disagreement between

countries over biodiversity utilisation and conservation. Developed countries felt (and many still feel) that conservation of biodiversity, wherever it may be located in the world, is a common concern of humankind, while developing countries tended to show a strong 'country driven approach' with reference to the use of biodiversity for their overall economic developments.

During the past years, the developed countries (industrialized) have developed new medicines, biotechnology produces, crops, etc. using the raw materials of tropical species, but without giving any return of due profits earned out of them. Thus, the countries in which the wild tropical species were originally found did not receive fair compensation from the developed countries for the use of their species in question. India was the first country to sign the Convention and ratified it on 18th February, 1994. The country is committed to achieve the goals of the Convention.

2.10.3 CITES

CITES stands for *Convention on International Trade in Endangered Species of Wild Fauna and Flora*. CITES, known in its early days as the 'Washington Convention', was the result of extensive lobbying by IUCN for international trade controls in species that are prioritised for conservation. The necessity for controlling international trade in endangered species, although recognised as early as 1911, and provisions to that effect incorporated in several international conventions on the conservation of wildlife, could not be realised in practice for a long time –not until CITES came into force. CITES was first arranged in 1973 in Washington DC. The trade agreements reached in this convention were enforced in 1975. By about 1994, the number of countries which agreed to enforce the recommendations of CITES had increased from an initial 10 to 125. By 2016, the number of signatories had reached 183. This list includes India.

CITES is a major global biodiversity protection statute and is intended to be followed internationally. Its goal is '*to regulate the complex wildlife trade by controlling species-specific trade levels on the basis of biological criteria*'. It includes all species '*threatened with extinction, which are or may be affected by trade*'. Thus, CITES focuses primarily on the species and its extinction are the important criteria. The statute of CITES is primarily based on listed endangered species and on laws spread

in individual countries. This leads to a situation wherein a particular species listed in CITES may be legally obtained and traded from one country, but not from another.

All the legal provisions of CITES apply not only to whole live or dead specimens of listed species, but also to their readily recognisable parts and derivatives; however, a small number of exceptions are listed. The role of CITES, therefore, is to provide the nations of the world a legal framework for combating the illegal trade in endangered taxa.

Another organisation, called TRAFFIC (Trade Record Analysis of Flora and Fauna in Commerce) monitors international trade of species. The unit was established in 1991 in the WWF-India headquarters in New Delhi.

2.10.4 Ramsar Convention

Also called the Convention on Wetlands of International Importance, the Ramsar Convention is an International treaty drawn up in 1971 at Ramsar in Iran. The convention came into force in December 1975. This convention expects its contracting nations to promote the wise use of wetlands situated in their territory; it also requires the contracting partiers to designate certain wetlands for inclusion on a list of wetlands of international importance. Such wetlands of international importance are called Ramsar Sites. The contracting nations should mandatorily make national wetland inventories; they should also establish nature reserves on wetlands and provide adequately for their maintenance. The major parameter for a wetland to qualify for inclusion in the international list is the presence in it of rare, vulnerable, endangered or endemic plants/animals.

The Convention was held in the city of Ramsar, Iran in February 1971 and was originally contracted by seven countries when it came into force on 21 December 1975. As of February 2018, there are 170 contracting parties and over 2, 000 designated sites covering over 200, 000, 000 hectares (490, 000, 000 acres). Every contracting country has at least one Ramsar site, and 31 of the contracting countries have only one site. The country with the most sites is the United Kingdom with 170. To become a Ramsar site, a site must be nominated by a contracting country, meet at least one of nine criteria, and undergo scientific review. The Convention was most recently ratified by North Korea in 2018.

A 'Wetlands Conservation Fund' was established to assist countries in implementing the objectives of the Ramsar Convention. Funding is provided only to those countries that have contracted for wetland conservation activities relating to any one of the following fields: improvement of management of Ramsar Sites, designation of new Ramsar Sites, promoting wise use of wetlands, training personnel in wetland management and organising promotional activities such as seminars, workshops, educational programmes, etc.

2.10.5 The Bonn Convention

The Convention on the Conservation of Migratory Species of Wild Animals (also known as CMS or the Bonn Convention, not to be confused with the Bonn Agreement) aims to conserve terrestrial, marine and avian migratory species throughout their range. It is an intergovernmental treaty, concluded under the aegis of the United Nations Environment Programme, associated with the conservation of wildlife and habitats on a global scale. Since the Convention's entry into force, its membership has grown steadily to include 130 Parties from Africa, Central and South America, Asia, Europe and Oceania. The Convention was signed in 1979 in Bonn (hence the name) and entered into force in 1983. Convention states that the Parties:

a. Should promote, cooperate in and support research relating to migratory species.
b. Shall endeavour to provide immediate protection for migratory species.
c. Shall endeavour to conclude AGREEMENTS covering the conservation and management of migratory species.

To date, seven Agreements have been concluded under the supports of CMS. They address:

- Populations of European Bats
- Cetaceans of the Mediterranean Sea, Black Sea and Contiguous Atlantic Area
- Small Cetaceans of the Baltic and North Seas
- Seals in the Wadden Sea
- African-Eurasian Migratory Water birds
- Albatrosses and Petrels
- Gorillas and their Habitats

Memoranda of Understanding (MOU) concluded to date aim to conserve Siberian Crane, Slender-billed Curlew, Marine Turtles of the Atlantic Coast of Africa, Marine Turtles of the Indian Ocean and South-East Asia, Middle-European Population of the Great Bustard, Bukhara Deer, Aquatic Warbler, West-African Populations of the African Elephant, Saiga Antelope, Cetaceans of Pacific Island States, Dugongs, Mediterranean Monk Seal, Ruddy-headed Goose, Grassland Birds.

In addition, the CMS Secretariat has launched an Action Plan for the *Central Asian Flyway*, one of the world's most vital routes for migratory birds, and an Action Plan for the conservation and restoration of the Sahelo-Saharan antelopes, while initiatives to develop agreements or MOU are ongoing with regard to raptors, migratory sharks, and western African aquatic mammals.

2.10.6 The World Heritage Convention

The World Heritage Convention (WHC) is one of the most important global conservation instruments created in 1972. The primary mission of the Convention is to identify and protect the world's natural and cultural heritage considered to be of Outstanding Universal Value.

It embodies a visionary idea – that some places are so important that their protection is not only the responsibility of a single nation, but is also the duty of the international community as a whole; and not only for this generation, but for all those to come. The implementation of the World Heritage Convention is facilitated through the Operational Guidelines, which define the procedures for new inscriptions, site protection, danger-listings, and the provision of international assistance under the World Heritage Fund.

The Convention is governed by the World Heritage Committee supported by the UNESCO World Heritage Centre, the secretariat for the Convention, and three technical advisory bodies to the Committee: IUCN, ICOMOS, ICCROM. IUCN is the Advisory Body on natural heritage. It monitors listed sites and evaluates sites nominated to the World Heritage List, in accordance with the relevant natural criteria for selection.

2.10.7 ITTA and ITTO

ITTA stands for *International Tropical Timber Agreement*. It came into force on 1st April 1985. The contracting parties entered into the agreement recognising the

importance of, and need for, proper and effective conservation and development of timber forests and concomitantly ensuring optimum utilisation of such forests in a sustainable manner and maintenance of ecological balance. Tropical timber reforestation and afforestation are encouraged at national and international levels and more than 66 projects and 35 pilot studies on these aspects have been approved and supported. ITTO (*International Tropical Timber Organisation*) has published guidelines for sustainable forest management of tropical forests and conservation of biodiversity in such forests (ITTO 1990, 1992, 1993, 1998a, b).

2.11 Biodiversity Information : Management and Communication

Readers have to understand that there is an urgent need for resonance between the needs of biodiversity science and scientists on the one hand, and databases on the other. Biodiversity workers live throughout the world and are all interdependent. They need information, and not just local, but regional and international as well. Moreover, biodiversity science depends critically on high level concepts on biomes, ecosystems, floras and faunas, hot spots, genetic resources, alien taxa, etc. Hence a strong effort for the collection, documentation, management and distribution of biodiversity information is needed so that effective decisions on managing bioresources can be made. Such information is also required for enacting national and international legislation and laws.

The use of biodiversity information is triggered by three principle categories of motivations:

- public policy (involves compliance with laws, rules, legislation, regulations and/or treaties),
- private sector (needed to advance commercial interests relating to breeding, ecotourism, bioprospecting involving biotechnology, etc.),
- public interest and cultural motivations (to advance the conservation and sustainable management of bioresources).

The important aspects involved here are *data collection* from the real world, *storage of data, analysis of organised and integrated data* (if necessary mathematical modelling as well) so as to obtain useful and pertinent *information*, derivation of

knowledge from such information through further analysis, interpretation and understanding and finally the attainment of wisdom (here, taking wise, proper and efficient biodiversity management initiatives and actions) through the intelligent use of knowledge.

2.11.0 Libraries

These are the main sources of information provided through collections of both published and unpublished literature and facilitating its exchange. Most libraries are regional and at best national. However, there are several international libraries. The most important among them are located at the Asian Institute of Technology, International Centre for Living Aquatic Resources Management, National Library of Agriculture (USA), The National History Museum (UK), Royal Botanic Gardens Kew and Edinburgh (UK), Smithsonian Institution (USA and Panama), IUCN, etc. All these libraries provide vital information on biodiversity.

2.11.1 Periodicals

Several periodicals contain articles on biodiversity. The names of the most important appear in Ulrich's International Periodicals Directory. ln addition, several newsletters are available. Some most important periodicals arelisted below.

- Biodiversity Letters
- Biological Conservation
- Conservation Biology
- Ecology
- Oikos
- Oecologia
- Journal of Biogeography
- Journal of Ecology
- AMBIO
- Annual Review of Ecology and Systematics
- Ecography
- Trends in Ecology and Evolution

- ❖ Biodiversity and Conservation
- ❖ Biotropica
- ❖ Biodiversity
- ❖ Threatened Plants Newsletter
- ❖ Journal of Intellectual Property Rights
- ❖ BDM Updates

2.11.2 Databases

Data refers to observations, measurements or facts referenced to some kind of accepted standard, which are subsequently integrated, processed, interpreted or otherwise manipulated to produce information. While Information is the knowledge (product) derived from the analysis and interpretation of data. Data should be stored, managed and readily made reliable for integration with other data so that information can be generated from data easily and used as and when required for whatever purpose.

All the nations of the world have now more than adequately realised their wider regional and global responsibilities regarding their biodiversity wealth and conservation as well as the pressing need to manage their biodiversity information and data generated thus far. In addition, individuals, local communities, industries, NGOs and other institutions have also realised that to make proper decisions and manage biodiversity, they need to develop databases and their own information system frameworks.

The absolute need for effective organisation, management and use of data and information on biodiversity is already reflected in many international agreements and legislation such as the CBD, CITES, etc. In response to the requirement of data management and information exchange on biodiversity, the UNEP and WCMC together designed and submitted to GEF the project proposal on “Biodiversity Data Management (BDM) capacitation in developing countries and networking biodiversity information”. The BDM is a UNEP/GEF project funded by GEF to the tune of US $4 million. This project was commenced in June 1994. The Bahamas, Egypt, Poland, Chile, Ghana, Thailand, China, Kenya, Costa Rica and Papua New Guinea were the ten countries that participated in the first phase of this project. The overall objective of BDM is to enhance the capacity building of developing countries in biodiversity data management relating to the implementation of CBD.

There are many biodiversity-related initiatives at the national level that are closely linked to the BDM project. These include Biodiversity Country Studies, National Biodiversity Strategies and Action Plans (NBSAP), National Environmental Action Plans (NEAP), National Conservation Strategies (NCS), National Sustainable Developmental Strategies, National Tropical Forest Action Plans (TFAP), etc. The BDM Newsletter 'BDM UPDATE' provides complete information on relevant issues and events.

Other Databases on Biodiversity:

Hundreds of databases on biodiversity have now been created throughout the world and some of them are listed here:

(i) IOPI World Plant Checklist

(ii) BIMS (Biodiversity Information Management System): A relational database for monitoring the conservation status of species, wildlife habitats and protected areas.

(iii) BRAHMS (Botanical Research and Herbarium Management System): A database on botanical collection system.

(iv) ENVIS (Environmental Information System, India)

(v) Abstract of Tropical Agriculture (ORBIT).

(vi) Agricola (DIMDI, Data-star/Dialog)

(vii) AGRIS International (DIMDI, Data-star/Dialog)

(viii) Biological and Agricultural Index (BRS)

(ix) BIOSIS Previews (DIMDI, Data-star/Dialog)

(x) CAB Abstracts (DIMDI, Data-star/Dialog)

Of the available databases worldwide (as of 1995 the number was 7500), 75% are related to biological sciences, of which more than 60% are bibliographic or directory type and the rest are numerical, textual, image or multimedia.

2.12 Summary

The information provided above clearly shows that that the international and national organizations are working in a connected network for the successful management of the earth's biodiversity. The government and private organizations of a country correctly follow the international laws, as well as the rules enacted in

different conventions to promote the sustainable use of the natural resources. Presently, bioinformatics revolution is fully capable of enabling biodiversity researchers to communicate efficiently with each other, thus providing a common language for progress. It was seriously felt a decade ago that both biodiversity components and accumulated knowledge about each species are in threat. But now, most of the knowledge has found place in the various types of information systems and databases (Krishnamurthy, 2003).

2.13 Questions and Answers

A. Multiple Choice Questions:

1. **Which factor is the reason for loss of genetic diversity?**

   a. Demographic uncertainty b. Habitat destruction

   c. Genetic drift d. Pollution

   Answer : c. Genetic drift

2. **If a taxon has lost 50% of its population in last 5 years, then it will be considered as-**

   a. Endangered b. Critically endangered

   c. Vulnerable d. Rare

   Answer : b. Critically endangered

3. **Match the following:**

A. Total threatened species	**(i) 57931**
B. Extinction	**(ii) 13, 136**
C. Vulnerable	**(iii) 30, 178**
D. Least concern	**(iv) 877**

   a. A(i) B(iv) C(ii) D(iii) b. A(iii) B(iv) C(ii) D(i)

   c. A(iv) B(iii) C(i) D(ii) d. A(ii) B(i) C(iv) D(iii)

   Answer : b. A(iii) B(iv) C(ii) D(i)

4. **An unnatural separation of extensive areas of habitat into spatially aggregated fragments are known as-**

   a. Habitat destruction b. Overkill

   c. Fragmentation d. Desertification

   Answer : c. Fragmentation

5. Which of the below organization associated with biodiversity management?

a. B.S.I b. IUCN c. CBD d. WHC

Answer : b. IUCN

6. Which of the following is sustainable development goals of UNEP?

a. Zero hunger b. Quality education

c. Climate action d. All of the above

Answer : d. All of the above

7. In India Plant introduction is controlled by

a. BSI b. IBPGR

c. NBPGR d. None of the above

Answer : c. NBPGR

8. Biodiversity act in India was based in

a. 1992 b. 2002 c. 2012 d. 1998

Answer : b. 2002

9. Convention on Biological diversity was adopted in

a. New Delhi, India b. Rio de Janeiro, Brazil

c. Gland, Switzerland d. Stockholm, Sweden

Answer : b. Rio de Janeiro

10. Convention for the conservation of wetland is known as-

a. Ramsar convention b. Bonn convention

c. World convention d. Convention on Biodiversity

Answer : a. Ramsar convention

11. Which of the below is a periodical related to Biodiversity?

a. Journal of Ecology b. OIKOS

c. AMBIO d. All of the above

Answer : d. All of the above

12. Which of the follow is an Indian database of Biodiversity

a. BIOSIS b. SCOPUS c. BRS d. ENVIS

Answer : d. ENVIS

B. Short answer type questions:

1. What is genetic drift?
   Answer : 2.2.0
2. Write the difference between true extinction and pseudo extinction.
   Answer : 2.3
3. What is mass extinction?
   Answer : 2.3
4. What is demographic uncertainity?
   Answer : 2.3.2
5. Define VU and EN.
   Answer : 2.3.3
6. Write the full form of IUCN and UNESCO.
   Answer : 2.9
7. What are the priority areas of IUCN?
   Answer : 2.9.0
8. Write three major activities of UNEP.
   Answer : 2.9.1
9. Write the name of a UNEP project in India.
   Answer : 2.9.1
10. Where is the headquarter of NBPGR?
    Answer : 2.9.4
11. What are the main objectives of C.B.D?
    Answer : 2.10.1
12. What is CITES?
    Answer : 2.10.2
13. Write the full form of ITTA & ITTO.
    Answer : 2.10.6

C. Long answer type questions:

1. Write reasons for loss of genetic diversity.
   Answer : 2.2.1

2. What are the processes responsible for species extinction?

   Answer : 2.3.2

3. Describe IUCN threat categories.

   Answer : 2.3.3

4. What are the factors for ecosystem degradation and loss?

   Answer : 2.4.1

5. Write a short note on any one of the following: UNEP/WWF/NBPGR.

   Answer : 2.9.1, 2.9.3, 2.9.4

6. Write the salient provisions of Biodiversity act of India.

   Answer : 2.10.5

7. Write briefly about CBD and Ramsar Convention.

   Answer : 2.10.2 & 2.10.4

8. Write a short note on databases of Biodiversity. Give the name of some significant periodicals on Biodiversity.

   Answer : 2.11.2 & 2.11.1

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Unit 3 □ Conservation of Biodiversity

Structure

3.0 Objectives

- To understand the conservation strategies for genetic, species, and ecosystem diversity.
- To the know the different categories of *in-situ, ex-situ,* and *in-vitro* conservation methods with their advantages and disadvantages.
- To provide knowledge about biodiversity awareness programmes including social approaches towards conservation (Bishnoi Movement, Chipko Movement, Narmada Bachao Andolan, Appiko Movement, Silent Valley Movement) for Biodiversity Conservation.
- To give a brief idea about key aspects and important measures for sustainable development.

3.1 Introduction

Undoubtedly, the need to save biodiversity is of utmost urgency. We all wish to retain our life-supporting system. The maintenance of species and ecosystems is a keystone to sustainable development that meets the needs of the present generation without compromising on the ability of the future generations to meet their needs. The term 'conservation' has variously been defined, but the most appropriate definition of conservation related to biodiversity is "the protection of biodiversity for sustainable utilisation". This may be confused with 'preservation', but the term 'preservation' implies the protection of biodiversity from any kind of human activity or interference. According to IUCN (1980), 'conservation is positive embracing preservation, maintenance, sustainable utilisation, restoration and enhancement of the natural environment'. Thus, conservation implies the management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations, while maintaining its potential to meet the needs and aspirations of future generations. Hence, if we do not conserve our biodiversity, we may lose a bit direct or indirect values of biodiversity which have already been known to us or are yet to be revealed. As biodiversity has been categorised into three levels – genes, species, and ecosystems, hence the conservation of biodiversity can be managed at three levels. Maintenance of both genetic diversity

and ecosystem diversity imply conservation of species. In addition, loss of species diversity is more observable as well as quantifiable than that of genetic and ecosystem diversity loss. As conservation of species diversity will ensure both ecosystem maintenance and genetic maintenance, hence species is the fundamental member in conservation of biodiversity conceptually, biologically and legally.

Aims for Conservation

(i) To create viable population in order to avoid extinction of rare and endangered species.

(ii) To maintain all the genetic diversity within the populations, thus enhancing their ability to undergo adaptive changes leading to speciation.

(iii) To preserve ecosystem processes such as primary and secondary productivity, energy flow, nutrients flow, water balance, soil conservation, etc. These are found to be the effective way of conserving both genetic and species diversities.

3.2 Conservation of Genetic Diversity

Genetic conservation strategies should be planned and performed at the population level as the unit for genetic conservation is basically a population of a species. Therefore, population seems to be the most reasonable level at which genetic conservation can be attempted. The reasons are as follows:

(i) The population, and not the species, is the ecologically and evolutionarily significant (i.e. functional) unit (ESU).

(ii) Genetic changes take place in the population over generations.

(iii) Local adaptive changes likewise occur in the population.

(iv) Geographically and genetically isolated populations offer the greatest potential for speciation.

(v) Conservation at the species level will overlook the dynamics and attributes of individual populations within it as well as their ecological functions.

(vi) Lastly, conservation at a level below the population, say at the allelic level, on the other hand, is impractical.

All genetic conservation strategies and actions should be compatible with the three aims of conservation mentioned in the above paragraph. The first level of concern has a time-scale of a few days to a few decades and if not met, the other two goals are automatically denied. Maintenance of genetic diversity must also be planned in such a way that the population and species are able to genetically adapt and evolve in an unhindered manner. This second level of concern has a time-scale of several decades to millennia. The third level of concern, the capacity for continuing speciation, is considered the creative part of biodiversity, just as extinction is the annihilating part. The potential of a population (thereby the species) for continuing speciation is to be maintained at any cost and should be the ultimate goal of conservation, although its time-scale, tens of thousands or more years, makes appreciation of it difficult for humans. In any case, mere short-term conservation goals should be discouraged in the interest of biodiversity.

Genetic conservation has its own limitations; it will not be the saviour of biodiversity. Application of genetics to conservation is a very young science still in the developmental stage; several aspects have yet to be understood and such limitations impel a realistic approach. Many genetic techniques useful in assessing genetic diversity are not cheap, are not easily learned and can be misused or misapplied; the techniques require experience, expertise and sophistication.

3.3 Conservation of Species Diversity

Species is the main subject for conservation both conceptually and legally. Many legislations and conventions on conservation at the world and national levels are focused on species. These include, for instance, CITES, Endangered Species Act of USA (ESA) etc. Loss of species diversity is also very obvious and more easily detectable and quantifiable than either loss of genetic or habitat diversity. Even conservation approaches based on habitats or ecosystems depend on an intimate understanding of the biology of their constituent species. The design and management of bioreserves are also often based on a knowledge of species-area relationships, life-history requirements of the species that are more focused for conservation in such reserves and the minimum of individuals of a species necessary to avoid major loss of genetic diversity.

3.3.0 Type of species to be conserved

The first category of species: In this category, the priority should be given to the threatened species (i.e., critically endangered, endangered and vulnerable species) following the International Union for Conservation of Nature and Natural Resources IUCN) Red list of Threatened species (also known as the IUCN Red List or Red Data List). Given (1984) proposed the several highly prioritised data for selection of threatened species to be conserved.

The second category of species: In this category, the directly harvested plants which are sources of propagating materials for planting elsewhere or such plants showing genetic variation useful for breeding programme are selected. These include medicinal plants, food and storage plants, dye yielding plants, spices, ornamentals, etc.

The third category of species: This category includes Keystone species, Umbrella species, Flagship species, etc.

(i) Keystone species: A species having impacts on many others, often far beyond what might have been expected from a consideration of their biomass or abundance (Simberloff, 1998). They are usually top predators or engineered species. A keystone species which plays its role in an ecosystem is analogous to the role of a keystone in an arch. Like the keystone in an arch, keystone species holds the ecosystem together and if it is removed, the structure it holds up will subside. The concept of keystone species was developed by Robert T Paine (1966). He described the role of keystone species in Mukkaw Bay in Washington. The keystone species e.g. sea stars (*Pisaster ochraceus*) eat mussels that have no other natural predators and keep their number in check. If the sea star is removed from the ecosystem, the mussel population will increase uncontrollably, driving out other species and as a result the number of other species will decline drastically.

Examples of other Keystone species:

(a) Caribbean Ivory tree coral (*Oculina varicosa*): 300 invertebrate species make this coral home. Many small-fishes live and breed here and become food for larger fishes.

(b) Sugar maple (*Acer saccharum*): It is a keystone species of hardwood forest that brings water from lower levels in the ground, thus helping other plants to grow there. It also provides shelter to many insects, birds and small animals.

(c) Elephant: One species of elephant (*Loxodonta africana*) native to Africa has two sub-species: the savanna or bush elephant (*L. africana* var. *africana*) and the forest elephant (*L. africana* var. *cyclotis*). They differ to some extent in form and size. The forest elephant is shorter, smaller with rounded ears, flattened forehead, longer and thinner tusks than the savanna subspecies. Forest elephant subspecies is keystone species in some woodlands in Western Africa. ln these forests, elephants are the only animal large enough to break larger fruits with thick shells, and also many other smaller hard fruits. The nutlike pits inside these seeds pass through the elephant's intestine and are subsequently deposited with the animal's dung that provides a rich source of nutrients. The seeds germinate and continue to grow. Thus, more than 30% of the larger tree species in these forests depend on elephant for their seed dispersal and germination.

The savanna elephant eats small trees and preserve the grassland. The grasses need open space so that they may get plenty of sun light for their survival. If elephants were not there, the savanna would convert to a forest.

(ii) Umbrella species: The term was first coined by Bruce A. Wilcox in 1984 who defined umbrella species as "one whose minimum area requirements are at least as comprehensive as the rest of the community for which protection is sought through the establishment and management of a protected area." According to Heywood (1995) "umbrella species are those whose occupancy area or home range are large enough and whose habitat requirements are wide enough that, if they are given a sufficient large area for their protection will bring other species under that protection" (Fig. 3.0). Thus, umbrella species are species selected for making conservation, typically because protecting these species indirectly protects the many other species within the ecosystem.

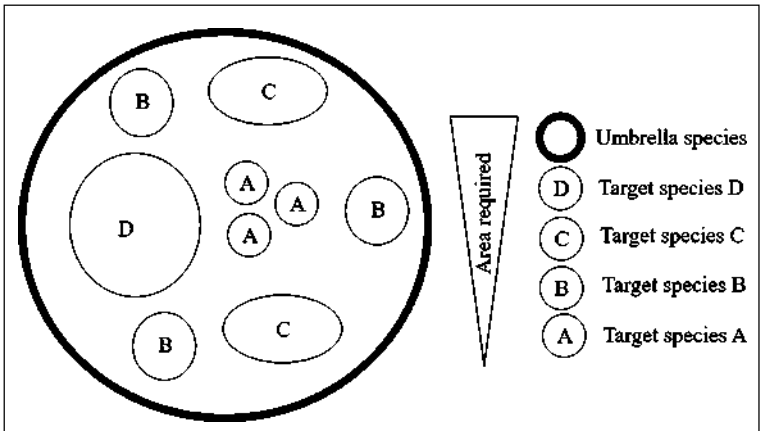

Fig. 3.0: Concept of umbrella species

Examples of Umbrella species: The reserves in Klamath-siskiyou forests of Northern California, set aside for the northern spotted owl, also protect molluscs and salamanders within that habitat. Thus, northern spotted owl and old growth trees are the umbrella species and molluscs and salamanders are within the protective boundaries of the northern spotted owl.

Tiger in India and elsewhere is served as an umbrella species. Project tiger was launched to save the tiger and thereby its habitat and thus other species are also protected within the protective boundaries of the tiger.

(iii) Flagship species: A flagship species is a plant or animal species which is used to represent a certain environmental issue or cause. According to Simberloff (1998), "a flagship species is a species that has become a symbol and leading element of an entire conservation campaign." A flagship species is selected in conservation campaign because of its attractiveness or because it has unique features. For examples, the polar bear above the ice berg is used as a flagship species to generate awareness about global warming.

(iv) Indicator species: These species are known to be particularly sensitive to pollutants, human interference, ecological instability or other disturbances.

(v) Charismatic species: These species are significant from social, cultural or anthropomorphic standpoints, and/ or usually attractive.

(vi) Recreational species: These species are popular for collection, growing or observation.

Once the species are identified for protection, conservation strategies can be worked out for them either through *in-situ* or *ex-situ* methods or through a judicious combination of both. Species-based approach has resulted in identification, at the national and international levels, of taxa that need conservation and which are then listed by IUCN or national agencies in Red Data Books or detailed in the IUCN Species Survival Commission (SSC).

3.4 Conservation of Ecosystem Diversity

Conservation of Ecosystem have been suggested by some researcher in place of genetic or species-based approaches. This method attempts to ensure that representative areas of ecosystems or important habitat sites are maintained through a network of

protected areas or through other controls on land use. A decision on which habitat should be selected for conservation is dictated by criteria such as species richness and degree of endemism (hot spots). Conservation potential / Threat Index (based on ecosystems), forecasts how current deforestation rates would affect the conservation and establishment of protected areas. Initially this approach was tested in 23 Indo-pacific countries and subsequently was adapted for the Indo-Pacific region and Latin America and West Indies.

Advantages:

(i) It is argued that if ecosystems are allowed to be kept intact and materials and energy flow unhindered through the ecosystem, then conservation of species and genetic diversity is automatically done.

(ii) Ecosystem diversity conservation is the cheapest and most effective way of conserving both genetic and species diversities.

(iii) It requires no detailed knowledge of the status and distribution of its constituent species. This method is particularly useful for conserving the tropical rain forest ecosystems, whose species diversity has not yet been adequately studied or quantified.

Disadvantages:

(i) There are no planned satisfactory habitat or ecosystem classification on which the protected area networks will depend.

(ii) Another problem is that populations of threatened species which need urgent conservation steps are likely not be included in a network of protected areas.

(iii) A third problem is that many ecosystems of the world are poorly known and understood. Also, the size, composition and complexity of an ecosystem can vary considerably in time and space.

Attempts to reconcile both species- and ecosystem-based approaches are the needs of the time. It is better to identify areas or ecosystems of high diversity, especially in threatened species, and undertake efforts to conserve such areas.

3.5 Types of Conservation of Biodiversity

Conservation can be defined as management of earth's resources such as biodiversity in a way that restores and maintains the balance between human

requirements and the other species of our Mother Earth. In other way, conservation is the protection of biodiversity for sustainable utilization. Conservation can broadly be categorised into three types:

(a) *In-situ* or on-site conservation: It is the conservation of habitat, species and ecosystems in their natural habitats. ln this type of conservation, the natural processes and interactions are conserved as well as the elements of biodiversity are protected, e.g. Biosphere reserves, National parks, Wild life sanctuaries, etc.

(b) *Ex-situ* or off-site conservation: It is the conservation of elements of biodiversity out of their natural habitats, e.g. Botanic gardens, Zoological gardens, seed banks, pollen banks, etc.

(c) *In-vitro* conservation: It is the conservation of germplasms through micropropagation or storage of seeds, embryos, buds, meristem, etc.

These three types of conservation have two aims:

(i) to maintain economic production;

(ii) to replant the ecosystem with local sources of seeds/ propagules.

3.5.0 *In-situ* conservation

It involves the conservation of species, ecosystem in their natural habitat where both wild and domesticated taxa can be conserved through a network of protected areas. According to the IUCN guidelines for Protected Area Management Categories, a protected area can be defined as “an area of land and/or sea specially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means”.

3.5.0.0 Categories of Nature Reserve

There are various types of protected areas with different degrees of protection and purposes. According to IUCN categories (2006), there are 6550 National parks and about 40,000 smaller protected areas. The various categories of Nature Reserves are mentioned below:

1. **Category Ia - Strict Nature Reserve:** These are often home to dense native ecosystems that are protected from human disturbance outside of scientific study, environmental monitoring and education. In some cases they are of spiritual significance for local communities.

2. **Category Ib - Wilderness Area:** In this category, the areas are generally larger and are protected in a slightly less stringent manner than that of strict nature reserves. Human visitation is limited, often allowing such persons who are willing to travel of their own devices, either by foot, or by ski or by boat. The Serengeti National Park of Tanzania is an example of Wilderness Area.
3. **Category II - National Park:** It displays similar characteristics to that of Wilderness Areas with reference to size. The main purpose of this category is to protect functioning ecosystems. Human visitation is more lenient than that of strict nature reserve and wilderness areas. National parks are managed in such a way that they contribute to local economics through promoting educational and recreational tourism.
4. **Category III - Natural Monument or Feature:** This denotes comparatively smaller areas that are specifically assigned to protect a natural monument and its surrounding habitat. The protected area of this category encompasses natural geological or geomorphological features, culturally-influenced natural features, natural cultural sites, etc.
5. **Category IV - Habitat/Species Management Area:** This concentrates on more specific areas of conservation, with regard to an identifiable species or habitat which needs continuous protection rather than that of a natural feature. Habitat or species management areas may be present as a fraction of a wider protected area which needs varying levels of active protection such as prevention of poaching, creation of artificial habitats, halting natural succession, supplementary feeding practices, etc. For example, Galapagos is managed under this category to preserve the island's native flora and fauna.
6. **Category V - Protected landscape/Seascape:** In this category, the area covers entire bodies of land and ocean with a clearer management plan relevance to nature conservation, but is more likely to include a range of for-profit activities. The basic principle is to protect regions that have built up a distinct character in view of their ecological, biological, cultural or scenic value.
7. **Category VI - Protected Area with sustainable use of natural resources:** This category may be principally suitable to huge areas that already have a low level of human activities in which local communities and their traditional

practices have had little permanent influence on the environmental condition of the region.

3.5.0.1 Biosphere Reserves and National Park

Objectives:

There are four primary objectives for preservation of Nature Reserves:

1. To preserve large and functioning ecosystems with an objective of providing adequate conditions to the resources so that the ecosystems will be sustained for a long time.
2. To preserve biodiversity with an objective of conserving maximum possible number of species.
3. To protect those species which are especially threatened.
4. To perpetuate plants for continuing and sustainable harvest.

McNeely *et al.* (1987) also added some other objectives of Nature Reserves in addition to the above four goals:

(i) To maintain and promote genetic diversity.
(ii) To manage wild life.
(iii) To conserve soil and water.
(iv) To protect social and cultural heritage.
(v) To serve the requirements of education and research.
(vi) To serve as sites of recreation and tourism.
(vii) To maintain scenic beauty and aesthetic integrity.
(viii) To promote integrated development within the reserve and between the reserves.
(ix) To promote options for the future.

Design of Biosphere Reserves/National Park:

According to Given (1996) six important issues are to be seriously considered while designing a Nature Reserve and these are very crucial to the success of Nature Reserve. These include:

(i) Reserve size
(ii) Spatial and temporal heterogeneity and dynamics

(iii) Ideal geographic context

(iv) Connection of different reserves

(v) Natural landscape elements

(vi) Creation of zones within a Reserve

(i) Reserve size: The reserves should be large enough so that they can cater viable population of species, and ecosystem functions in a sustainable way. Large reserves have no edge effects; hence they can minimize the impact of external factors and also can accommodate disturbances in a much better way. A global survey showed that 76% of World's significant Nature Reserves are less than 100,000 ha in size area and only 3.5% exceeded a million hectare.

(ii) Spatial and temporal heterogeneity and dynamics: The nature is dynamic and changes over time, hence heterogenous reserves are better than homogenous ones. The spatially heterogenous reserves better accommodate the biotic and abiotic disturbances which also promote the occurrence of metapopulations of a species.

(iii) Ideal geographic context: The context refers to the shape and location of the reserves. There are guidelines for setting up a reserve. The context of the reserve must be considered individually for every potential reserve. The shape of the reserve is predetermined if it includes natural features like lake, riverbank or mountain top. If the shape is not predetermined, the best shape is circular, because it is compact and has the smallest amount of edge effect. Generally, one large and several small areas are better than one large area.

(iv) Connections of different reserves: Reserves are made contiguous through corridors, i.e. strips of areas similar to reserves that connect two or more reserves for maintaining overall integrity of the physical environment. The corridors allow easy movement of species and become species rich as high proportion of species from both communities inhabit or utilize the area. The corridors also help to reduce erosion and increase aesthetic value of landscape.

(v) Natural landscape element: These include valleys, ridges, slopes, canyons, drainage basins, streams, etc. The various diversities of landscape enhance the value of a reserve. Any modification of natural landscape elements makes the reserve inferior.

(vi) Creation of zones within a reserve: Any Nature Reserve should have three district zones namely, a central core zone, buffer zone and manipulation or transition zone (Fig. 3.1).

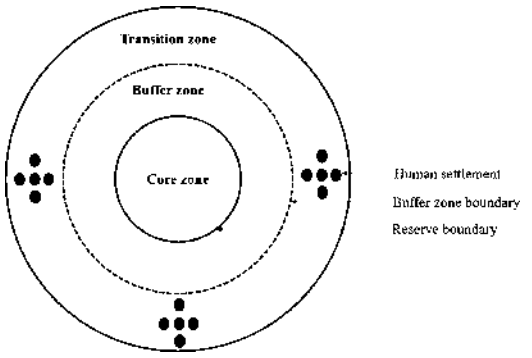

Fig. 3.1. Zones of biosphere reserve

(a) Core zone: It comprises of legally protected ecosystem with suitable habitats and landscape elements where no human activity is allowed.

(b) Buffer zone: Next to the core zone, a buffer zone is created which helps to absorb edge effects such as changes in temperature, relative humidity and light; more exposure to wind; increased leaf fall; decrease population size of the species; elevated levels of tree mortality etc. ln this zone, limited human activity is permitted. There are different kinds of buffer zones, of which 'extension buffering' and 'socio-buffering' are important types. Extension buffering (Fig. 3.2):

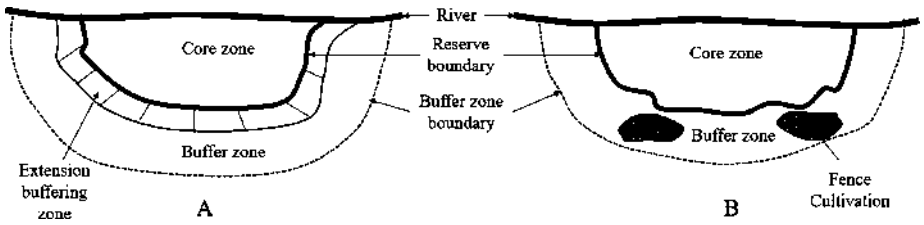

Fig. 3.2. A. Extension buffering, B. Socio-buffering

It extends habitats of the core area into the buffer zone so that much larger populations, especially of extremely rare species can be survived. Socio-buffering (Fig. 3.2): It permits several human activities like production of crops, harvesting of bioresources, so that the traditional use of bioresources of core area by the people native to the reserve can be minimized.

(c) Manipulation or Transition zone: It is the peripheral zone of the reserve where several human activities can occur such as settlement, cropping, forestry, recreation, etc.

A total of 18 biosphere Reserves have been designated by the Ministry of Environment and Forests, India on August 25, 2011 (Table 3.0). Ten Indian popular National parks and sanctuaries have been given in Table 3.1.

Table 3.0 Biosphere reserves of India (according to the year of establishment)

Sl. No.	Establi-shment	Name of Reserve	Location	State	Type of reserve	Key Fauna	Total Area (km^2)
1*	1986	Nilgiri Biosphere Reserve	Part of Waynad, Nagarhole, Bandipur and Mudumalai, Nilambur, Silent Valley, and Siruvani Hills	Tamil Nadu, Kerala, and Karnataka	Western Ghats	Nilgiri Tahr, Liontailed Macaque	5520
2*	1988	Nanda Devi	Part of Chamoli District, Pithoragarh District and Bageshwar District	Uttarakhand	Western Himalayas	Snow Leopard, Himalayan Black Bear	5860
3*	1988	Nokrek	Part of Garo Hills	Meghalaya	N.E. Himalayas	Red Panda	820
4*	1989	Gulf of Mannar	Indian part of Gulf of Mannar extending from Rameswaram island in the North to Kanyakumari in the South of Tamil Nadu	Tamil Nadu	Coasts	Dugong or Sea Cow	10500
5*	1989	Sundarbans	Part of delta of Ganges and Brahmaputra river system	West Bengal	Gangetic Delta	Royal Bengal Tiger	9630
6	1989	Manas	Part of Kokrajhar, Bongaigaon, Barpeta, Nalbari, Kamrup and Darrang Districts	Assam	N.E. Himalayas	Golden Langur, Red Panda	2837
7*	1989	Great Nicobar Biosphere Reserve	Southern most islands of Andaman and Nicobar Islands	Andaman and Nicobar Islands	Islands	Saltwater Crocodile	885
8*	1994	Simlipal	Part of Mayurbhanj district	Odisha	Deccan Peninsula	Gaur, Royal Bengal Tiger, Wild Elephant	4374
9	1997	Dibru-Saikhowa	Part of Dibrugarh and Tinsukia Districts	Assam	N.E. Himalayas	Golden Langur	765
10	1998	Dihang-Dibang	Part of Siang and Dibang Valley	Arunachal Pradesh	North East Himalayas	Mishmi Takin, Red Goral, Musk Deer, Red Panda	5112

Table 3.0 ***Contd.***

Sl. No.	Establi-shment	Name of Reserve	Location	State	Type of reserve	Key Fauna	Total Area (km^2)
11*	1999	Panchmarhi Biosphere Reserve	Parts of Betul District, Hoshangabad District and Chhindwara District	Madhya Pradesh	Semi-Arid Flying Squirrel	Giant Squirrel,	4981.72
12	2000	Khangchend-zonga	Parts of Kanchanjunga Hills	Sikkim	N.E. Himalayas	Snow Leopards, Red Panda	2620
13	2001	Agasthyamalai Biosphere Reserve	Neyyar, Peppara and Shenduruny Wildlife Sanctuary and their adjoining areas	Kerala, Tamil Nadu	Western Ghats	Nilgiri Tahr, Elephants	1828
14*	2005	Achanakamar Amarkantak	Part of Annupur, Dindori and Bilaspur districts	Madhya Pradesh, Chhattisgarh	Maikala Range	4-horned Antilope, ndian Wild Dog, ISarus Crane	3835
15	2008	Great Rann of Kutch	Part of Kutch, Rajkot, Surendranagar and Patan Districts	Gujarat	Desert	Indian Wild Ass	12454
16	2009	Cold Desert	Pin Valley National Park and surroundings; Chandratal and Sarchu and Kibber Wildlife Sanctuary	Himachal Pradesh	Western Himalayas	Snow Leopard	7770
17	2010	Seshachalam Hills	Seshachalam Hill Ranges covering parts of Chittoor and Kadapa Districts	Andhra Pradesh	Eastern Ghats	Slender Loris	4756
18	2011	Panna	Part of Panna and Chattarpur Districts	Madhya Pradesh	Catchment area of the Ken River	Tiger, Chinkara, Chital, Sambhar and Sloth bear	543

* 9 of the 18 biosphere reserves are a part of the world network of Biosphere Reserve based on UNESCO Man & Biosphere Reserve Programme List

Table 3.1 Popular National park and Sanctuaries of India

Name	Location
Corbett National Park	Uttar Pradesh
Kanha National Park	Madhya Pradesh
Gir National Park	Gujarat
Sultanpur Lake Bird Sanctuary	Haryana
Dachigam Sanctuary	Jammu and Kashmir
Simlipal	Orissa
Desert National Park	Rajasthan
Annamalai	Tamil Nadu
Bandipur National Park	Karnataka
Bir Molibagh Sanctuary	Punjab

3.5.0.2 On-farm Conservation

On-farm conservation is an important type of *in-situ* conservation for maintenance of traditional crop varieties by farmers. The local crop varieties maintained 'on-farm' are called landraces which have developed over time by adaptation to the natural and cultural environment in which they live. Landraces are genetically and physically more diverse than formal breeds. The term 'traditional variety' is often applied to plant landraces. Though landrace populations are morphologically highly variable, but they are each identifiable and have certain genetic integrity. Thus, farmers often give them local names. A landrace has particular properties and each has a reputation for adaptation to particular soil type. All components of landrace population are adapted to local climatic condition, cultural practices and disease and pests (Harlan, 1975).

Landraces are not only derived from ancestral stock, but modern plant cultivars can also quickly produce new landraces through undirected breeding. On-farming conservation ensures the protection and preservation of ancient landraces and wild species for prosperity.

3.5.0.3 Home Garden Conservation

Home Garden Conservation involves the smaller-scale conservation of plants grown in home, kitchen or back yard gardens. Generally, vegetables, fruit plants or

ornamental plants are grown in home garden. This method often provides conservation of indigenous germplasm in the form of landraces, obsolete cultivars and rare species. Several reports on Home Garden Conservation of landraces are available. Hawkes (1983) reported 45 cultivated species and 25 wild medicinal plants that are conserved in gardens of a village in Central Java. Alcorn (1984) reported that the Huastec Indians in Mexico maintain several home gardens where 300 species are grown. In Cuba, farmers manage several larger gardens called *Conucos*, which form the place for local cultivars of crops.

Advantages of *in situ* conservation

1. It allows easy conservation of a diverse range of wild relatives.
2. There is a possibility of multiple target taxa within a single reserve.
3. It provides easy access for genetic and evolutionary studies.
4. It is an appropriate method for conservation of recalcitrant species.
5. It is a dynamic conservation method in relation to environmental changes, pests and diseases.

Disadvantages of *in situ* conservation

1. In this method, materials are not easily available for utilization.
2. It requires high level of active supervision and monitoring.
3. A limited genetic diversity can be conserved in any one reserve.
4. An appropriate management regime remains poorly understood for some species.
5. This type of conservation is vulnerable to natural and man-directed disasters, e.g., climate change, fire, vandalism, urban development and air pollution.

3.5.1 *Ex-situ* Conservation

Ex-situ conservation can be followed for both wild plants and domesticated crops. While the first section under this heading is concerned mainly with domesticated crops, all subsequent sections are applicable to both wild and domesticated taxa.

3.5.1.0 Germplasm collections

It refers to the collection of domesticated taxa and their relatives in the form of plants, seeds, tubers and other propagules through *in vivo* method or in the form of

single cells to parts of whole plants through *in vitro* method. In this technique, assemblages of genotypes or populations are maintained as research materials for plant breeders, taxonomists, evolutionists, etc. The first systematic seed germplasm collections were made from all over the world by Nicolai Vavilov-a Russian geneticist and botanist in 1920s and 1930s through botanic-agronomic expeditions. He set up one of the first seed banks in Leningrad (now St. Petersburg) which is now known as "the Vavilov Institute of Plant Industry". Inspired by the concept of Vavilov, several seed bank projects have been undertaken and as a result there are now about 6.2 million accessions or samples of 80 different crop plants stored in 750 gene banks and related facilities in 131 countries (Food and Agricultural Organisation, 2010). The "Millennium Seed Bank Project" is the largest seed bank (100 times bigger than "Svalbard Global Seed Vault") established at the Welcome Trust Millennium Building, in the grounds of Wakehurst place in West Sussex near London. The aim of this centre is to store every plant species possible, of which l0% collection have already been done in 2009, and hopefully next 25% collection to be achieved by 2020. This centre also distributes seeds to other key locations around the world.

The "Svalbard Global Seed Vault" (was made inside a Sandstone mountain in a tunnel on frozen Norwegian island of Spitzbergen–about 1370 km from North pole, which is operated by the 'Global Crop Diversity Trust'. The permanent frost in the area keeps the vault below the freezing point of water and the one-meter thick steel-reinforced concrete walled seed containers make the area resistant against all sorts of catastrophes such as nuclear war and world war. The seed bank has also been established in the Australian Botanic Gardens, Mount Annan in collaboration with the Millennium seed bank since 2003 for conservation of native Australian flora, especially the threatened species.

In India, seed banks were created to store native varieties of seed after the 'Beej Bachao Andolan' (means, save the Seeds Movement) started in the late 1980s in Uttarakhand, led by Vijay Jardhari. Other important seed banks in the world are the United States National Seed Storage Laboratory at Fort Collins, Colorado; The Izmir Centre, Turkey; The Royal Botanic Gardens, Kew, U.K.; The Iberian Gene Bank, Madrid, Spain, etc.

3.5.1.1. Botanic Gardens

Although a satisfactory definition is still wanting, a botanic garden can be broadly defined as a place of collection of living plants grown for educational, recreational, economic, medicinal or scientific purposes. A botanic garden is the most important form of *ex-situ* conservation. The most widely known function of botanic gardens is to assemble and maintain a diversity of plant species in the open or in greenhouses for reference and study. Botanic gardens conduct or facilitate research in diverse aspects of plant science, especially in taxonomy. There are more than 1600 Botanic Gardens and Arboreta throughout the world and these receive over l50 million visitors a year. Many of thesegardens have seed bank facilities. Some of the plant species that disappeared from the wild or is survived by a single population are preserved in Botanic Gardens through ex-situ conservation. The Botanic Gardens Conservation Institute (BCCI) was set up in 1987 tor collection and making available information on plant conservation. Some of the plants that are preserved in different Botanic Gardens are mentioned below:

Tambourissa tetragonia earlier survived by two specimens are now propagated through tissue culture technique in Kew Botanic Gardens, U.K. *Limonium tuberculatum* was disappeared from the wild which is now survived by a dozen population in the Botanic Carden of Canary island, Spain. Similarly, a few populations of *Ramosmania heterophylla* are maintained in the Botanic Garden of Mauritius. Endangered plants in the wild such as *Ginkgo biloba, Franklinia alatamaha, Encephalartos woodii, Swietenia humilis, Dracaena draco* and others have been perpetuated in this manner.

There are many kinds of botanic gardens and arboreta:

(i) traditional, state supported gardens, with associated herbarium and laboratories (e.g. Acharya Jagadish Chandra Bose Indian Botanic Garden, Berlin Botanic Garden, Kew Botanic Garden);

(ii) municipal or civic supported, sometimes with associated herbarium and laboratories, normally open to the public (e.g. Gothenberg, Glasgow, Nantes);

(iii) university gardens with an associated herbarium and laboratories, usually open to the public (e.g. Calcutta university Garden, Cambridge, Berkeley, Hamburg, Montpellier);

(iv) private, often with some state support, with an associated herbarium and laboratories, invariably open to public (e.g. Missouri Botanical Garden, Fairchild Tropical garden at Miami);

(v) private, without state support, usually lacking a herbarium or laboratory (e.g. Les Cedres, Maurimurta);

(vi) Government/State arboreta with an associated herbarium and laboratories: (e.g. US National Arboretum) or without herbarium (e.g. Westonbirt);

(vii) university arboreta with an associated herbarium and laboratories (e.g. Arnold Arboretum);

(viii) private arboreta, with or without herbarium or laboratories (e.g. Hilliers, Morton arboretum, Bickelhaupt);

(ix) botanical-zoological gardens/parks (e.g. Hongkong, Wilhelma Stuttgart);

(x) agrobotanical gardens (e.g. Botanical garden of the Agri-Horticultural society of India, Godollo arboretum, Hungary).

3.5.1.2. Seed Banks

Seed bank is the most effective method of *ex-situ* conservation for reproductively propagated plants. Seed banks allow the storage of genetic diversity of whole plant populations. A seed bank can be defined as a collection of seeds stored in a viable state for planting in case seed reserves elsewhere are destroyed. It is a type of gene bank. Seeds are shed from the plants and are deposited on the floor of forest soil year after year. Hence soil is considered to be the natural seed or gene bank, where majority of seeds germinate to produce new plants. Thus, conservation of seed germplasm is one of the best methods of *ex-situ* conservation.

Seeds can be categorised into two types based on their retention of viability in storage.

(i) Orthodox or Conventional or Desiccation tolerant seeds: This type of seeds can be stored in a seed bank for a long time without substantial loss of vitality and without genetic change. According to Roberts (1975) orthodox seeds can be defined as “Seeds for which the viability period increases in a logarithmic manner as one reduces the storage temperature and the moisture content of the same”. Most of the orthodox seeds are either from tropical pioneer species where dormancy is enforced

by hot and dry climate or temperate species where dormancy is enforced by cold winters.

Seeds may be viable for thousands of years. One notable example of a long-lived orthodox seed that has grown into a viable plant in 2005 was a Judean date Palm seed (cultivar of *Phoenix dactylifera*) about 2000 years old, excavated from Herod the Great's palace in Israel. In 2012, Russian scientists had regenerated *Silene stenophylla* plant from a 32,000-year-old seed collected from a burrow 124 feet under Siberian permafrost along with 800,000 other seeds.

(ii) Recalcitrant Seeds or Unorthodox Seeds: Seeds that do not survive drying and freezing (temperature less than 10°C) during *ex-situ* conservation are called recalcitrant seeds. Thus, recalcitrant seeds cannot be stored for long period, because they will lose their viability. The common examples of such plants that produce recalcitrant seeds are mango/ Jackfruit, avocado, citrus, coffee, tea, cocoa, coconut, rubber, maple, oak, cinnamon, chestnut, etc. Most climax species produce recalcitrant seeds. About 20% of the World's total plants produce recalcitrant seeds which have no natural dormancy and cannot survive if not allowed to germinate immediately.

The recalcitrant seeds have a moisture content of 12 to 31% and any reduction in moisture content renders them non-viable. A decrease in moisture content of recalcitrant seeds infringes viability and so must be continuously replanted to replenish seed stocks.

Maintenance of Seed banks: Preservation of the orthodox seed for future use is a long process, it involves: Cleaning, X-ray analysis, Drying, Packaging and storage, and Germination monitoring.

- **Cleaning**: Cleaned seeds are collected from the field. Even in some instance's seeds are collected still they are in fruits, and seeds must be taken from the fruit undamaged. This reduced bulk and disease risk. Seeds are often liberated from fruits by hand.
- **X-ray analysis:** A few seeds are taken at random and treated with X-ray. This is done to check how many seeds are empty and how many insect larvae hiding in the seeds. The X-ray treated seeds are thrown away afterwards as they may be genetically damaged. Hence, this method will help to determine the percentage of viable seeds.

- **Drying, packaging and storage:** Drying and freezing of seeds often increases the time that the seeds will remain viable. There are three different methods of seed storage.

(i) Short-term storage: It is a general practice for common farmers. ln this technique, seeds are stored for one to few years by sun drying and are kept in sealed containers at 5°C temperature or at room temperature.

(ii) Mid-term storage: In this technique, orthodox seeds can be stored for 5 to 25 years at 0 to 5°C and their moisture content must be between 2 to 5%. The seeds are preserved in airtight sealed containers. According to FAO (1975) the recommended conditions for medium-term seed storage are 1-6°C.

(iii) Long-term storage: According to FAO (1975) the recommended temperatures for seed storage are -18°C or less and seed moisture contents must be 2-5%. Seeds can be stored for very long periods at sub-zero temperature, if previously dried to 5 to 8% moisture content. Even orthodox seeds can be stored up to 100 and more years if stored at -10° to -20°C temperature. The storage of seeds in liquid nitrogen (-196°C) give better and problem free results. The life of the seeds will be doubled in every 5°C drop in temperature. Similarly, the life of seeds will be doubled with each 17° decrease in water content. If these two factors are judiciously reduced there will be several fold increase in seed life span. Koopowitz and Kaye (1990) have shown that when temperature drops by 5°C and water content decreases by 1%, the seed lives become four times longer.

- **Germination monitoring:** A few seeds at random are tested for viability once they have been frozen. If seeds do not germinate, they are either dead or dormant. Generally, Tetrazolium test is performed to distinguish between dead and dormant seeds. A few seeds are tested every five to ten years to check germination.

3.5.1.3 'Test tube' Gene Banks

This is the place where germplasms of vegetative propagules such as tubers, bulbs, corms, rhizomes, roots, tree cuttings, etc., of vegetatively propagated plants are conserved. Many plants especially short-lived shrubs or trees do not produce seeds and thus propagated vegetatively from propagules. These plants are conserved

in an appropriate place through the maintenance of their propagules under proper environments.

3.5.1.4 Field Gene Banks

This is a method of planting plant species for the *ex-situ* conservation of genes. In this method germplasm of important crops are conserved so that the gene banks provide valuable crop plants for various purposes such as breeding, reintroduction and research. More land area, adequate soil and appropriate weather are the basic requirements for field gene banks. It is useful in conservation of perennial species, so it has greatest importance in agriculture and forestry. The International Bureau of Plant Genetic Resources (IBPGR), Rome has initially established 23 field gene banks for germplasms of domesticated and wild relatives of domesticated crops. At present 50 institutions are involved in IBPGR's activity and more than 100 species are being conserved globally in field gene banks. In this method, 42,000 varieties of rice have been conserved in the Central Rice Research Institute of Cuttack, Orissa. According to IBPGR (1991), there are five operational procedures for characterization and documentation of germplasm resources in a field gene bank. These include:

(i) Establishing the origin of the plant materials,

(ii) Characterization of mature plants,

(iii) Preliminary Evaluation of development of plants and their character expression,

(iv) Further Evaluation on the mechanism of reactions in plants against physical stress, pathogen and predators,

(v) Management Data on handling of genetic resource, its distribution, regeneration and maintenance.

3.5.1.5 DNA Banks

A DNA bank is a 'gene library' where samples of DNA extract are stored and maintained. The DNA samples are categorised into three types: (i) DNA libraries, (ii) total genomic DNA, and (iii) individual cloned DNA fragments. Several international network of DNA banks have been established for conservation of DNA. The National Institute of Agrobiological Sciences (NIAS) DNA Bank was set up in 1994 as a Section of Ministry of Agriculture, Forestry and Fisheries (MAFF) Genebank System. The major role of this DNA Bank is to collect and distribute DNA materials derived

from agricultural organisms-both plants and animals. It also gives support to the scientific community. The DNA Bank provides right to use all genomic data originated from the rice, animal and silkworm genome project and also collects and administers all publicly available nucleotide and amino acid sequence data. The various homology search system such as BLAST, FASTA, WAIS, SRS, etc., with available databases have been created to make easy to analysis of sequence information.

The DNA Bank network was set up in 2007 by the initiation of Global Biodiversity Information Facility (GBIF), Germany. It offers a worldwide network of DNA bank databases of microorganisms, protists, plants, algae, fungi and animals which are available via a central web portal.

Recently, The Global Genome Biodiversity Network (GGBN) has been launched in 2011 to make well-documented and vouchered collection that store DNA and tissue samples of biodiversity. This will be reachable through the GGBN Data portal (http://data.ggbn.org) that links globally distributed biodiversity databases and bridges the gap between biodiversity repositories, sequence databases and research results. GGBN and DNA Bank Network have similar objectives and rules, and all partners of the DNA Bank Network are members of GGBN.

3.5.1.6 Pollen Banks

A Pollen Bank is a collection of pollen grains stored in a viable state for crossing and breeding of a new cultivar. As pollen is representing a male gametophytic generation, so pollen can be germinated to produce a haploid plant where all the phenotypic characters would be expressed. Thus, pollen banks have many-fold importance. Comprehensive studies have been done to assess the different storage conditions that can enhance the viability of pollen grains. This storage can be conveniently grouped as short term and long term storage method. (Bhattacharya *et al.,* 2017)

Short term pollen storage: It includes the effect of temperature and humidity, and pollen storage in organic solvent.

(i) Effect of temperature and humidity: In general, low temperature and low relative humidity favour pollen germination in most taxa. However, a large number of pollens can be stored for a limited period of time by manipulating

of storage temperature and humidity. Pollen are stored in appropriate containers like glass or plastic vials for an extended period of time. Such containers are stored in desiccators with dehydrating agents to control humidity. Tricellular pollen of grasses requires sophisticated environmental conditions even for a short period of time.

(ii) Storage in organic solvent: Pollen grains stored in non-polar organic solvents like benzene, diethyl ether and cyclohexane retained viability and showed very little leaching of phospholipids, sugars and amino acids. On the other hand, extensive leaching of substance and loss of viability were seen in polar solvents. Insect pollinated species such as *Camelia japonica*, *Ginkgo biloba, Juglans regia*, *Malus pumilus* stored in organic solvent at 4°C for 35-40 days exhibited the needed viability.

Long term pollen storage: Storage of pollen at temperatures above 0°C slows down the metabolic activity of the pollen, resulting in gradual decrease and finally total loss of viability. Thus, for a long term preservation, cryogenic technique seems to be more promising. Some of the methods of long term preservation of pollen are described below:

(i) Storage at sub-zero temperature: Using a storage temperature of -10°C to -34°C the longevity of bicellular pollen (desiccation tolerant) and pollen with original low content of moisture have been extended between one to three years.

(ii) Freezing or vacuum drying (Lyophilization): The desiccation-tolerant pollen can be preserved for a long period of time by freeze or vacuum drying method. Freeze-drying involves the rapid freezing of pollen to sub-zero temperature of -60°C or -80°C using inert gas like helium or nitrogen and then the gradual removal of water under vacuum sublimation. In vacuum drying the pollen grains are directly exposed to a vacuum and simultaneously cooling. Then moisture is withdrawn by evaporative cooling. In a number of species, freeze drying followed by lyophilization showed better result.

(iii) Cryopreservation by deep-freezing: Long term preservation can be done by ultra-low temperature, ranging between -180°C and -196°C (in liquid nitrogen). Several agronomically important Gramineae (grasses) species have been stored through cryopreservation for long period (one to 12 years). Examples, *Zea mays, Triticum aestivum,* etc.

3.5.1.7 Ecosystem or Habitat Restoration

The ecological restoration is crudely defined as "making nature" (Jackson, 1992), while the Society of Ecological Restoration described it as "the process of intentionally altering a site to establish a defined, indigenous, historical ecosystem". The purpose of this process is to mimic the structure, diversity, function and dynamics of the specified ecosystem. This process is now fast growing and intellectually an exhilarating field of conservation.

Advantages of *Ex-situ* conservation

1. Greater diversity of target taxa can be conserved as seeds.
2. Easy access for characterization and evaluation.
3. Feasible for medium and long-term secure storage and disease resistance.
4. Little maintenance costs once material is conserved.
5. Easy access for plant breeding.

Disadvantages of *Ex-situ* conservation

1. Genetic diversity may be lost with each generation cycle.
2. Restricted to a single target taxon per accession.
3. Problem of storing recalcitrant seeds 4. Freezes evolutionary development

3.5.2 *In-vitro* Germplasm Conservation

In vitro method of germplasm conservation is mostly appropriate for vegetatively propagated crops and also for recalcitrant seeds. The vegetatively propagated crops are preserved *in vitro* in variety of forms including isolated protoplasts, cells from suspension or callus cultures, meristem tips, somatic embryos, shoot tips or propagules at various stages of development. This tissue culture-based method is mainly utilized for conservation of somaclonal and gametoclonal variations in cultures, plant material from endangered species, plants of medicinal value, storage of pollen, for production of disease-free plants and genetically engineered materials.

Methods for *in vitro* Germplasm conservation : There are two main approaches to *in vitro* germplasm conservation: slow growth techniques and cryopreservation.

1. **Slow growth techniques:** This is a simple and economic method which can be used in all species where shoot tip or nodal explant are available. It is

possible to maintain the healthy growth of stocks which must be sub-cultured every 4-6 weeks. Thus, it is labour-intensive as well as there is risk of contamination by pathogen and genetic change may also occur.

2. **Cryopreservation:** In general, cryopreservation (Creek *kryos* denotes frost) means preservation in the frozen state. In practice, materials are preserved in very low temperature, for example, over solid CO_2 (-79°C), in deep freezers (-80°C), in vapour phase of N_2 (-150°C) or in liquid N_2 (-196°C). Actually, cryopreservation is the process of freezing living material to preserve it at or near the temperature of liquid nitrogen, -196°C (-320°F). This method is also called freeze preservation and at this very low temperature, the cells stay in a completely inactive state where physical and cellular metabolic processes are stopped and they are free of contamination by pathogen, but with risk of genetic drift. Thus, plant tissues/organs/cells can be stored at very low temperature for indefinite period which can be recovered and grown again to regenerate a whole plant whenever required. Two major factors have to be considered before freezing of specimens: (a) degree of freeze tolerance displayed by a given genotype to reduce temperature, (b) the formation of ice crystals within the cells.

3.6 Social Approaches to Conservation

Loss as well as conservation of diversity is an issue of great social concern, since biodiversity has very great intrinsic value in a sociocultural system. However, the intimate relationship between society and biodiversity has not yet been fully realised by many people in this mechanised world. This is evident from the OTA (1987) report, 'Social and political processes influencing how biological diversity is perceived and valued are the least well understood and, in the long run, the most important factors affecting success of onsite diversity maintenance'. In fact, sociologists, anthropologists and historians have to develop very important descriptions of social factors affecting biodiversity maintenance at specific sites. It is also important to remember to educate people that science alone cannot protect biodiversity. Society and social and cultural values must be called in for the conservation and protection of nature and its bioresources. This section highlights how society practised biodiversity

conservation in the past by attaching ethical, aesthetic and religious values to it. The role of NGOs in persuading and pressurising society to fight against attempts by the State to degrade and deplete bioresources on the pretext of developmental activities and welfare measures to people is also emphasised.

3.6.0 Sacred Groves

The present political and scientifically oriented society thinks that religion is not interested in protecting and managing biodiversity. But they are absolutely wrong, as the religious values always help to protect biodiversity. The practice of protection of patches of forests with temples in their vicinity has long been a trend in India and a few other parts of the world. In some instances, forest patches or gardens with local floristic elements (often called *Nandavanas*) have been specially created near established temples and declared sacred to ensure their protection and conservation. Such sacred groves and gardens dedicated to the worship of the Presiding Deity of each temple are mentioned in ancient Greek, Latin American and Indian literary works as well as in epigraphical records and copper plates of these countries. Data also come from folk traditions, history and traditional knowledge passed on through several generations.

There are reports of sacred groves in the Near East, Europe, North and Sub-Saharan Africa, India, S.E. Asia, Oceania, China, Japan, Siberia and the Americas. There are several references to sacred groves in the Old Testament also. Touching plants (and animals associated with them) in these sacred groves and gardens was forbidden to all except the temple priest, and his too restricted to offerings to the Presiding temple Deity and curing the ailments of local people (the temple priest was invariably the village doctor). The groves were considered the property of Gods, who maybe male or female, and represented in the temple as a slab of stone, a hero stone, sati stone or trident.

Since sanctity was ascribed to the plants of such groves and since spiritual beings were believed to reside in such places, ordinary human activities were voluntarily precluded. These activities included tree-felling, gathering of wood/fuel and plants and leaves, hunting, fishing, grazing by domestic animals, ploughing, planting and harvesting, and dwelling. This ensured the conservation and preservation of the local vegetation for posterity. It should not be thought that such groves and gardens and the idea behind their establishment passed away with the ancient world. On the

contrary, several sacred groves and temple gardens persist in many parts of India and a few other countries even today, in spite of the fact that adjacent forests and vegetation have been totally or partially lost. For example, *Ginkgo biloba*, the living fossil, is presently growing in one of the largest 'seminatural' populations at Tian Mu Shan, near the Kaishan Buddhist temple in China.

In India, several thousands of sacred groves and temple gardens of various sizes (from clumps of trees to several hundred hectares) and diverse floristic composition have been reported in all vegetation types ranging from evergreen forests to desert/ arid vegetation. About 4215 sacred groves covering an area of 39,063 hectares are estimated to be distributed in India. Groves are reported in areas from the highest mountain peaks to sea level. The largest sacred grove, Mawflong, occurs in Meghalaya near Shillong. Sacred groves are known by several names in India depending on the place, *Kan* in Karnataka, and part of Maharashtra, *Kavus* in Kerala, Deorai in Madhya Pradesh, *Devarakadu* in northern Karnataka and Goa, *Orans* in Rajasthan, *Mawflong* in Assam and Meghalaya, *Koilkadu* in Tamil Nadu, etc. Floristically such groves even today contain taxa lost/endangered in adjacent regions. Several endemics are today reported only from such groves, for example *Dipterocarpus indicus*, *Myristica fatua*, *Pinanga dicksonii*, *Manilkara hexandra*, etc. Responsibility for protecting groves and enforcing rules were assumed by the local community since the grove was an integral part of the village society.

Local autonomy was given to these groves, although epigraphical records indicate that the committee in charge of temples and associated groves included a representative of the state/king of that region. The priest of the temple was often the only person authorised to enter the grove and that too only for collecting flowers/fruits to offer to the presiding deity or herbals to cure diseases of the local people. Sacred groves, wherever still present, should be preserved and restored for several reasons, including their value as historical evidence for the relationship of human beings to nature.

3.6.1 Sthalavrikshas

Sthalavrikshas is a Sanskrit word meaning temple trees. In India every temple, whether Hindu, Jain or Buddhist, had and still has a specific tree taxon cultivated very near to the sanctum sanctorum, the place where the Presiding Deity/Idol is erected. That particular tree is the temple tree for that temple. The idea behind this is that the people of the village where the temple is located should be very much

concerned to protect trees in general and express their society's sentiment by selecting a representative local tree taxon as the temple tree. This is yet another form of people's regard for nature, nature worship and expression of social concern for the conservation of plants. Ancient Tamils, for example, thought that Gods resided in trees and by worshipping trees they worshipped God. They further thought that different Gods resided in different types of trees and hence they planted the specific temple tree in temples meant for specific Gods. As many as 65 temple trees are recorded in Tamil Nadu alone, each in specific temples. (Krishnamurthy, 2003)

3.6.2 People's Movements for Biodiversity Conservation

A large number of environmental movements have emerged in India especially after 1970s. Biodiversity conservation was not the specific objective of these movements. But invariably they tried to protect their ecosystem which in turn was responsible for biodiversity conservation. These movements are independent responses to local issues in different places at different times. There are a number of reasons for emergence of such movements. Some of the reasons are as follows:

(i) control over natural resources,

(ii) false developmental policies of the government,

(iii) socioeconomic reasons,

(iv) environmental destruction and, degradation

(v) spread of environmental awareness and media.

The emergence of environmental movements has not been restricted to any particular part of the country, rather the whole country has witnessed such movements. Some of the important movements are as follows:

3.6.2.0 Bishnoi Movement

Amrita Devi, a female villager around 1700s could not bear to witness the destruction of both her faith and the village's sacred trees at Khejarli, Marwar region, Rajasthan state. She hugged the trees and encouraged others to do the same. 363 Bishnoi villagers were killed in this movement. The Bishnoi tree martyrs were influenced by the teachings of Guru Maharaj Jambaji, who founded the Bishnoi faith in 1485 and set forth principles forbidding harm to trees and animals. The king who came to know about these events rushed to the village and apologized, ordering the soldiers to cease logging operations. Soon afterwards, the maharajah designated the

Bishnoi state as a protected area, forbidding harm to trees and animals. This legislation still exists today in the region.

3.6.2.1 Chipko Movement

'Chipko' means 'to hug' or to embrace in affection. The chipko movement is a success story in environmental conservation and credit for it goes to the women of Reni village of the Alaknanda catchment area in the Uttarkhand region of the Himalayas of India, who sought to protect the local forests called Myka ('mother's house'). It was prompted by an order issued in the 1960s by the Government of India to cut trees in the Himalayan foothills on a large scale. This led to severe floods in 1970 which swept away 6 bridges, 16 footbridges and over 600 houses, in addition to destroying crops over hundreds of hectares, affecting no less than 100 villages in the area. The Chipko Andolan (Chipko revolution) was born when the women of the village sought to sale the forests in this extremely sensitive region of the Alaknanda catchment by marching to them shouting slogans and hugging the trees when contractors were ready to cut them down. As a result of this pressure, the contractors had to abandon their operations.

The same story was repeated in 1975 when 200 women in Gopeshwar, Chamoli district, waged a war against the cutting of oak trees by the district administration. Women of Bhyundar village in the lower reaches of the famous Valley of Flowers also went on the warpath with their 'Chipko'. In 1980, women of Dungri-Paitoli villages in the Chamoli region of Uttarakhand also resorted to the Chipko agitation to save their forests. The action was repeated in the 1980s in Bached village of Gopeshwar by 200 women, who prevented the felling of 1600 trees. The local women argued that even dead trees should not be removed, as the lumbering practices would invite soil erosion.

The mother organisation of the Chipko movement was the Dasholi Gram Swarajya Mandal (DGSM) led by Mr. Chandi Prasad Bhat and Mr. Sunderlal Bahuguna. Chipko was only one of the Andolans. The DGSM educated the villages about the importance of forests and their conservation through lectures, ecodevelopment camps, tree plantation programmes, construction of simple water distribution schemes, and setting up microhydel projects with locally available technologies.

Chipko movement has had six demands-

1. Complete stoppage of commercial cutting of trees,

2. On the basis of minimum needs of the people, a reorganization of traditional rights should take place,
3. Arid forest should be made green with people's participation and increased tree cultivation,
4. Village committees should be formed to manage forests,
5. Forest related home-based industries should be developed and the raw materials, money and technique for it should be made available and
6. Based on local conditions and requirements, local varieties should be given priority in afforestation.

3.6.2.2 Narmada Bachao Andolan

The most popular movement in the environmental history of India is the movement against the Narmada River Valley. The Narmada is the largest west-flowing river on the Indian peninsula. More than twenty-one million people live in the valley, mostly in villages. Many tribal groups, such as the Bhils and the Gonds, occupy the forested 12 uplands. In the Year 1985, Medha Patker, Baba Amte, adivasis, farmers, environmentalists and human rights activists organized a social movement against a number of large dams being built across the Narmada River. The movement first started as a protest for not providing proper rehabilitation and resettlement for the people who have been displaced by the construction of Sardar Sarovar Dam. Later on, the movement turned its focus on the preservation of the environment and the eco-systems of the valley. Activists also demanded the height of the dam to be reduced to 88 m from the proposed height of 130m. World Bank withdrew from the project.

The environmental issue was taken into court. In October 2000, the Supreme Court gave a judgment approving the construction of the Sardar Sarovar Dam with a condition that height of the dam could be raised to 90 m. This height is much higher than the 88 m which anti-dam activists demanded, but it is definitely lower than the proposed height of 130 m. The project is now largely financed by the state governments and market borrowings. The project is expected to be fully completed by 2025.

3.6.2.3 Appiko Movement

Appiko Movement is one of the forest-based environmental movements in India. The movement took place in the Uttara Kanada district of Karnataka in the Western Ghats, known as the 'forest district'. The area has rich forest wealth. During the

colonial rule, the rich forest resources were exploited. After independence, the government also began felling trees for revenue and the Forest Department, which continued the colonial forest policy, converted the tropical forests into monoculture teak and eucalyptus plantation. A group of youth in Balegadde village, protesting against moves to establish teak plantations, wrote to forest officials asking them to stop clearing the natural forest. But this appeal was ignored. Then the villagers decided to launch a movement. They invited S. L. Bahuguna, the architect of Chipko movement and gathered local people to take up oath to protect trees by embracing them. In September 1983, when the axe-men came for felling to the Kalase forests, people embraced the trees and thus the 'Appiko' movement was launched.

The Appiko movement succeeded in its threefold objectives include

1. protecting the existing forest cover
2. regeneration of trees in denuded land, and
3. utilizing forest wealth with proper consideration to conservation to conservation of natural resources.

The Appiko movement created awareness among the villagers throughout the Western Ghats about the ecological danger posed by the commercial and industrial interests to their forest which was the main source of sustenance.

3.6.2.4 Silent Valley Movement

In the year 1978, The Kerala Sastra Sahitya Parishad (KSSP) an NGO, and the poet-activist Sughathakumari played an important role to protect the Silent Valley, the moist evergreen forest from being destroyed by a hydroelectric project. The Kerala State Electricity Board (KSEB) proposed a hydroelectric dam across the Kunthipuzha River that runs through Silent Valley. In February 1973, the Planning Commission approved the project at a cost of about Rs 25 crores. Many feared that the project would submerge 8.3 sq. km of untouched moist evergreen forest. Several NGOs strongly opposed the project and urged the government to abandon it. In January 1981, bowing to unrelenting public pressure, Indira Gandhi declared that Silent Valley will be protected. In June 1983 the Centre re-examined the issue through a commission chaired by Prof. M.G.K. Menon. In November 1983 the Silent Valley Hydroelectric Project was called off. In 1985, Prime Minister Rajiv Gandhi formally inaugurated the Silent Valley National Park.

3.6.3 Participatory Forest Management

A young forest officer, Ajith Kumar Banerjee, initiated PFM in Arabari, state of West Bengal, India in l972. It subsequently expanded to other states of India and became a very significant turning point in the history of forest conservation not only in India, but other Asian countries. The essential feature of PFM is that the State and Society become partners in the management of forest resources. The State continues to own the resources but the benefits are shared, especially access to non-timber forest products for the community. This leads to the community developing an economic stake in the preservation of forests, which ensures its conservation and sustainable exploitation. Thus, forest degradation can be reversed through PFM, which has been observed in several forest tracts of India over the last 25 years.

3.7 Biodiversity Awareness Programmes

Public awareness about biodiversity is at a stage of infancy. Of late, some awareness has taken place related to biodiversity degradation, pollution, etc. but incomplete knowledge and information and ignorance about many aspects has often led to misconceptions.

Development has paved the path for rise in the levels or standards of living but it has simultaneously led to serious loss of biodiversity. Issues related to environment have often been branded as antidevelopment. The wisdom lies in maintaining a balance between our needs and supplies so that the delicate ecological balance is not disrupted.

Some of the main reasons responsible for widespread ignorance of biodiversity can be summed up as follows:

(i) Our courses in Science, technology, economics etc. have so far failed to integrate the knowledge in biodiversity aspects as an essential component of the curriculum.

(ii) Our planners, decision-makers, politicians and administrators have not been trained so as to consider the biodiversity aspects associated with their plans.

(iii) In a zeal to go ahead with some ambitious development projects, quite often there is purposeful concealment of information about essential aspects of biodiversity.

(iv) There is greater consideration of economic gains and issues related to eliminating poverty by providing employment that overshadows the basic biodiversity issues.

3.7.0 Methods to Propagate Biodiversity Awareness

Environmental awareness needs to be created through formal and informal education to all sections of the society. Everyone needs to understand it because 'environment belongs to all' and 'every individual matters' when it comes to conservation and protection of environment. Various stages and methods that can be useful for raising environmental awareness in different sections of the society are as follows:

(i) Among students through education: Education about Biodiversity must be imparted to the students right from the childhood stage. It is a welcome step that now all over the country we are introducing environmental studies as a subject at all stages including school and college level, following the directives of the Supreme Court.

(ii) Among the Masses through mass-media: Media can play an important role to educate the masses on biodiversity related issues through articles, environmental rallies, plantation campaigns, street plays, real eco-disaster stories and success stories of conservation efforts. TV serials related to the conservation of biodiversity will be effective in propagating the seeds of environmental awareness amongst the viewers of all age groups.

(iii) Among the planners, decision-makers and leaders: Since this elite section of the society plays the most important role in shaping the future of the society, it is very important to give them the necessary orientation and training through specially organized workshops and training programmes. Publication of environment, and biodiversity related resource material in the form of pamphlets or booklets published by Ministry of Environment & Forests can also help in keeping this section abreast of the latest developments in the field.

3.7.1 Role of Non-Government Organisations (NGO's)

Voluntary organizations can help by advising the government about some local biodiversity related issues and at the same time interacting at the grass-root levels. They can act as an effective and viable link between the two. They can act both as

an ‘action group’ or a ‘pressure group’. They can be very effective in organizing public movements for the protection of environment through creation of awareness. The ‘Chipko Movement’, ‘Narmada Bachao Andolan’, ‘Appiko Movement’(discussed before) are some of the instances where NGO’s have played a landmark role in the society for conservation of environment. The Bombay Natural History Society (BNHS), the World Wide Fund for Nature - India (WWF, India), Kerala Sastra Sahitya Parishad, Centre for Science and Environment (CSE) and many others are playing a significant role in creating environmental awareness through research as well as extension work. The recent report by CSE on more than permissible limits of pesticides in the cola drinks sensitized the people all over the country. Before we can all take up the task of environmental protection and conservation, we have to be environmentally educated and aware. It is aptly said *“If you want to act green, first think green.”*

3.8 Sustainable Development

Sustainable development is defined as “*meeting the needs of the present without compromising the ability of future generations to meet their own needs.*” This definition was given by the Norwegian Prime Minister, G.H. Brundtland, who was also the Director of World Health Organisation (WHO). Today sustainable development has become a buzz word and hundreds of programmes have been initiated in the name of sustainable development. If you want to test whether or not a proposal will achieve the goals of sustainability just try to find out the following. Does it protect our biodiversity? Does it prevent soil erosion? Does it slow down population growth? Does it increase forest cover? Does it cut off the emissions of CFC, SO_2, NO_2 and CO2? Does it reduce waste generation and does it bring benefits to all? These are only a few parameters for achieving sustainable growth.

Until now development has been human-oriented, that too mainly, for a few rich nations. They have touched the greatest heights of scientific and technological development, but at what cost? The air we breathe, the water we drink and the food we eat have all been badly polluted. Our natural resources are just dwindling due to over exploitation. If growth continues in the same way, very soon we will be facing a “doom’s day” - as suggested by Meadows *et. al.* (1972) in their world-famous academic report “**The Limits to Growth**”, this is unsustainable development which will lead to a collapse of the interrelated systems of this earth.

Although the fears about such unsustainable growth and development started in 1970's, yet a clear discussion on sustainable development emerged on an international level in 1992, in the UN Conference on Environment and Development (UNCED), popularly known as The Earth Summit, held at Rio de Janeiro, Brazil. The Rio Declaration aims at "*a new and equitable global partnership through the creation of new levels of cooperation among states...*" Out of its five significant agreements **Agenda-21** proposes a global programme of action on sustainable development in social, economic and political context for the 21st Century. Sustainable development became an issue on the environmental agenda in the second half of the 1980s, especially after the publication of the book *Our Common Future* by the World Commission on Environment and Development (WCED). Now sustainable development has become a composite discipline including science, technology, sociology, economics, ethics, trade, law and politics, incorporating several dimensions (Fig. 3.3).

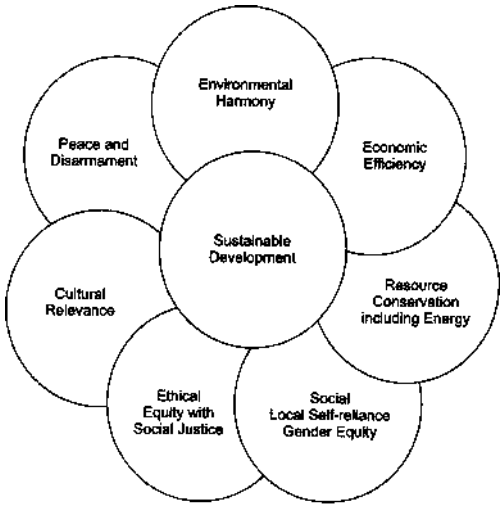

Fig. 3.3. Major dimensions of Sustainable Development.

These are the key aspects for sustainable development:

(a) Inter-generational equity: This emphasizes that we should minimize any adverse impacts on resources and environment for future generations i.e. we should hand over a safe, healthy and resourceful environment to our future generations. This can be possible only if we stop over-exploitation of resources, reduce waste discharge and emissions and maintain ecological balance.

(b) Intra-generational equity: This emphasizes that the development processes should seek to minimize the wealth gaps within and between nations. The Human Development Report of United Nations (2001) emphasizes that the benefits of technology should seek to achieve the goals of intra-generational equity. The technology should address to the problems of the developing countries, producing drought tolerant varieties for uncertain climates, vaccines

for infectious diseases, clean fuels for domestic and industrial use. This type of technological development will support the economic growth of the poor countries and help in narrowing the wealth gap and lead to sustainability.

3.8.0 Measures for Sustainable Development

Some of the important measures for sustainable development are as follows:

- **Using appropriate technology** is one which is locally adaptable, eco-friendly, resource-efficient and culturally suitable. It mostly involves local resources and local labour. Indigenous technologies are more useful, cost-effective and sustainable. Nature is often taken as a model, using the natural conditions of that region as its components. This concept is known as "*design with nature*". The Technology should use less of resources and should produce minimum waste.
- **Reduce, Reuse, Recycle approach:** The 3-R approach advocating minimization of resource use, using them again and again instead of passing it on to the waste stream and recycling the materials goes a long way in achieving the goals of sustainability. It reduces pressure on our resources as well as reduces waste generation and pollution.
- **Prompting environmental education and awareness:** Making environmental education the centre of all learning process will greatly help in changing the thinking and attitude of people towards our earth and the environment. Introducing the subject right from the school stage will inculcate a feeling of belongingness to earth in the small children. '*Earth thinking*' will gradually get incorporated in our thinking and action which will greatly help in transforming our life styles to sustainable ones.
- **Resource utilization as per carrying capacity:** Any system can sustain a limited number of organisms on a long-term basis which is known as its **carrying capacity**. In case of human beings, the carrying capacity concept becomes all the more complex. It is because unlike other animals, human beings, not only need food to live, but need so many other things to maintain the quality of life.

Sustainability of a system depends largely upon the carrying capacity of the system. If the carrying capacity of a system is crossed (say, by over exploitation of a resource), environmental degradation starts and continues till it reaches a point of no return.

Carrying capacity has two basic components:

- **Supporting capacity** i.e. the capacity to regenerate
- **Assimilative capacity** i.e. the capacity to tolerate different stresses.

In order to attain sustainability, it is very important to utilize the resources based upon the above two properties of the system. Consumption should not exceed regeneration and changes should not be allowed to occur beyond the tolerance capacity of the system. (Kaushik and Kaushik, 2004)

3.8.1 The Indian Context

India has still to go a long way in implementing the concept of sustainable development. We have to lay emphasis on framing a well-planned strategy for our developmental activity while increasing our economic growth. We have tremendous natural diversity as well as a huge population which makes planning for sustainable growth all the more important and complex. The National Council of Environmental Planning and Coordination (NCPC) set up in 1972 was the focal agency in this regard. The Ministry of Environment & Forests, set up in 1985 has formulated guidelines for various developmental activities keeping in view the sustainability principles.

3.9 Summary

Many of today's initiatives towards conservation of biodiversity may turn out to be a stop-gap arrangement unless advances are made in dealing with overconsumption of resources, population growth, misguided resource management policies and social and economic inequities. The need to conserve our planet's biological wealth gives nations even more impetus to solve these knotty problems. At the same time, sustaining biodiversity may help provide the means for crafting solutions. In this unit we have discussed about the various aspects of conservation strategies by government, voluntary

organizations, public participation as well as the individual efforts, that how they commutatively play a major role for the conservation of the biodiversity.

Human is only one more of natural creatures and should not be alien to the other life-forms. We have no moral right to destroy nature and other beings that dwell on earth. We should treat all animals and plants with compassion. Every individual can make a small and yet significant effort in the race to save our planet and conserve biodiversity.

3.10 Questions and Answers

A. Multiple Choice Questions:

1. **A species that has become a symbol and leading element of an entire conservation campaign is known as –**

   a. Umbrella species
   b. Flagship species
   c. Keystone species
   d. Charismatic species

   Answer : b. Flagship species

2. **Which of the below is an advantage of ecosystem diversity-**

   a. There are no planned satisfactory habitat or ecosystem classification on which the protected area networks will depend.
   b. Populations of threatened species which need urgent conservation steps are likely not be included in a network of protected areas.
   c. It is the cheapest and most effective way of conserving both genetic and species diversities.
   d. none of the above.

   Answer : c. It is the cheapest and most effective way of conserving both genetic and species diversities.

3. **Which one of the below is an example of *ex-situ* conservation:**

   a. National parks
   b. Botanic gardens
   c. Biosphere reserves
   d. Sanctuary

   Answer : b. Botanic gardens

4. A biosphere reserve should have:

a. Reserve space
b. No connection of different reserves
c. Ideal geographic context
d. no zonation within a reserve

Answer : c. Ideal geographic context

5. Match the following:

A. Nilgiri Biosphere reserve	**i. N. E. Himalaya**
B. Nokrek Biosphere reserve	**ii. Deccan peninsula**
C. Nanda Devi Biosphere reserve	**iii. Western ghat**
D. Simplipal Biosphere reserve	**iv. Western Himalaya**

a. A(i), B(ii), C(iii), D(iv)
b. A(iii), B(ii), C(iv), D(iii)
c. A(ii), B(iii), C(i), D(iv)
d. A(iii), B(i), C(iv), D(ii)

Answer : d. A(iii), B(i), C(iv), D(ii)

6. Dihang-Dibang biosphere reserve situate at –

a. Madhya Pradesh
b. West Bengal
c. Arunachal Pradesh
d. Assam

Answer : c. Arunachal Pradesh

7. Name a National Park situated at Madhya Pradesh –

a. Corbett National Park
b. Kanha National Park
c. Bandipur National Park
d. Gir National park

Answer : b. Kanha National Park

8. What is the best temperature for long-term storage of seeds?

a. –196°C b. –5°C c. –1°C d. –4°C

Answer : a. –196°C

9. GGBN is an example of

a. Pollen bank
b. Seed bank
c. DNA bank
d. None of the above

Answer : c. DNA bank

10. Which of the below is an example of peoples movement for biodiversity conservation?

a. Chapati movement
b. Chipko movement
c. Namantar movement
d. None of the above

Answer : b. Chipko movement

B. Short answer type questions:

1. What is keystone species? Give example.
   Answer : 3.3.0
2. What do you mean by Biosphere Reserve?
   Answer : 3.5.0.1
3. Write the name of two biosphere reserves of India which are part of World Netwrok of Biosphere Reserve based on UNESCO.
   Answer : Table 3.0
4. Write the name of two National Parks from Southern region of India.
   Answer : Table 3.1
5. Define Umbrella species.
   Answer : 3.3.0
6. What is recalcitrant seed?
   Answer : 3.5.1.2
7. Define Cryopreservation.
   Answer : 3.5.2
8. What is gene library?
   Answer : 3.5.1.5
9. Give an example of germplasm collection.
   Answer : 3.5.1.0
10. Who was the founder of Bishnoi movement?
    Answer : 3.6.2.0
11. Appiko movement takes place at which region in India?
    Answer : 3.6.2.3

C. Long answer type questions:

1. Why genetic conservation is mostly attempted at population level?
   Answer : 3.2
2. What is species diversity? Write a short note about the three category of species.
   Answer : 3.3
3. What are the advantages and disadvantages of ecosystem diversity?
   Answer : 3.4

4. What is *in-situ* conservation? What are the objectives and design of a biosphere reserve?
   Answer : 3.5 & 3.5.0.1
5. Write the different categories of a nature reserves.
   Answer : 3.5.0.0
6. Write the role of Seed bank and DNA bank in *ex-situ* conservation.
   Answer : 3.5.1.2 & 3.5.1.5
7. Write a short note on *in-vitro* germplasm conservation.
   Answer : 3.5.2
8. How pollen grains can be stored for longer periods?
   Answer : 3.5.1.6
9. How social approaches are necessary for conservation. Write briefly about Chipko movement and Narmada bachao andolon.
   Answer : 3.6, 3.6.2.1, & 3.6.2.2
10. What do you mean by sustainable development? What bare the key aspects and measures of sustainable development?
    Answer : 3.8, 3.8.0, & 3.8.1
11. Write a short note about biodiversity awareness programmes.
    Answer : 3.7 & 3.7.1

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Unit 4 □ Role of Plants in Relation to Human Welfare

Structure

4.0 Objectives

- To know the significance of forestry with their utilization and commercial aspects.
- To know about the type of avenue trees found in Kolkata and their role.
- To give an idea about the different ornamental plants (mainly shrubby, and tree species) in our surroundings.
- To provide knowledge about the role of plant in production of different alcoholic beverages throughout the world.
- To know the common names and uses of common temperate and tropical fruits found in India.
- To understand the different features of wood and their uses in our daily life.

4.1 Introduction

The average man is likely to consider himself as a being apart from the rest of the organic world, enabled by reason of his superior intellect to lead a self-sufficient and independent existence. He loses sight of the fact, or is ignorant of it, that he is absolutely dependent on other organisms for his very life, and his material happiness as well. His superior intelligence has made him more dependent rather than less so. Although various animal and mineral products contribute to his welfare, it is the plant kingdom that is most essential to man's well-being.

Man's dependence on plants for the essentials of his existence has been of paramount importance in his life since the human race began. Primitive man probably had few needs other than food and a little shelter. Civilization, however has brought with it an ever-increasing complexity, and has increased man's requirements to an amazing degree. The man of today is no longer content merely to exist, with food and shelter as his only wants. He desires other commodities as well, and raw materials that can be converted into the many useful articles and products which contribute to his enjoyment of life, and which incidentally increase his debt to plants.

The three great necessities of life – food, clothing, and shelter – and a host of other useful products are supplied in great part by plants. An adequate food supply

is, and always has been, man's most outstanding need. Actually, all his food comes from plants. To be sure he may eat the flesh of animals, but these lower animals are just as dependent on plants as man himself, and they are equally unable to manufacture any of their food from raw materials. Clothing and shelter, the other prime necessities of life, are derived in great part from plant fibres and from wood. Wood is one of the most useful plant commodities in the world today, and it played an even greater role in the past. Aside from its use as a structural material, wood is valuable as a source of paper, rayon, various chemicals, and fuel. Other types of fuel, such as coal and petroleum, make available for man the energy stored up by plants that lived and died ages ago. Drugs, used to cure disease and relieve suffering, are to a great extent plant product. Industry is dependent on plants for many of its raw materials. Cork; tanning materials and dyestuffs; the oils, resins, and gums used in making paints, varnishes, soap, and perfumes; and rubber, one of the most outstanding materials of modern civilization, are but a few of the valuable products obtained from plants.

Aside from that plants are important to man in many other ways. The role that bacteria play in disease and many industries; and the effects of forests and other types of natural vegetation in controlling floods and erosion are but a few examples. The aesthetic value of plants has no small influence on man's enjoyment of life, as evidenced by the host of garden enthusiasts and flower lovers. Generally, the role of plant in human life will be discussed in this topic.

4.2 Importance of Forestry, their Utilization and Commercial aspects

Forests are one of the most important natural resources on this earth. Covering the earth like a green blanket these forests not only produce innumerable material goods, but also provide several environmental services which are essential for life. About 1/3rd of the world's land area is forested which includes closed as well as open forests. Former USSR accounts for about a 5th of the world's forests, Brazil for about a 7th and Canada and USA each for 6-7%. But it is a matter of concern that almost everywhere the cover of the natural forests has declined over the years. The greatest loss occurred in tropical Asia where one third of the forest resources have been destroyed. Importance of forest and forest products are given below:

4.2.0 Forests products

Forests products were used by human beings even before the advent of human civilization. Man was primarily a forest dweller who depended on the forest for food and shelter. Today, in spite of the vast strides that have been made in science and technology, a high proportion of the earth's population depend on forests for their basic requirements and well-being. Even in the most advanced countries life would come to a standstill without direct and direct use of forest products. In a developing country like India the dependence on forest products is high both in the urban and rural areas. Important commercial and non-commercial forest products of India have been listed below:

i) Fuelwood, charcoal, or energy.

ii) Fodder, mainly grasses and leaves.

iii) Timber, structural timbers, specific utility or industrial timbers, ornamental timbers.

iv) Bamboos and canes which may be used for various purpose, such as furniture, building construction, fodder, etc.

v) Grasses used as raw material for paper and pulp manufacture, fodder, matting, ropes, cordage and thatching.

vi) Fibres, such as jute, flax, leaf fibres and cotton.

vii) Flosses for stuffing of mattresses, pillows, cushions and life belts.

viii) Coir, primarily coconut coir.

ix) Essential or volatile oils, such as grass oils, flower oils, leaf oils, root oils, and wood oils.

x) Fixed oils, such as castor oil, cotton seed oil, coconut oil, mahua oil, neem oil, and sal butter.

xi) Waxes, such as candelilla wax and white wax.

xii) Dyes mainly flower and fruit dyes, bark and wood dyes and root dyes.

xiii) Tannins obtained from species, like khair, sal and Terminalia.

xiv) Medicines and drugs obtained from different parts of forest species are used for the treatment of different disorders and diseases.

xv) Food – the principal edible parts being leaves, pulp of fruits, seeds, enlarged starchy rhizomes, young and succulent culms and nut kernels.

xvi) Gums exuded by many tree species.

xvii) Resins including gum resins, oleo resins and gum oleo resins.

xviii) Lac excreted by the lac insect which feeds on some trees.

xix) Leaves of certain forest species may be used for wrapping, cups, plates, fodder, thatching, finishing and polishing. Beedi or tendu leaves are an important forest product.

xx) Honey and wax.

xxi) Soap substitutes.

4.2.1 Commercial uses

Forests provide us a large number of commercial goods which include timber, firewood, pulpwood, food items, gum, resins, non-edible oils, rubber, fibres, lac, bamboo canes, fodder, medicine, drugs and many more items, the total worth of which is estimated to be more than $300 billion per year. Half of the timber cut each year is used as fuel for heating and cooking. One third of the wood harvest is used for building materials as lumber, plywood and hardwood, particle board and chipboard. One sixth of the wood harvest is converted into pulp and used for paper industry. Many forest lands are used for mining, agriculture, grazing, and recreation and for development of dams.

Forestry in India is a significant rural industry and a major environmental resource. India is one of the ten most forest-rich countries of the world. India's forest cover grew at 0.20% annually over 1990-2000, and has grown at the rate of 0.7% per year over 2000-2010, after decades where forest degradation was a matter of serious concern. As of 2010, the Food and Agriculture Organization of the United Nations estimates India's forest cover to be about 68 million hectares, or 22% of the country's area. In 2013, Forest Survey of India states its forest cover increased to 69.8 million hectares by 2012, as per satellite measurements; this represents an increase of 5,871 square kilometres of forest cover in 2 years. However, the gains were primarily in northern, central and southern Indian states, while north-eastern states witnessed a net loss in forest cover over 2010 to 2012. In 2018, the total forest and tree cover in India increased to 24.39% or 8,02,088 km^2. It increased further to 24.56 percent or 807,276 square kilometres in 2019.

In 2002, forestry industry contributed 1.7% to India's GDP. In 2010, the contribution to GDP dropped to 0.9%, largely because of rapid growth of the economy in other sectors and the government's decision to reform and reduce import tariffs to let imports satisfy the growing Indian demand for wood products. It's all direct benefits are accounted for forest resources, contribute around 2.9% to the adjusted Net Domestic Product for the country as a whole. Forestry and logging made up 1.66 trillion Indian rupees of agricultural gross value added in fiscal year 2017. India produces a range of processed forest (wood and non-wood) products ranging from wood panel products and wood pulp to make bronze, and pern resin. India's paper industry produces over 3,000 metric tonnes annually from more than 400 mills. The furniture and craft industry are another consumer of wood. India's wood-based processing industries consumed about 30 million cubic meters of industrial wood in 2002. India annually consumes an additional 270 million tonnes of fuelwood, 2800 million tonnes of fodder, and about 102 million cubic meter of forest products - valued at about 27,500 crore (US$3.9 billion) a year. India is one of the world's largest consumers of fuel-wood. Fuel-wood meets about 40% of the energy needs of the country. Around 80% of rural people and 48% of urban people use fuel-wood.

Forestry in India is more than just about wood and fuel. India has a thriving non-wood forest products industry, which produces latex, gums, resins, essential oils, flavours, fragrances and aroma chemicals, incense sticks, handicrafts, thatching materials and medicinal plants. About 60% of non-wood forest products production is consumed locally. About 50% of the total revenue from the forestry industry in India is in non-wood forest products category. In 2002, non-wood forest products were a source of significant supplemental income to over 400 million people in India, mostly rural. The forests also provide whole time daily employment to about 15 lakh persons engaged as wood-cutters, sawyers, carters, and craftsmen and in other related forest industries.

4.2.2 Ecological uses

While a typical tree produces commercial goods worth about $590 it provides environmental services worth nearly $196,250. The ecological services provided by our forests may be summed up as follows:

Production of oxygen: The trees produce oxygen by photosynthesis which is so vital for life on this earth. They are rightly called as earth's lungs.

Reducing global warming: The main greenhouse gas carbon dioxide (CO_2) is absorbed by the forests as a raw material for photosynthesis. Thus, forest canopy acts as a sink for CO_2 thereby reducing the problem of global warming caused by greenhouse gas CO_2.

Wild life habitat: Forests are the homes of millions of wild animals and plants. About 7 million species are found in the tropical forests alone.

Regulation of hydrological cycle: Forested watersheds act like giant sponges, absorbing the rainfall, slowing down the runoff and slowly releasing the water for recharge of springs. About 50-80% of the moisture in the air above tropical forests comes from their transpiration which helps in bringing rains.

Soil Conservation: Forests bind the soil particles tightly in their roots and prevent soil erosion.

Pollution moderators: Forests can absorb many toxic gases and can help in keeping the air pure. They have also been reported to absorb noise and help in reducing air and noise pollution.

Forest influences: Forests have important influences on the climate, soil, erosion, run-off and the environment. These influences have been summarized below:

Climate

1. Forests have a considerable moderating effect on the speed and direction of prevailing winds. On entering a forest, it is noticed that there is relative calm even it is widely outside. The physical obstacle offered by forests deflects upwards a large part of the moving mass of air.
2. Air temperature is moderated by forests. This influence is more pronounced in stands having a dense foliage.
3. The air outside a forest is more humid than that in open areas, even though the variation in absolute moisture content is somewhat less than what would be expected in view of the large quantity of water transpired by trees.

Soil

1. Soil temperature is influence by the forest cover to a great extent. There is an increase in the minimum and decrease in the maximum soil temperatures.

2. Every year the forest cover adds large quantities of organic matter to the soil in the form of raw humus which is later decomposed and passed on to the layers below.
3. Less water is evaporated from soil under a forest cover and up to a certain distance on the leeward side. The forest cover improves both the physical and chemical condition of the soil.
4. Forests also maintain a balance in the soil moisture content.

Erosion and Run-off: Forests prevent or substantially check soil erosion and control run-off.

Environment Protection: Forests help to protect the environment by reducing soil erosion, maintaining the ecological balance, regulating the water cycle, keeping the atmosphere free of air pollutants, lowering noise pollution and moderating temperatures.

4.2.3 Recreation

Forests are also a major source of recreation, particularly in large towns and cities.

4.3 Avenue Trees

Avenue is a way of access to a country house bordered by trees. Generally, it means a row of trees planted along roads and paths. Avenue plantation is one of the important practices of growing trees along roadside and the canal side to increase aesthetic value and to provide shade to the stray animals and travellers during Emperor Ashoka as well as Akbar's rule. Besides, the National Forest Policy 1988 emphasized in conducting research on social forestry aspects in India. The avenue trees play an important role in maintaining the ecological balance in an urban area. It plays a major role reducing the pollution caused by vehicular movement and also reduces concentration of CO_2 in atmosphere in the form of biomass. Some studies were conducted on the effect of vehicular pollution on avenue trees viz., *Azadirachta indica* and *Polyalthia longifolia*. Moreover, the avenue trees have been drastically affected due to modernization and developmental projects in the developing cities.

The trees in the streets of Kolkata are doubtless much the same as those that line the main roads of the Indian Countryside to day and are still almost the only trees to be seen in many small towns and villages. The survivors and descendants of these can be found to this day in many parts of Kolkata, especially in the poorer quarters, where banyan, the peepul, and the neem are still the commonest trees. But for many years a wider selection has been made by those responsible for planting our streets and avenues, and in the parts of the town that have recently been laid out a new type of tree has almost displaced the huge, untidy kinds on which the city once relied for shade. The qualities required in such trees are a reasonably quick rate of growth, a spreading shady head (preferably evergreen), a fairly long life, and a compact habit that will limit the ultimate size of the tree and will prevent it from throwing out sprawling limbs likely to interfere with neighbouring wires or buildings. It must be sturdy too, and should not be liable to shed its branches without warning, and must be able to stand up to the violent winds that occasionally sweep down the streets. If it bears beautiful flowers, so much the better, but this is a consideration of minor importance.

Among the larger trees used for the purpose the commonest are perhaps the child-life tree – *Putranjiva roxburghii*, the debdaru – *Polyalthia longifolia,* and the Spanish mahogany – *Swietenia mahogoni*; of these the first two are extremely suitable, but the third although excellent in other respects and one of the finest trees to be found in India, will eventually attain a size that will probably be found too vast for most situations in a town. The bakul – *Mimusops elengi,* and the devil tree or Chhattim – *Alstonia scholaris,* are excellent compact tree of fair size with dense evergreen foliage, and the former is very frequently planted in streets as well as in gardens. The desi badam – *Terminalia catappa* has horizontal branches, a flat head, and handsome bright green leaves, all of which make it suitable for street planting.

Coming now to trees of rather smaller proportions, we find that in recent years many streets have been lined with the paras – *Hibiscus populneus,* or Portia tree, a quick-growing, evergreen tree with a rounded bushy head, leaves rather resembling in shape those of a peepul, and yellow hisbiscus-like flowers; where space is restricted a better choice can hardly be made. Another tree of rather similar habit, but slower in growth, is the Alexandrian laurel – *Calophyllum inophyllum,* which has very beautiful evergreen leaves and preety white flowers. Less common, though indigenous

round about and often planted on roadsides, is the Karanja – *Pongamia pinnata*, or Indian beech, a beautiful tree only marred by the fact that its foliage is prone to attack by a disease that causes it to turn an ugly whitish colour. Moreton Bay Chest nut – *Castanospermum australe* has been planted here and there in the city, but it is probably too liable to damage by wind to be very suitable; moreover, its flowers are of no great merit because they are largely concealed by leaves. *Lepisanthes tetraphylla*, a introduced plant from south India, has been planted in some numbers; it has dense evergreen foliage and a fairly compact habit, but special beauty.

A few trees are commonly grown in streets for their flowers, and some of the roads in the residential areas are a magnificent sight in hot season when these are in bloom. Unfortunately, however, few of them are really suitable for street planting, because they are either too delicate and fragile or they provide insufficient shade. The gul mohor – *Delonix regia*, although planted in quite large number of streets, is really only suitable for parks and gardens, because it has brittle branches and is easily blown over. Some roads of Kolkata and surroundings are largely lined with the Jarul – *Lagerstroemia speciosa*, but these trees do not seem to thrive in such urban surroundings and, also their lilac colour flowers are beautiful for a short time in the hot weather, passers-by would probably prefer stronger trees and dense shade. The jarul's near relative *Lagerstroemia thorellii*, a introduced plant from Indo-China, has also been much planted, but although it thrives in Kolkata, it must be considered too small for an avenue tree. The only species that may be thought really suitable for street planting, and at the same time to be able to compare with the best for beauty of bloom, is *Peltophorum pterocarpum*, which has beautiful evergreen foliage, a compact growth, and a wealth of lovely yellow flowers, appearing in the hot weather and succeeded by attractive rust-coloured pods; this is perhaps the best of all the ornamental trees to be found in India, and should be more widely planted everywhere.

Another tree need special mention is the rain tree – *Samanea saman*, which was introduced into India at the end of eighteenth century, is well known to the city. Many streets in the suburbs are lined with this huge, quick-growing tree. Where there is space for its sprawling limbs it cannot be beaten as a shade-giver, but it may be feared that falling branches will cause a great deal of trouble and damage. There is no doubt that they should really be confined to parks and the larger gardens, or to the sides of country roads. (Benthall, 1984).

Table 4.0. Name of some Avenue trees:

Name	Family	Common name
Dillenia indica	Dilleniaceae	Chalta
Polythia longifolia	Annonaceae	Debdaru
Bombax ceiba L.	Malvaceae	Simul
Sterculia foetida	Malvaceae	Jangli badam
Pterygota alata	Malvaceae	Buddha narikela
Kleinhovia hospita	Malvaceae	Rola
Pterospermum acerifolium	Malvaceae	Kanak champa
Berrya cordifolia	Malvaceae	
Garuga pinnata	Burseraceae	Jum
Azadirachta indica	Meliaceae	Nim
Swietenia mahagoni	Meliaceae	Mahogony
Swietenia macrophylla	Meliaceae	Mahogony
Toona ciliata	Meliaceae	Tun
Aphanamixis polystachya	Meliaceae	Tikta raj
Schleichera oleosa	Sapindaceae	Kusum
Dimocarpus longan	Sapindaceae	Asphal
Mangifera indica	Anacardiaceae	Am
Myroxylon balsamum	Leguminosae	
Dalbergia sissoo	Leguminosae	Sisu
Castanospermum australe	Leguminosae	
Peltophorum pterocarpum	Leguminosae	Radhachura
Delonix regia	Leguminosae	Gul mohor
Colvillea racemosa	Leguminosae	
Cassia fistula	Leguminosae	Sonaalu, Bandarlathi
Cassia siamea	Leguminosae	Minziri
Albizia lebbeck	Leguminosae	Siris
Albizia richardiana	Leguminosae	
Albizia saman	Leguminosae	Belati Sirissa

Name	Family	Common name
Terminalia catappa	Combretaceae	Desi badam
Terminalia arjuna	Combretaceae	Arjuna
Syzygium cumini	Myrtaceae	Kala jam
Barringtonia acutangula	Lecythidaceae	Hidjal
Lagerstroemia speciosa	Lythraceae	Jarul
Lagerstroemia thorelii	Lythraceae	Belati Jarool
Breonia chinensis	Rubiaceae	Kadam
Mimusops elengi	Sapotaceae	Bakul
Diospyros malabarica	Ebenaceae	Gab
Alstonia macrophylla	Apocynaceae	
Alstonia scholaris	Apocynaceae	Chatim
Millingtonia hortensis	Bignoniaceae	Akas nim
Kigelia pinnata	Bignoniaceae	The sausage tree
Tectona grandis	Lamiaceae	Sagun
Trewia nudiflora	Euphorbiaceae	Pitali
Putranjiva roxburghii	Putranjivaceae	Jia pata
Bischofia javanica	Phyllanthaceae	
Trema orientalis	Cannabaceae	Jilan or Chikun
Artocarpus integer	Moraceae	Kathal
Ficus benjamina	Moraceae	
Ficus retusa	Moraceae	Jir
Ficus virens	Moraceae	Pakur
Ficus rumphii	Moraceae	Gaiasvattha
Ficus religiosa	Moraceae	Asvattha
Ficus benghalensis	Moraceae	Bot
Casuarina equisetifolia	Casuarinaceae	Belati jhau
Phoenix sylvestris	Arecaceae	Khajur
Borassus flabellifer	Arecaceae	Tal

Fig. 4.0: Photographs of some common avenue trees.

4.4 Ornamental Plants of India

Ornamentals are all those plants which are cultivated with the main aim of being marketed and used for decorative purposes. With a few exceptions (such are the flowers of daylilies *Haemerocallis* or those of nasturtiums *Tropaeolum*) they are not edible, or at least, not used primarily as food sources. Their short discussion in EOLSS (Encyclopedia Life Support Systems-UNESCO) is justified by the fact that ornamental plants are, and have always been, an indispensable part of human life: planted outdoors, they improve our environment, while in indoor use they contribute to our health, well-being and creativity.

Classification of ornamental plants

The range of ornamental plants is enormously wide and diverse, it includes practically the whole Plant World. (Most of them, however, belong to the higher plants.) Their classification is not so much on a botanical (systematic) basis, but instead is usually on a practical basis:

According to the method of cultivation we can distinguish protected cultivation and open-ground cultivation.

According to the application, the two main groups are plants used for indoor decoration and plants used for outdoor decoration.

In most cases, ornamental plants grown under protection (in glasshouses, plastic houses, etc.) are used for indoor and those grown in the open (without protection) are for outdoor decoration. There are, however, many overlaps and exceptions. Bedding plants, for example, are produced in protected structures but the finished product is planted out in the open. Fewer ornamental crops are grown (at least partially) in the open and later used for indoor decoration. Such are the flower bulbs grown for forcing, or open-ground cut flowers. Other examples are some foliage plants (*Yucca, Dracaena, Cycas,* etc.) which are grown first to half-finished stocks in the tropics in open ground, and after being transported to the place of final destination, they are finished under glass to market-ready products for use in the temperate zone. Based either on the method of cultivation or on use, further subdivision of the two main groups is essentially the same, and goes as follows:

Protected cultivation (plants grown and used mainly for indoor decoration), subdivided to :

- Cut flowers
- Cut foliage
- Pot plants (flowering pot plants and foliage pot plants)
- Bedding plants and balcony plants (annual, biennial and partially perennial ornamentals, grown under cover but used mainly outdoors)
- Open ground cultivation (plants grown mainly for outdoor decoration or as a starting material for protected cultivation)
- Woody nursery stocks (deciduous trees and shrubs, broadleaved evergreens, climbers, and conifers, grown either in the field or in containers)
- Herbaceous perennials (usually container- or pot-grown in perennial nurseries)
- Rose bushes (grown in specialized rose-nurseries)
- Flower bulbs, corms, and tubers (grown for forcing in greenhouses or for planting out in the open)
- Open-ground cut flowers and cut foliage
- Dried flowers, and
- Some bedding plants, grown (or finished) in the open.

Gardening which was only an art and science in the earlier days has now emerged as a huge industry. With the importance and need of gardening in improving and conserving the environment being strongly felt now, the concept of landscaping and gardening is growing rapidly. Ornamental gardening and landscaping have expanded as a multi-faceted industry encompassing activities such as propagating and rearing ornamental plants, landscaping, production of growing media, pots and other accessories, etc., generating huge employment opportunities and simultaneously promoting activities that would improve the environment.

For centuries a number of beautiful plants, mostly of Indian origin but a few imported from other countries, have been cultivated for aesthetic reasons in Indian gardens, and since the early days of the nineteenth century a succession of enthusiastic European botanists and gardeners have added to the list of exotic plants grown in Kolkata, until today they hold perhaps one of the richest collections of tropical plants of horticultural interest to be found in the world. Very fine displays of ornamental

trees may be seen in the Victoria Memorial Garden and in the grounds of the Tollygaunge club, as well as in the Royal Agri-Horticultural Garden and, of course, in the famous Royal Botanic Garden at Shibpur. Apart from many rare kinds found only in these collections, a complete list of the trees cultivated in private gardens around and about Kolkata would certainly include nearly all the species described in this book and probably a good many more as well. To attempt a complete account of all these species is clearly impossible here and all that can be done is to mention some of the commonest and the most striking.

- **The following have red or orange flowers (Fig. 4.1):**

Bombax ceiba (Simul). The silk cotton tree. A tall deciduous tree bearing large crimson flowers in early spring among the bare branches.

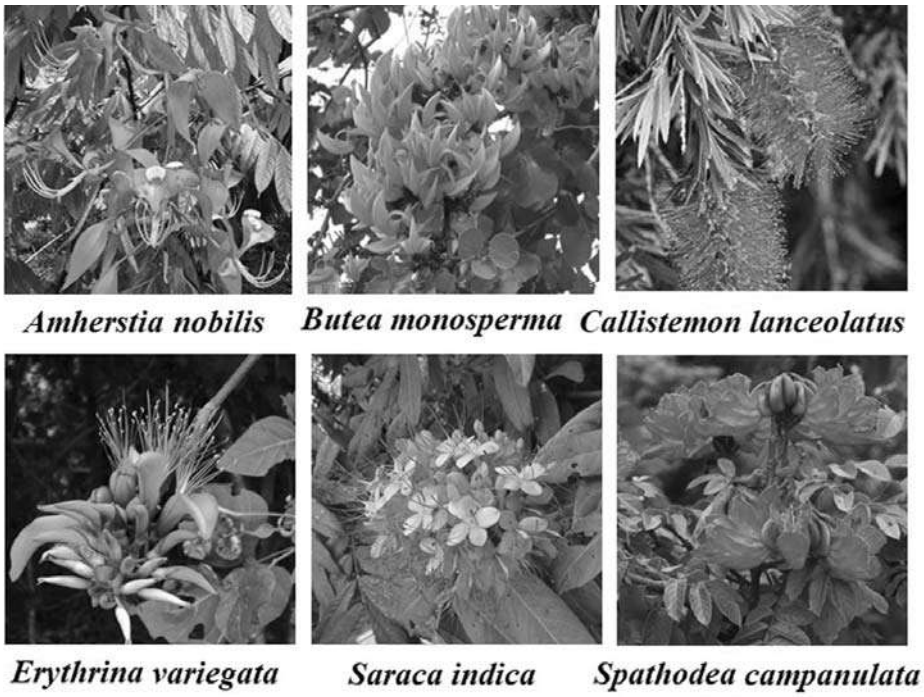

Fig. 4.1: Photographs of some ornamental plants.

Erythrina variegata (Palita mandar). A small tree or a shrub, bearing clusters of crimson flowers in early spring before the leaves appear.

Butea monosperma (Palas). “The flame of the forest”. An ungainly tree with large leaves, bearing in the early spring masses of scarlet flowers with brown velvety calyces.

Delonix regia (Gul mohr). "The gold mohur". A spreading tree with feathery leaves, bearing magnificent red or orange flowers at the end of the hot weather.

Colvillea racemosa. A rather rare relative of the last; bears tight clusters of dull orange flowers in August and September.

Saraca indica (Asoka). A low, spreading, evergreen tree bearing in the hot weather masses of small crimson, orange, or yellowish flowers close to the branches.

Brownea coccinea (Mountain Rose). A tree similar in general appearance to the last, bearing large dense clusters of bright red flowers in the hot season and also during the rains.

Amherstia nobilis (Pride of Burma, Urbasi). A low tree rather similar to the last two, bearing in the hot season magnificent pendulous sprays of scarlet and yellow flowers.

Callistemon lanceolatus (Bottle brush tree). A small evergreen tree with very narrow pointed leaves and red flowers arranged in cylindrical spikes near the ends of the twigs.

Cordia sebestena (Geiger tree). A low evergreen tree or shrub, bearing almost all the year-round small clusters of orange-red flowers at the ends of the twigs.

Spathodea campanulata (Rudrapalash). The African tulip-tree. A fairly tall evergreen tree bearing in the early spring large crimson flowers in compact clusters at the ends of the branches.

- **The following have pink or mauve flowers (Fig. 4.2):**

Hibiscus mutabilis (Sthalpadma). The changeable rose. A small tree or shrub with broad, lobed leaves and large flowers, which, in the typical variety, open pure white in the morning and fade through pink to deep crimson in the evening; other varieties remain pink throughout.

Kleinhovia hospita (Bola). A fairly tall evergreen tree with broad leaves, bearing small pink flowers during the latter part of the rains.

Sesbania grandiflora (Agati). A small quick growing tree, bearing large pink or white flowers from September to April.

Pongamia pinnata (Karanja). The Indian beech. A middle-sized, nearly evergreen tree with shining, bright green leaves and rather inconspicuous, dull pink or mauve flowers, born in May or June.

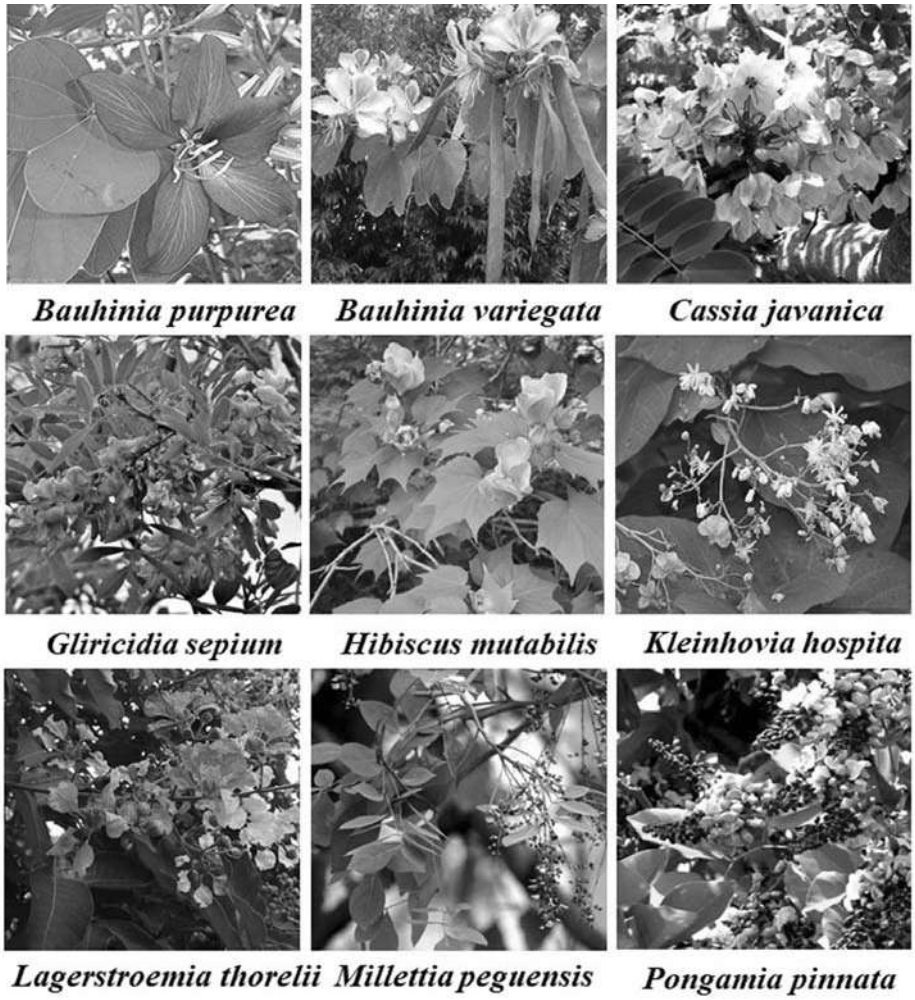

Fig. 4.2: Photographs of some ornamental plants.

Gliricidia sepium (Saranga). A small tree bearing pale pink or almost white flowers in dense clusters scattered along the otherwise bare branches in early spring

Millettia peguensis (Tuma). A very pretty little deciduous tree with a rounded crown and drooping twigs, bearing a profusion of bright mauve flowers in the early part of the hot season.

Cassia javanica (Burmese Shonalu Ful). A small spreading tree bearing pink and white flowers during the hot season.

Bauhinia variegata (Rakta kanchan). A small tree with leaves shaped like a camel's hoof-print, bearing in the early spring large white, pink, or purplish flowers on the bare branches.

Bauhinia purpurea (Deva kanchan). A tree similar to the last but bearing its flowers among the leaves at the end of the rains.

Albizia saman (Belati sirissa, The rain tree). A large spreading tree bearing rather inconspicuous pink flowers in the hot season and rains.

Lagerstroemia speciosa (Jarul). A tall tree with leaves in opposite pairs, bearing large flowers in open clusters at the ends of the branches in April and May. The common form has lilac flowers but there are varieties with pink and cerise flowers.

Lagerstroemia thorelii (Belati Jarool). A tree very similar to the last but smaller in all its part; bears mauve or pale purplish flowers during the rains.

- **The following have bright yellow flowers (Fig. 4.3):**

Cochlospermum religiosum (Sonali Simul) The yellow silk-cotton. A small tree with broad, lobed leaves, bearing large yellow flowers on the bare branches early in March.

Thespesia populnea (Paras). The Portia tree. A middle sized, evergreen tree with leaves shaped rather like those of the Peepul, and yellow, hibiscus-like flowers which fade to dull purple.

Brya ebenus. A low, slender, evergreen tree, or a shrub, with very small dark green leaves grouped in pairs, and scented orange flowers borne throughout the hot weather and rains.

Peltophorum pterocarpum (Radhachura). An evergreen tree of moderate size bearing yellow flowers in large clusters at the ends of the branches during the hot season.

Cassia fistula (Amaltas, Bandarlathi). "The Indian laburnum". A small deciduous tree bearing beautiful pendulous sprays of yellow flowers towards the end of the hot weather.

Cassia glauca. An evergreen shrub or a small tree, bearing numerous small clusters of yellow flowers at most seasons; the leaves are of a rather bluish green.

Cassia multijuga. A beautiful shrub or a small tree with bright green leaves and a rather straggling habit; the flowers are borne in large clusters at the ends of the branches in October or November.

Acacia auriculiformis (Akashmoni). A medium-sized evergreen tree with drooping twigs and minute yellow flowers combined in small spikes; the flowers are produced at intervals almost throughout the year.

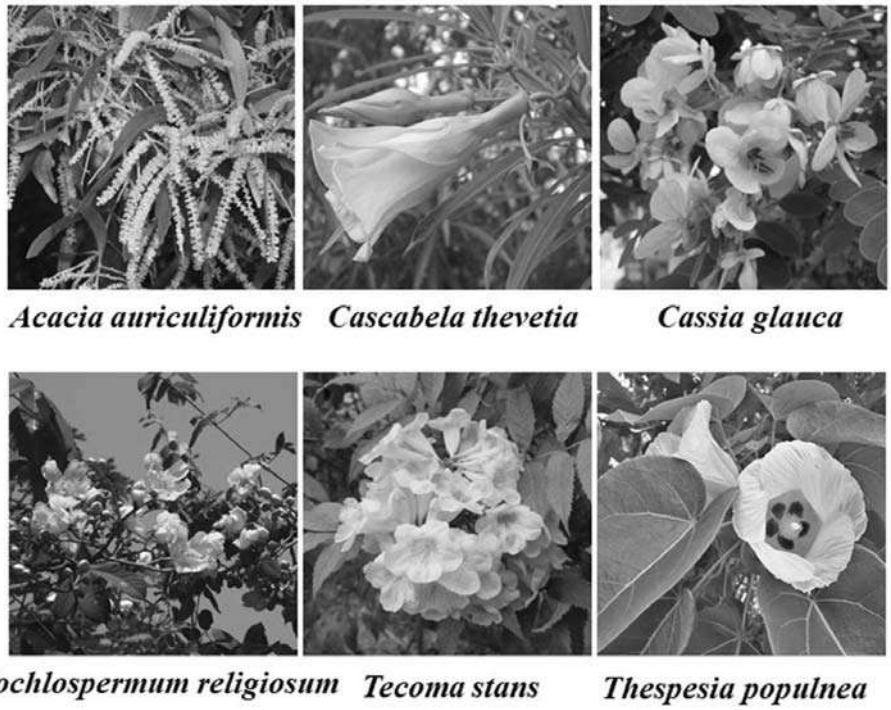

Fig. 4.3: Photographs of some ornamental plants.

Acacia farnesiana. A small thorny tree or a shrub with minute yellow flowers joined in small spherical heads; very like the common babul (*Acacia arabica* Willd.), but the flowers are scented. Blooms from June to February. Not very common.

Cascabela thevetia (Kokla phul). "The yellow oleander". A small spreading evergreen tree with very narrow leaves and large, yellow, pinkish, or whitish flowers borne almost all the year round.

Tecoma stans (Chandaprabha). An evergreen shrub or small tree bearing tubular yellow flowers in small clusters throughout the hot weather and rains.

- **The following have blue or lilac- coloured flowers :**

Lagerstroemia speciosa (Jarul). The common variety of this tree has lilac-coloured flowers. It is a tall tree, though it often blooms when only about 15 feet high. The flowers appear in April and May.

Jacaranda obtusifolia. A medium-sized, deciduous tree with fern-like leaves and numerous pale-violet flowers borne in clusters along the bare twigs, mostly in February and March.

Jacaranda mimosifolia (Neelkantha). A tree similar to the above but taller, with more finely divided leaves, and flowering later in March and April, or even later.

● **The following have flowers that are predominantly white or cream-coloured (Fig. 4.5):**

Muntingia calabura (The Chinese cherry). A small, spreading, evergreen tree with pointed leaves, which are silvery beneath, small white flowers, and cherry-like fruits.

Murraya paniculata (Kamini). An evergreen shrub or small tree with dark green leaves and short clusters of scented white flowers.

Gardenia jasminoides (Gandharaj). An evergreen shrub or small tree with dark green leaves and short clusters of scented white flowers.

Plumeria rubra (Gorurchampa). The frangipani. A small deciduous tree with large, dark green leaves and soft, thick twigs; the tubular white and yellow flowers are borne at the ends of the twigs throughout the hot weather and rains. There are several other species and cultivated varieties, some of which have red or yellow flowers, or various combinations of pink, yellow, and white.

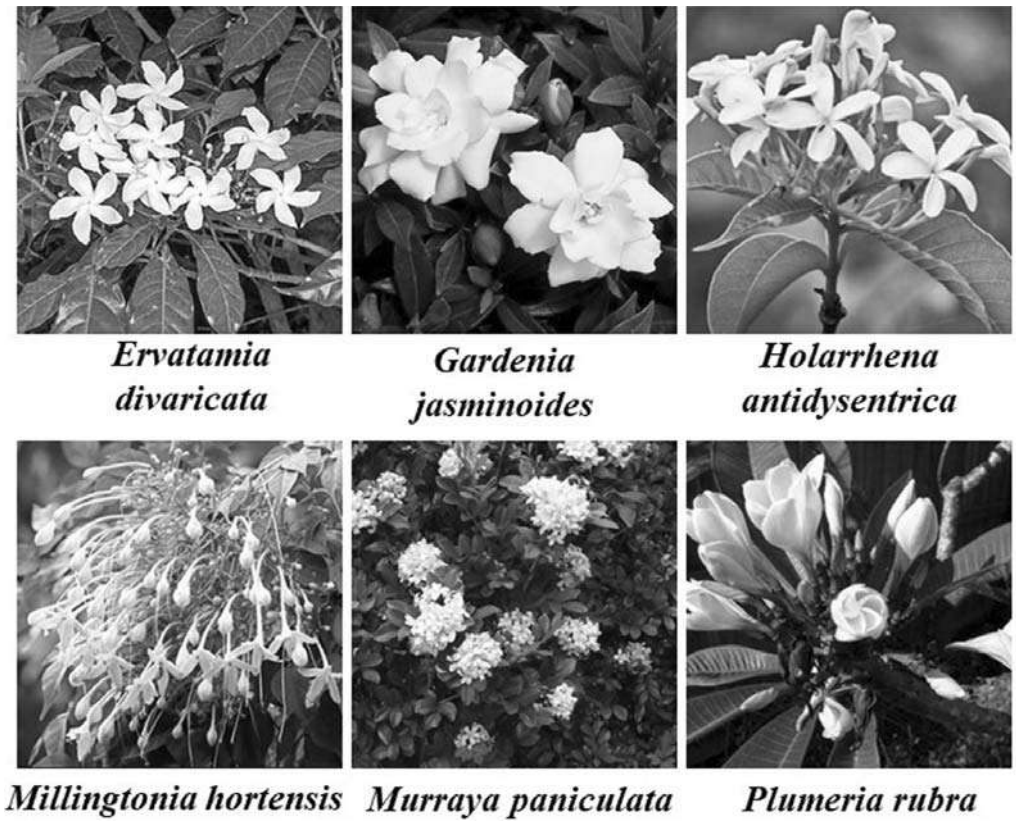

Fig. 4.5: Photographs of some ornamental plants.

Ervatamia divaricata (Tagor). An evergreen shrub or small spreading tree with narrow shining leaves and numerous white flowers, scented at night, borne almost throughout the year. Some varieties have flowers with yellow eyes and others have "double" flowers.

Holarrhena antidysentrica (Kurchi). The Easter tree. A small deciduous tree bearing creamy-white, scented flowers on the bare twigs in March and April.

Millingtonia hortensis (Akas nim). The Indian cork tree. A tall tree with corky bark, nearly vertical limbs and drooping twigs; the long, tubular, white, scented flowers appear in November and December.

- **The following are grown chiefly for their handsome foliage :**

Polyalthia longifolia (Debdaru). A variety of the common debdaru with short drooping branches giving the tree a pillar-like outline resembling that of a Lombardy poplar.

Caesalpinia violacea. A low evergreen tree with very graceful foliage and slender, spreading branches; it occasionally bears small clusters of yellow flowers.

Haematoxylum campechianum (The logwood tree). A low spreading tree with delicate foliage not unlike that of the last. It bears small, pale yellow flowers from January to March.

Albizzia richardiana. A very beautiful, lofty, evergreen tree with smooth bark, a few gradually spreading limbs, and feathery foliage borne only at the tips of the branches, forming a graceful, rounded crown.

Corymbia citriodora (The lemon-scented eucalypt). A fairly tall tree with a slender trunk, a few slender branches, and sparse foliage consisting of narrow, pointed leaves, highly scented when rubbed.

Grevillea robusta (Rupasi) A fairly tall tree with a slender outline and fern-like leaves, dark green above and silvery-grey beneath.

Araucaria columnaris (Christmas Tree). A tall tree with stiff, dark green foliage consisting of thorn-like leaves crowded on green twigs.

Araucaria cunninghamii (Christmas Tree). A tall tree rather like the last, but with softer, more cypress-like foliage.

Thuja orientalis (Jhau). A dense, evergreen shrub or small tree, often pyramidal in shape, with flat fern-like foliage.

In conclusion mention must be made of the various *Cycas* sp., and palms that make up an important part of the ornamental vegetation. In former days indigenous palms were much grown in Indian parks and gardens but they have now been almost entirely replaced by more graceful exotic kinds, e.g. *Roystonea regia*, *Dypsis lutescens*, *Liquala spinosa*, *Corypha* sp., *Sabal* sp., etc. (Benthall, 1984).

4.5 Alcoholic Beverages

One of the most important and best-known industrial fermentation is that in which ethyl alcohol is produced from sugars by yeasts. The chemical manufacturer, the brewer, the distiller, the baker, the vinegar manufacturer, the scientist, the housewife and many others depend in one way or another on the ability of the yeast to convert sugars to alcohol, carbon dioxide, and other end products. From the time immemorial the man has exploited the natural process of fermentation, and used its products for his own pleasure. In all ages, he has celebrated the occasions with alcoholic beverages. Today the alcoholic beverages are consumed all over the world. Alcohol is a poison, and when taken to excess, produces hazardous effects on the human system. The alcoholic beverages bring about cerebral excitation, followed by depression, and may produce the complete, though temporary, suppression of the functions. The evils of excessive drinking are known all over the world.

4.5.0 Manufacture of ethyl alcohol

Generally, the ethyl alcohol is manufactured from molasses. The molasses mash is adjusted to the desired sugar concentration and temperature by the addition of water and to the desired pH by the addition of a measured quantity of acid. A yeast ‘starter’ is mixed with the mash in the fermentation tank, which is usually covered. Streams of the adjusted mash and the starter flowing simultaneously into the fermenter may be caused to converge on a baffle board located in the upper part of the tank. The mash and starter become well mixed as they spatter and fall to the bottom of the tank. The fermentation rapidly becomes vigorous with the evolution of large quantities of carbon dioxide. In the modern plant, this gas is collected, purified and used for the manufacture of dry ice or for other purposes. Within 50 hours or less the fermentation is usually complete. The fermented molasses, is distilled in a continuous still to separate the alcohol and other volatile constituents from the mash. The alcohol

is purified by means of rectifying columns and then stored in a bonded warehouse. There are two distinct categories of alcoholic beverages:

l. The fermented beverages - the alcohol is formed by the fermentation of sugar.

2. The distilled beverages - by the distillation of some alcoholic liquor.

4.5.1 Fermented Beverages

Beer : *Brewing* or the production of malt beverages, is the name given to the combined process of preparing beverages from infusion of grains that have undergone sprouting (*malting*), and the fermenting of the sugary solution by yeast, whereby a portion of the carbohydrate is changed to alcohol and carbon dioxide. It is an ancient industry and was probably invented by the Egyptians.

Composition of beer : The substances found in a beer depend largely upon the nature of the quality of the raw materials, the treatment of the sprouted grain or malt used in mashing, and the character of the ensuing fermentation, but storage and finishing operations affect the final composition. In normal beer carbohydrates – such as dextrin, maltose and glucose – and protein derivatives – such as peptones, amino acids and amides are present. The products are produced mainly as the result of the action of the enzymes of the malt. Hops contribute bitter substances such as resins, essential oils and tannins. As a result of alcoholic fermentation, the sugars of the wort are being converted, in part to ethyl alcohol and carbon dioxide. Some of the amino acids are being transformed to higher alcohols and acids. Salts and traces of oil are always found. The finished beer contains 82 to 92 percent water by volume.

Kinds of beer

Lager beer: It means literally, the stored beer. Larger beer is produced by bottom fermentation and is rather high in alcohol and extract with a relatively low proportion of hops.

Bock beer: This is a heavy beer, dark in colour and high in alcohol. It is brewed for consumption in early spring.

Ale: It is produced by top fermentation. It is pale in colour, tart in taste, and high in alcohol and contains more hops than does beer.

Porter: It is a dark ale, high in extract and sweeter than the usual ale in taste. It is brewed from dark or black malt (malt roasted at a high temperature) to produce a wort of high extract.

Stout: It is a strong porter that is high in alcohol and extract. It is dark in colour and possesses a sweet taste and strong flavour of malt. The flavour of hops is better than porter.

Weiss beer: A beer made mainly from wheat, is produced by top fermentation. It is rather light, possesses a distinct flavour of malt and hop, is tart and contains a large quantity of natural fermentation gas. It is somewhat turbid in appearance.

Cereal beverage: This beer contains less than 0.5 per cent alcohol. It is sometimes known as 'near beer'.

4.5.2 Other Fermented Alcoholic Beverages

Fermented alcoholic beverages are consumed all over the world. In some countries the use of a particular beverage has been passed down from ancient times, for example, *Kuass* in Russia, *Pulque* in Mexico, *Sake* in Japan, *Taette* in Scandinavia and *sorgho* in Manchuria. Some beverages are enlisted here.

Kuass: It is prepared by mixing equal parts of barley malt, rye malt and rye flour, adding boiling water, and then inoculating with yeast and permitting fermentation to take place. Peppermint is added to the fermented product for flavouring. This beverage is quite common in Russia.

Pulque: It is a common fermented alcoholic beverage in Mexico. It is prepared by allowingthe sweet juice of agave to undergo fermentation which usually completes in one day. Yeasts produce alcohol from the sugars.

Hardcidar: The fresh apple juice is allowed to ferment for 24 hours. It gradually increasesin alcoholic content and hard cider is resulted. Instead of apple juice pear juice may also be fermented.

Taette: It is a common fermented alcoholic beverage in Scandinavia. It is an alcoholic beverage prepared from milk. Yeasts cause the characteristic changes in flavour. It has a pleasant acid taste.

Sake: It is the widely used alcoholic beverage of the Japanese. It is a yellow rice wine containing 14 to 24 per cent of alcohol. It is prepared by fermenting rice. No hops are used. It has been used in Japan for 2600 years.

Pombe: This is an alcoholic beverage made by permitting millet grain to sprout and undergo conversion of the starch to sugars and by allowing a spontaneous fermentation of the starch water.

Ginger beer: It is characterized by its distinctly acid nature, the ginger flavour, and presence of a small amount of alcohol.

Palm wine: The fermented juice obtained from the inflorescences of many palms is a beverage of great antiquity. Palm wine or toddy (Tari) was known to Herodotus as early as 420 BC. The important species of palms which yield toddy are *Phoenix dactylifera, Borassus flabellifer, Cocos nucifera,* etc.

Root beer: It consists of an infusion of various roots, barks and herbs, with the addition of sugar and yeast. The herbs commonly used for the purpose are ginger, sarsaparilla and winter green. Fermentation sets and the beverage becomes charged with carbon dioxide.

Wine : Wine is the product made by the normal alcoholic fermentation of the juice of sound, ripe grapes (*Vitis vinifera*). Relatively small amounts of wine are made from apples, raisins, berries, peaches, cherries, oranges, currants, apricots, grapefruit, pomegranates, raspberries, pears, honey and strawberries. The wine made from the fruit is named after the fruit, for example, 'apple wine'.

Wine-making areas: A large part of the world's wine is made in the countries located near the Mediterranean Sea. France leads the world in wine making, followed by Italy, Spain, Algeria, Portugal, Rumania, Argentina, Russia, Hungary, Yugoslavia, United States, Chile, Greece, Bulgaria, South Africa, Germany and other countries. In France, the region around Bordeaux produces most of the wine. This district is the most outstanding single wine producing area in the world. Burgundy wines are produced in the hilly country of the Cote d' Or in east central France. Champagnes are produced in the vicinity of Reims and Epernay. Only wines made in this Champagne region have a right to the name. Black and red grapes are used and the manufacture involves a series of elaborate processes which extend over a period of six or seven years.

Making of wine: Selected grapes of the proper maturity are crushed and stemmed; treated with sulphur dioxide, or a sulphite, or pasteurized; and inoculated with a starter containing a pure culture of yeast. After a short fermentation period the wine is drawn off, placed in storage tanks for further fermentation, racked, stored for aging and packaged. Wines vary considerably in their characteristics. The alcoholic content varies from 7 to 16 per cent. The sugar content of the grapes is from 12 to 18 per cent. Fermentation of the fruit juice is carried on in vats, usually with the aid of selected yeasts (strains of *Saccharomyces cerevisiae*). The optimum temperature is

68°F. The aroma and flavours are due to various aromatic principles present in the fruit. The characteristic bouquet develops only after the wine has been aged from four or five years to several decades. White wines are made from white grapes, or expressed juice. Red wines are made from coloured grapes and derive their own colour from the pigments present in the skins of the fruits. (Pandey, 2006).

4.5.3 Distilled Beverages

Whisky: Whisky is an alcohol distillate from a fermented mash of grains. Whisky is obtained by distillation from a fermented mash of malted or unmalted cereals or potatoes. After several distillations of the mash the "low wines" are resulted. Further distillation yields the "high wines". A mixture of water and high wines makes straight whisky. At first several principles are present which make whisky harsh and unpalatable. It must be aged to allow these principles to disappear. The whiskies are aged in charred oak containers. At first the whisky is colourless; the colour develops during the aging process. A continued distillation of high wines results in the formation of 'neutral spirits' which are used in blended whiskies and cordials. The Scotch whisky is prepared from barley malt. Irish whisky is made from malt or unmalted grains of barley, oats and maize. The Russian Vodka is made from fermented wheat mash. The Vodka is not aged and bottled immediately after distillation and therefore, it remains colourless.

Rum: Rum is an alcoholic distillate from the fermented juice of sugarcane, sugarcane syrup, sugarcane molasses or other sugarcane by-products. Rum is manufactured in general in the countries which grow sugarcane or import molasses or other sugarcane products. It possesses a characteristic flavour, aroma, and colour. The flavour and aroma, improve with aging. Rum contains about 40 percent alcohol. Rum is usually aged in charred white-oak barrels. Rum may be used in the preparation of ice cream, candies and mincemeat; in the curing of tobacco; as a beverage; and as a medicinal.

Brandy: Brandy is distilled only from wine. It is also distilled from the fermented juice of various fruits. The best brandy is made in France in the Charente district. Only this product is known as *cognac*. The other French brandies are known as *armagnac*. The finest grades of brandy are made from white wines. The brown colour of brandy develops when it is stored in wooden casks. Sometimes the brandy is

coloured with caramel. It contains about 65 to 70 percent alcohol. Apple brandy is known as applejack.

Gin: It is obtained by distillation from a fermented mash of malt or raw grain. The finest gin is distilled from the malt of barley and rye. It requires several distillations. The flavour of gin and any medicinal value are due to oil of juniper. (Pandey, 2006).

4.6 Fruits and Nuts: Important Fruit Crops Their Uses

India grows a large variety of fruits belonging to the tropic and temperate regions. However, their present availability is only 1.5 ounces per adult per day, whereas a balanced diet requires 3 ounces of fruits per adult per day. A good number of the fruits grown in India are introduced from foreign countries. The climatic diversity of the Indian Subcontinent has generated significant genetic diversity in cultivated tropical, subtropical, temperate, and arid fruits. Rich diversity is also exhibited in the wild relatives of these fruit types. Tropical fruits constitute a major proportion of the spectrum of fruit diversity available with large cultivation of indigenous fruits like mango (*Mangifera indica*), banana (*Musa* spp.), citrus fruits (*Citrus* spp.), jackfruit (*Artocarpus heterophyllus*), litchi (*Litchi chinensis*), etc., which produces about 66.4% of the annual fruit production. The cultivation of temperate fruits in the subcontinent extends from Northwest Himalayas, starting from Jammu and Kashmir to the subtropical plains in the north, to Arunachal Pradesh in the Eastern Himalayas. These fruits are also grown in the hilly regions of South India around 100°N and 75°E. Apple (*Malus domestica*), pear (*Pyrus communis*), peach (*Prunus persica*), plum (*Prunus domestica*), almond (*Prunus amygdalus*), apricot (*Prunus armeniaca*), cherry (*Prunus avium*), and walnut (*Juglans regia*) are commercially cultivated in the Northwest Himalayan region (Jammu and Kashmir, Himachal Pradesh, and Uttarakhand). The hot arid and semi-arid region spread over the Northwest India occupies around 12% of countries land, covering the states of Punjab, Haryana, Rajasthan, Gujarat, Maharashtra, Andhra Pradesh, and Karnataka. These regions have comparatively few fruit species, but there is wide diversity within species, though confined to small pockets. Many fruits, such as amla (*Emblica officinalis*), bael (*Aegle marmelos*), kul (*Ziziphus mauritiana*), chironji (*Buchanania lanzan*), jamun (*Syzygium cumini*), karonda (*Carissa carandas*), ker (*Capparis decidua*), khejri (*Prosopis cineraria*), lasoda (*Cordia myxa*), phalsa (*Grewia asiatica*), pilu (*Salvadora*

persica), date palm (*Phoenix* sp.), and wood apple (*Limonia acidissima*), are indigenous and present significant genetic diversity. Comparatively fewer species occur in the northern and north western plains and in the Aravalli hills, such as *Carissa congesta*, *Capparis decidua*, *Grewia asiatica*, and *Ziziphus* spp. (*Z. mauritiana, Z. nummularia*).

Morphologically a fruit is the seed-bearing portion of the plant, and consists of the ripened ovary and its contents. Simple fruits are derived from a single ovary, and compound fruits from more than one. The aggregate fruits are formed from numerous carpels of the same flower, while composite fruits develop from the ovaries of different flowers of an inflorescence. In the next portion important fruit crops with their uses have been discussed.

4.6.0 Tropical Fruits

Mango. *Mangifera indica* L.; Family – Anacardiaceae; Eng.-mango; Bengali-Am; Hindi-Am, amb. (Fig. 4.6)

Fig. 4.6. Mango

Uses. The mango fruit is one of the most highly prized dessert fruits of the tropics. It has a rich, luscious, aromatic flavour and delicious taste in which sweetness and acidity are delightfully blended. Young and unripe fruits are usually acidic and used in pickles, chutney, and culinary preparations. Ripe fruits are preserved by canning or used in manufacture of juice and squash, jams and jellies, preserve (murabba) and ampapur. Sucrose, glucose and fructose are the principal carbohydrates present in ripe mango; maltose is also present. Unripe fully developed mangoes of pickling varieties contain citric, malic, oxalic, succinic acids. As the fruit ripens the acidity gradually decreases with a steep fall at ripe stage. Ripe fruits constitute a rich source of vitamin A; some varieties contain fairly good amounts of vitamin C also. The fruit is a rich source of potassium.

Ripe mango fruit is considered invigorating, refreshing and fattening. The juice, along with aromatics, is recommended as restorative tonic. It contains vitamins A and C and is useful in heat apoplexy.

Citrus Fruits. (Fig. 4.7) They are supposed to be natives of Eastern and Southern Asia. Some of the citrus fruits have been cultivated for over 3,000 years. The citrus fruits contain considerable amounts of the essential vitamin C, the antiscorbutic vitamin as well as fruit acids. They are also used in the preparation of juices, squashes and other canned products.

Fig. 4.7. Citrus

***Citrus aurantiifolia* (Christm.) Swing.,** Family-Rutaceae; Eng.-Lime; Hindi-Kaghzinimbu; Bengali-Kaghzinimbu, patinebu.

Uses. The fruits make a good source of vitamin C. They are used raw and pickled. The oil distilled from the peel is used in confectionery, pharmaceuticals and toilet preparations. Fruits are extensively used for culinary purposes; for flavouring jams, jellies, marmalades, and alcoholic drinks, and as a garnish. Considered as appetizer, stomachic, and antiscorbutic.

***Citrus reticulata* Blanco;** Family-Rutaceae; Eng.-Mandarin; Hindi-santara; Bengali-Kamala.

Uses. The fruits are delicious. They are rich in vitamin C. The peel is used for marmalades. The essential oil is distilled mainly in Nagpur and Coorg and used in confectionery, pharmaceuticals and toilet preparations. It is most valued commercial orange. Fruit is used mainly as dessert and in the production of orange juice. Petitgrain oil is obtained from leaves and twigs. peels yield Mandarin Oil.

Citrus sinensis (Linn.) osbeck; Family-Rutaceae; Eng.-Sweet orange; Hindi-Musambi; Bengali-Musambi.

Uses. The fruits are edible. They are good source of vitamin C. The peel is the source of orange oil. Fruit is sweet and juicy, nutritious, highly esteemed dessert fruit. peels are the source of an essential oil called orange Oil. Flowers also yield an essential oil, Neroli Oil. Leaves and young roots are another source of Petitgrain Oil. Fruit juice is useful in bilious affections.

***Citrus aurantium* L.;** Family-Rutaceae; Eng.-Sour orange; Hindi-Khatta.

Uses. The fruits are edible. The leaves are the source of an essential oil, which is used in confectionery, cosmetics and perfumery. Used in the preparation of

confections, marmalades, liqueurs, and other drinks. Rich source of provitamin A and B. Lime oil obtained from the fresh rinds is the source of Bergamot Oil extracted from the peels. Leaves and tender twigs yield Petitgrain oil.

***Citrus maxima* (Burm.) Merrill**; Eng. Shaddock; Hindi-Chakotra; Bengali-Mahanibu, Sadaphal.

Uses. The fruits are edible. They are good source of vitamin C (ascorbic acid). Fruits esteemed for dessert; made into jams and marmalades; considered nutritive and refrigerant. Leaves are used in epilepsy, chorea, and convulsive coughs.

***Citrus medica* L.;** FamilyRutaceae; Eng.-Citron; Hindi-Baranimbu; Bengali-Bara nimbu, begpura.

Uses. The fruits are edible. They are enriched with vitamin C. Fruits are used mainly for pickling, also candied. Peel is made into marmalades and other preserves. Preserved rind is used in dysentery. Citron oil is obtained from fresh rinds.

***Citrus limettioides* Tanaka**; Family-Rutaceae; Eng.-Sweet lime; Hindi, Bengali-Mithanimbu;,

Uses. The fruits are edible and good source of vitamin C. It is also used as a root stock for sweet oranges and mandarins. The leaves yield an essential oil known as ‘petitgrain oil’, which is used in confectionery and cosmetics as a flavouring substance.

***Citrus paradisi* Macf.;** Family-Rutaceae; Eng.-Grapefruit.

Uses. The fruits are edible. Rich in vitamin C. Also, a fair source of vitamin B1. Used mainly as a breakfast fruit. Rinds yield grapefruit oil, employed in perfumery and as a flavouring. Grapefruit juice is recommended for building up resistance to common colds. Dry and fortified wines, brandies and cordials are prepared from the fruits.

***Citrus limon* (L.) Burm. f.;** Family-Rutaceae; Eng.-Lemon; Hindi-Nimba; Bengali-Baranebu, goranebu.

Uses. The fruits are eaten raw and pickled. The juice is used for lemonade and other beverages and as a flavouring substance. Bleaching agent and stain remover. The rind is the source of oil of lemon. Lemon oil is used in perfumery and toilet soaps. It is also utilized in confectionery. Used for culinary purposes and in the preparation of beverages. Citric acid, pectin, and lemon oil are obtained as by products. Oil of lemon is also used as carminative and for flavouring liqueurs. Lemon juice is very useful for scurvy. Pickled fruit is useful in hypertrophy of spleen.

Litchi

***Litchi chinensis* (Gaertn.) Sonn**.; Family-Sapindaceae; Eng.-Litchi; Hindi-Lichi; Bengali- Lichu.

Uses. Litchi fruits are usually consumed fresh. They remain in fit condition for 3-5 days. The litchi fruit consists of peel, aril and seed. The aril which can be readily separated from seed, is soft and juicy with a delicious flavour and is generally eaten fresh. Litchi arils can be preserved try canning with syrup.

Banana

***Musa paradisiaca* L.;** Family-Musaceae; Eng.-Banana; Hindi-Kela; Bengali-Kola.

Uses. There are many varieties of bananas. The most popular ones are – *Poovan* of Tamil Nadu which is also known as *Lalvelchi* in Maharashtra, *Champa* in Bengal and *Karpura Chakkerakeli* in Andhra Pradesh. *Basrai Dwarf* also known as *Dwarf*, in certain places, *Yamankeli* in South India. *Kabuli* in Bengal and Orissa, *Bhusavali* in Maharashtra and Madhya Pradesh. *Harichhal*, also known as Bombay green in certain areas '*Nendran'* and '*Kadali'* varieties of Kerala are also important.

Uses. The fruits are edible. They have a high content of carbohydrates with some fats and proteins. Their food value is three times that of wheat. Green bananas may be cooked and eaten as vegetable, Banana powder can be used as baby food and in the manufacture of chocolate and biscuits.

The Kerala banana chips famous all over India, are prepared from raw '*Nendran'* varieties. Ripe '*Nendran'* when cooked in steam and dried under the Sun, can be kept months together like dried date palm fruits and it forms a very good breakfast.

Edible bananas of hybrid origin valued for their seedless fruits. Unripe fruits are eaten as vegetable. Fruit-pulp is dried and made into flour; used also for jams and jellies, sugar coated chips and several Indian confections. It makes a fair source of minerals and vitamins particularly of B group. Peels are used as cattle feed. Inflorescence before opening is used as a vegetable. Core of pseudostem is eaten after cooking; starch in pseudostem is used for finishing of textiles. Banana fruit is laxative and used in intestinal disorders, uraemia, nephritis, hypertension and other vascular diseases. It is a very nutritious fruit.

Guava

***Psidium guajava* L.;** Family-Myrtaceae; Eng.-Guava; Sanskrit-Mansala; Hindi-Amrud, safed safari; Bengali-Goachhi, peyara, piyara.

Uses. The fruits are edible. It is aromatic, sweet, juicy and highly flavoured. Ii contains acid, sugar and pectin. It is one oi the richest sources of vitamins A, B and C and of ascorbic acid. It is commonly used for making jellies, jams and pastes.

Fruits are also canned, preserved, spiced or made into jam, butter, marmalade, pies ketchups and chutneys. Seeds yield a fatty oil. Leaves contain an essential oil used as a flavouring. Leaves are used as an astringent for bowel troubles. Decoction of bark is given in diarrhoea. Fruits are tonic. cooling, and laxative, useful in colic and bleeding gums.

Sugar Apple

***Annona squamosa* L.;** Family Annonaceae; Eng. Sugar apple; sweet sop; Hindi-Sharifa; Sanskrit-Sitaphal; Bengali-Ata. (Fig. 4.8)

Uses. The fruits are edible and quite popular. The pulp of fruit is eaten. The edible pulp is juicy white or cream-yellow delicately flavoured, sweet flesh. They can be made into drinks and fermented liquor. Seeds yield a fatty oil.

Fig. 4.8. Sugar apple

Papaya

***Carica papaya* L.;** Family-Caricaceae; Eng.-Papaya; Hindi-Papita; Bengali-Pappaiya, pepe.

Uses. It is an excellent breakfast fruit. The orange coloured flesh possesses sweet musky taste. It is also used for salads, sherbets and confections. Unripe fruits are cooked as vegetable and pickled. The latex, obtained from the fruits, is used in preparing chewing-gums and for tenderizing meat. It is also used in medicine as an anthelmintic. The latex of papaya is known as papain which is used medicinally. The ripe fruits are source of vitamins and papain. Fruit pulp may be used as an ingredient in face creams and hair shampoos. Milky juice of unripe fruits is used as a cosmetic to remove freckles and other blemishes from the skin. Plant yields a blood anticoagulant. Leaves yield an alkaloid carpaine. Seeds yield a fatty oil.

Pomegranate

***Punica granatum* L.;** Family-Punicaceae; Eng.-Pomegranate; Hindi-Anar; Bengali-Dalim. (Fig. 4.9)

Fig. 4.9. Pomegranate

Uses. This is a very refreshing fruit. The bark and fruit shells are used for tanning. The peel of the fruit is used medicinally in dysentery and diarrhoea. Fleshy testa is edible. Among the numerous types grown, *Bedana* and *Kandhari* are considered the best. Seeds of wild trees are sour and dried ones constitute *Anardana*, used as condiment. Fruit is a good source of sugars, vitamin C, and a fair source of iron, but poor in calcium. Seed juice is a favourite drink, and may also be used for making wine. Bark is used to expel tapeworms, *iso-pelletierine* is the most potent among the active principles; given as decoction. Rind is used as an astringent in diarrhoea and dysentery. Flower-buds are used in bronchitis. Fruit rind is rich in tannin and used as a tanning material, also yields a dye. Flowers yield a red dye.

Pineapple

***Ananas comosus* (L.) Merr.**; Family-Bromeliaceae; Eng.-Pineapple; Hindi-Ananas; Bengali-Anaras. (Fig. 4.10)

Fig, 4.10. Pineapple

Uses. The fruits are edible. In addition to the content of sugar and fruit acids, a valuable digestive ferment, *bromelin*, is present. The slices of pineapples and pineapple juice are canned for export and domestic consumption. In the fresh form the fruit is a good source of vitamins A and B and is very rich in vitamin C. It is highly valued as a fresh fruit. In countries like Hawaii, Australia, etc., where the canning industry is well developed, as much as 40% or more of the total small quantities are consumed by the industry.

The dried waste after extraction of juice, known as pineapple bran, is a valuable stock feed. Alcohol, calcium citrate, citric acid and vinegar are other products for the

manufacture of which pineapple juice is utilized, although in small quantities. The leaves are the source of a strong fibre, which is made into fabrics. Pineapple waste is used for making vinegar. Juice from ripe fruit is diuretic and antiscorbutic (vitamin C 63 mg/100 gm); that from unripe fruits, purgative and abortifacient. Leaves yield a fibre, Pina, a delicate fabric of Philippines, is made from the fibre. Waste material, after extraction is used for paper making.

Date Palm

***Phoenix dactylifera* L.**; Family: Arecaceae; Eng.-Date Palm; Hindi-Pindkhajur; Bengali-Khajur, Khejur.

Uses. The dried fruits are rich in sugar (75-80%), mainly glucose and fructose. In addition, it also contains a very significant level of potassium, iron and nicotinic acid. The fruits are used as common table fruit and also used in jams, alcoholic beverages, pastes, etc. The dates are also used in bakery and made into preserves. Brandy of good quality is prepared from dates. Sap is sweet, nutritive and laxative; used for preparation of jaggery and sugar. The dates are demulcent, expectorant, and also used in respiratory diseases and fever. Leaves are used in the preparation of mats etc. The fibre from leaves is used for making ropes, baskets, and cordage.

Jambolana

***Syzygium cumini* (L.) Skeels**; Family-Myrtaceae; Eng.-Java plum, Jambolana; Hindi- Jamun; Bengali-Jam, Kalajam.

Uses. The fruits are edible. They are rich in Iodine. The vinegar is prepared from fruit juice. The seeds are used as fodder. A spirituous liquor as well as wine is prepared from the ripe fruits. The fruits are also used for making preserves, jams, squashes, and jellies.

Bael

***Aegle marmelos* (L.) corr.;** Family-Rutaceae; Eng.-Bael; Hindi-Bel; Bengali-Bel.

Uses. The ripe fruits are edible. The cold drinks and squashes are prepared from the fruits. The unripe fruits are eaten after roasting. The fruits are used as astringent, stomachic and also in the treatment of diarrhoea and dysentery. The mucilaginous substance of the fruits is used as gum and is also used as varnish. The pulp of ripe fruits is aromatic and cooling and used in the form of sherbet. Marmelosin is the active constituent; it acts as a laxative and diuretic, in strong doses a cardiac depressant. Dried fruits, freed from pulp, are used as pillboxes. Stem yields a gum. Leaves contain an essential oil.

Water Melon

***Citrullus vulgaris* Schrad. ex Eckl. & Zeyh**; Family-Cucurbitaceae; Eng.-Water melon; Hindi-Tarbooz; Bengali-Tarmooz. (Fig. 4.11)

Fig. 4.11. Water Melon

Uses. The red pulp of the fruit is eaten. The white solid flesh of the fruit is used for making jams, jellies and preserves. The seeds are used as food. They are considered cooling, tonic, diuretic; yield a fatty oil. Fruit juice forms a cooling and refreshing beverage; also considered diuretic.

Melon

***Cucumis melo* L.;** Family-Cucurbitaceae; Eng.-Melon; Hindi-Kharbuza; Bengali-Kharmuj. (Fig. 4.12)

Fig. 4.12. Kharmuj

Uses. The fruits are edible. They are rich in sugar and proteins. The melons are eaten as dessert. The seeds are edible and contain a fixed oil. The seeds are diuretic, refrigerant and nutritious. The pulp is useful in chronic eczema.

4.6.1 Temperate Fruits

Apple

***Malus pumila* Mill.;** Family-Rosaceae; Eng.-Apple; Sanskrit-Seba; Bengali and Hindu-Seb, sev. (Fig. 4.13)

Fig. 4.13. Apple

Uses. Apples are valued mainly as dessert fruits. Fruits may be preserved for later use after slicing and drying; they are also canned and jams and jellies are made from them. The juice extracted from the fruits is used fresh or after fermentation into cider wine and vinegar; apple brandy is obtained by distilling cider.

Apples are rich in pectin and are useful in diarrhoea. Apple juice, syrup and vinegar reduce curd tension of milk used in infant feeding. *Apple murabba*, a preserve popular in India, is regarded as a stimulant for the heart; it is reported to relieve physical heaviness and mental strain. The vitamins, salts and organic acids are concentrated particularly in and just below the skin. and the fruit should be eaten unpeeled. Apple is considered as a good source of potassium. The edible portion of fresh apples contains Ca, Mg, K, Na, P, Cl, S and Fe. The mineral constituents of the apple are considered valuable for human nutrition.

Pear

***Pyrus communis* L.;** Family-Rosaceae; Eng.-Pear; Hindi-Nakh, Bengali-Nashpati. (Fig. 4.14)

Fig. 4.14. Pear

Uses. The fruits are edible. They are eaten as such or canned. The fruits are rich in sugars, salts, and vitamins.

Plum

***Prunus domestica* ssp. *insititia* (L.) Schneid.**; Family-Rosaceae; Eng.-Plum; Hindi-Alucha, alubukhara.

Uses. Plums are used for fresh fruit, cooking, canning, and jams.

Sweet Cherry

***Prunus avium* L.;** Family-Rosaceae; Eng.-Sweet Cherry; Hindi-Gilas.

Sour Cherry

***Prunus cerasus* L.;** Family-Rosaceae; Eng.-Sour Cherry; Hindi-Alubalu.

Uses. Cherries are used as table fruits and in canning. Cherry brandy is distilled from cherry juice. The juice is also used for syrup, cherry cidar and jelly.

Peach

***Prunus persica* (L.) Stokes;** Family-Rosaceae; Eng.-Peach; Hindi-Aru.

Uses. The fruits are edible. They are the most popular fruit for canning. The oil obtained from the seeds, is used for cooking and as illuminant.

Apricot

***Prunus armeniaca* L.;** Family-Rosaceae; Eng.-Apricot; Hindi-Khubani. (Fig. 4.15)

Fig. 4.15. Apricot

Uses. They are used as a table fruit in the regions where they are grown. They are also canned and candied. The oil obtained from the seed, is used for cooking, burning and for the hair. The seed is also known as anticancerous.

Strawberries

***Fragaria vesca* L.;** Eng.-Perpetual strawberry

Uses. Strawberries are a dessert fruit primarily, but are also canned and used in jams and preserves, and as a flavouring material.

Raspberries

***Rubus ellipticus* Smith;** Family-Roasceae; Eng.- Himalayan yellow raspberry; Hindi-Lal anchu, hisalu.

Uses. It is used freshed or cooked, and is utilized for jams, jellies, vinegar and as flavouring material.

Mulberry (Fig. 4.16)

***Morus alba* L.;** Family-Moraceae; Eng.-White mulberry; Hindi-Tut; Bengali-Tut.

***Morus australis* Poir.;** Eng.-Common mulberry; Hindi-Tut.

Fig. 4.16. Mulberry

Uses. The fruits are edible. The leaves are the source of food of silkworms. The fruits are refrigerant, used also for sore throat, dyspepsia and melancholia. The leaves are rich in calcium and vitamin C, and eaten as vegetable. The fruits are also used in the form of juices, stews and tarts, and fermented to yield spirituous liqueurs.

Grapes

***Vitis vinifera* L.;** Family-Vitaceae; Eng.-Wine grape; Hindi-Angur, Bengali-Angurphal. (Fig. 4.17)

Fig. 4.17. Grapes

Uses. Grape is a delicious, refreshing and nourishing fruit. It is classed as a protective food, is easily digestible and has large quantities of sugar, minerals like calcium and iron, and vitamin B.

Grapes good for eating fresh are called "table grapes". Some varieties are known as 'raisins', can better be dried and preserved, while others are used in making juices and wines. Black grapes are also dried and preserved like raisins. They are available in plenty in South India.

4.7 Wood and its uses

From the time immemorial food, clothing, and shelter have been the three great necessities of mankind. The wood is the most familiar and most important forest products. The wood has contributed a lot to the advancement of civilization. Today the wood is the most widely used commodity other than food and clothing. It is one of the most important and versatile of the raw materials of the industry. It has so many advantages over the metals.

It is cheap, light and may easily be worked with tools. It is very strong for its weight and it is embodiment of strength, toughness, and elasticity. It is a bad conductor of heat and electricity. Wood is also used in the form of thin sheets or *veneers.* The wood is definitely superior to metals in several aspects.

4.7.0 Features of Wood

Commercial woods may be identified based on several important diagnostic features.

Porus and Nonporus woods: Porous and nonporous woods. The presence or absence, and the nature and arrangement of *pores*, serve as a ready means of classifying

woods. The coniferous woods do not possess pores, and are known as *nonporous woods*, whereas the angiospermic woods possess numerous pores and are termed as *porous woods*. On the basis of the distribution of pores, the woods may be of wo types- *ring porous* and *diffuse porous* woods. In ring porous woods (e.g., ash, elm, oak, etc.) the pores are found to be arranged in concentric circles, the outer and inner portions of which differ with regard to the number and size of the pores. In diffuse porous woods (e.g., beech maple, walnut, etc.) the pores are small and nearly of the same size and are found to be scattered uniformly throughout the wood.

Early wood and late wood. In temperate regions, every year new wood is formed in a limited growing season, with the result definite growth layers develop, which show two distinct areas within each layer. The wood thus formed in the spring is called the *spring wood* or early wood, and that formed in winter is called the *autumn wood* or late wood. There is a sharp contrast between the late autumn wood and the early spring wood, and this makes the successive rings distinct. The growth ring of a single year is called an *annual ring* and the number of these annual rings gives-an indication of the age of tree. Annual rings of successive years may vary greatly in width. Wide rings are formed under favourable conditions of growth of the tree, and narrow ones are formed when conditions are unfavourable.

Sapwood and heartwood: The outer region of the wood which is of lighter colour is known as the *sapwood*, and this alone is used for conduction of water and salt solutions. The cells of this region are alive and physiologically active. In old trees the central region of the secondary wood is filled up with tannin and other substances which make it hard and durable. This region is known as the *heartwood.* It looks black owing to the presence of tannins, oils, gums, resins. etc., in it. Heartwood gives mechanical support to the stem. The heartwood usually takes good polish and is used for cabinet work, furniture and other high-grade woodworking industries.

Texture, grain and figure: *Texture* refers to the relative size and quality of the various woods, while *grain* refers to their structural arrangement. *Figure* is applied to the design or pattern which appears on the surface of wood.

Rays. The rays are made of parenchyma cells that are oriented at right angles to the main axis of the stem. They vary greatly in width, height and arrangement.

4.7.1 Uses of Wood:

Agricultural implements: Agricultural implements refers to the appliances as ploughs, harrows, rollers and clod crushers. A strong, hard tough timber is required for this type of work. *Acacia nilotica* (Babul), *Anogeissus latifolia* (axle wood), *Syzygium cumini* (Jaman), *Grewia tiliifolia* (Dhaman), *Shorea robusta* (Sal), *Xylia xylocarpa* (Irul), etc., are used for agricultural implements of different kinds.

Axe helves and tool handles: Woods for helves and tool handles must be strong and tough and must also possess great shock resisting abilities. *Dalbergia* spp. (Shisham), *Grewia* spp. (Dhaman), *Diospyros* spp. (ebony), etc., are recommended for this purpose.

Boat and ship-building: Timber used in all small boats and large ships is subjected to very great strains, and is often employed under circumstances which tax its durability to the utmost. For this reason, any timber used for ship and boat-building should be strong, elastic, durable and free from defects. *Tectona grandis* (Teak-Sagaun) is the best ship-building timber in the world, due to its relatively small co-efficient of expansion and contraction and to its durability. The other recommended timbers for this purpose are- *Acacia nilotica* (Babul), *Dalbergia* spp., *Dipterocarpus* spp., *Shorea* spp., *Xylia* spp., *Grewia* spp., *Morus* spp., *Terminalia* spp., *Bombax* spp., etc.

Boot lasts and shoe heels: There is a considerable demand in India for boot and shoe lasts, and recently demand for shoe heels, and especially ladies shoe heels, has grown enormously. For boot lasts and shoe heels, a tough wood which is not too hard is required. The important woods used for the purpose are- *Dalbergia sissoo* (Shisham), *Gardenia* spp., *Mitragyna parvifrora* (Kaim), *Mangifera indica* (Am), etc.

Cart and carriage building: The various parts of a cart or carriage are subjected to different kinds of stresses and strains, and require different qualities of wood for real efficiency. The important woods recommended are- *Dalbergia* spp., *Shorea* spp., *Dipterocarpus* spp., *Syzygium* spp., *Acacia* spp., *Grewia* spp., *Terminalia* spp., and several others.

Construction and general joinery work. Constructional woods are those timbers used for superstructures, which include all parts of houses and buildings, bridges and similar structures not actually in contact with water or the earth. For this purpose, a timber should be strong and durable. Lightness of wood is sometimes an asset if

strength and durability are not sacrificed There are three very important woods which stand out above all others as building timbers. These are- *Tectona grandis* (Teak-Sagaun), *Shorea robusta* (Sal) and *Cedrus deodara* (Deodar). The other important timbers used for this purpose are-*Acacia* spp., *Toona ciliata* (toon), *Dalbergia* spp., *Mangiferaindica* (Am), *Pinus* spp., *Terminalia* spp.

Cooperage: Cooperage or barrel-making consists of two types, "tight cooperage", i.e., barrels used for liquids, and "loose or slack cooperage" used for dry goods like cement. The oaks, *dhaman* are used for tight cooperage for beer and liquor casks. *Bombax ceiba* (Simul), mango spruce, etc., are used for slack cooperage.

Electric poles: The qualities necessary to make a good pole are that it should be straight, i.e., without crooks and bends, that it should not split or crack excessively, and that it should have the required strength for the work it has to do. The woods used in India for use as electrical transmission poles are- *Pinus roxburghii* (Chir), *Shorea robusta* (Sal), *Tectona grandis* (Teak), *Cedrus deodara* (Deodar), *Terminalia tomentosa* (Laurel), etc.

Engraving and printing blocks: *Dalbergia sissoo* (Shisham) in North India, and *Dalbergia latifolia* (Rosewood) in South India, are the most popular woods for calico-printing blocks. Sissoo (Shisham) is considered to be excellent for the purpose. *Toona ciliata* (toon) and *Tectona grandis* (teak) are also sometimes used.

Furniture, cabinet making and panelling: For high class furniture, cabinet-making and decorative panel work, there are several very ornamental and excellent woods in India. The chief characteristics required for these uses are non-liability to crack and split, retention of shape, ease of working and good colour figure and grain. The most commonly used and recommended timbers for the purpose are *Albizia* spp., *Toona ciliata* (toona), *Artocarpus* spp., *Dalbergia* spp., *Juglans regia* (walnut), *Tectona grandis* (teak), *Terminalia tomentosa* (Laurel), etc.

Match splints and boxes: A good match wood for splint manufacture must be soft, straight grained, white and cheap. India possesses many woods which are suitable for box making and splints. The woods are- *Bombax ceiba* (simul), *Anthocephalus indicus* (kadam), *Salix* spp., etc.

Mathematical instruments: The better class of mathematical instruments such as set squares, rulers, etc., are usually made of *Buxus wallichiana* (box wood),

Juglans regia (walnut) and *Aesculus indica* (horse chestnut), but cheaper instruments intended for school use are often made of *Adina cordifolia* (Haldu), *Toona ciliata* (Toon), *Gardenia* spp., etc.

Musical instruments. In India, many woods are used for making musical instruments as tanpura, sitars, violins, etc., teak, toon, sissoo, mulberry, haldu being among the commonest. For sitars, teak is used for the long neck and deodar or shisham for keys. Toon is almost universally used for the bodies. For banjos, teak is most commonly used. For drums, mulberry, sissoo, siris etc, are used. *Canarium euphyllum* (Dhup) is used for guitars.

Packing cases and boxes: Wood for these purposes must be light, easily worked and cheap. Tea is now generally packed in plywood chests, which are strong, light and cheap. Hollock (*Terminalia myriocarpa*) is used for making good plywood tea chests. The commonest Indian woods for packing cases and boxes are- *Dalbergia* spp., toon, teak, mango, siris, kadam, *Terminalia chebula*, *Pinus* spp., etc., Cigar boxes are used made in South India of *Toona ciliata, Melia azedarach*, etc. *Terminalia chebula* is a popular wood in South India for coffee boxes, while poplar (*Populus* spp.) is much used in Kashmir for fruit crates.

Pencils and pen-holders: Amongst the timbers used in India for pencil making may be mentioned Cypress, blue pine or kail, simul, toon, *Salix tetrasperma*, *Melia* spp., etc. Pen-holders may be made of Haldu, *Gardenia* spp., Kaim, etc., Spruce and fir are used in North India for cheap pen-holders.

Picture framing: No very special qualities are required for picture framing, so long as the wood used is well seasoned and not liable to warp. For picture framing in India, the most commonly used wood is teak, sissoo, rosewood, ebony and haldu. However, light conifer woods such as fir and spruce are the best. School slate frames can be made from a variety of woods, e.g. *Trewia nudiflora* (gutel), *Terameles nudiflora* (maina), *Terminalia chebula,Mangifera indica* (Am), etc.

Railway carriage and wagon building: The qualities required of a wood to be in railway carriage and wagon work are that it should be sufficiently strong and durable. It should be free from bad seasoning defects, and it should be available in sufficient quantities. Teak complies with this specification better than any other timber,

and for this reason teak is the main timber used by all the railway wagon and carriage works in India. The other important timbers used for this purpose are- *Shorea robusta*, *Pterocarpus* spp., *Adina cordifolia*, *Cedrus deodara*, *Dalbergia latifolia*, *Toona ciliata*, *Acacia nilotica*, *Dipterocarpus* spp., and several others. For Railway sleepers, the most commonly used woods are- sal, deodar, teak, pyinkado, and bijasal.

Rifle parts: Walnut (*Juglans regia*) is the chief timber used for the manufacture of rifle work all over the world, as it stands up exceptionally well when worked to a fine finish on high speed cutting and drilling machines. The wood is also very steady and is not prone to excessive shrinking, swelling, warping or splitting, once it is properly seasoned.

Shuttles: Shuttles is a very important subject in India. All cotton, jute, wool and other textile mills use wooden shuttles in large quantities. The important wood which may be used for making shuttles are- *Diospyros melanoxylon* (ebony), *Gardenia latifolia*, *Acacia nilotica*, *Mitragyna parviflora*, *Dalbergia latifolia*, *Dalbergia sissoo,* etc.

Sporting requisites: Billiard cue shafts in India are made of *Diospyros melanoxylon* (ebony), *Grewia tiliifolia* (dhaman), *Polyalthia fragrans*. For the butts of cues ebony, *Hardwickia pinnata* and *Dysoxylum glandulosum* are used.

More than 200 manufacturers in India are involved in the production and export of world class sports goods. These goods are of such superior quality that over 70 countries import from India. There are several good reasons for the tremendous popularity of Indian sports goods abroad: excellent quality, superb finish, carefully selected raw material, and enhanced durability.

Cricket bats are made of *Salix* spp. (Willows, Especially Kashmir Willows). *Populus* spp. has also been used for cheap types of bat. Golf clubs are made of *Terminalia* spp., *Grewia* spp., *Anogeissus* spp., and *Pyinma.* Hockey sticks are made of *Morus alba* (malberry). Hockey sticks from India are known the world over for their balance and strong drive. The timbers employed for the skis are *Dalbergia sissoo* (shisham) and *Anogeissus latifolia* (axle wood). Stumps and bales are made of *Morus* spp. (mulberry) and *Grewia tiliifolia* (dhaman). In India, tennis and badminton rackets are made of mahogany and maple wood. The racket frames are made of *Prunus padus,Dalbergia sissoo, Toona ciliata*. *Melia azedarach*, etc.

Turnery, carving, combs, toys, etc: Very close-grained woods are acquired for high class turnery and carving. Walnut is much in demand in North India and Kashmir for this purpose. The sandalwood carvings of Mysore are equally well known. Sissoo and ebony are also used high class carving and inlay work in North India. *Dalbergia latifolia* is commonly used in Kerala for carvings of idols, animals, birds, etc. Wood carving is an ancient craft in which the West Bengal excels. The items include are dolls and toys, owl, horse, etc. Recently many piece goods including stands for table lamps are being manufactured. *Shisham* wood is used in abundance.

Erythrina spp., *Gyrocarpus* spp., *Bauhinia malabarica* are used for making toys in Karnataka. *Hymenodictyon orixense* (Kuthan) is the best toy wood in U.P. Indian combs such as those used by Sikhs in the hair are made of *Buxus* spp. (boxwood), *Adina cordifolia* (Haldu), ebony and sandal-wood.

Veneers: The veneers are thin slices or sheets of wood of uniform thickness. The common thickness is about 1/20 in. to 3/8 in. In making veneers or logs pieces of woods are peeled and boiled and then cut with sharp knife. The veneers are used in the manufacture of boxes, baskets, door panels, cooperage, trunks, mirrors, musical instruments and several other articles.

Plywood: To overcome some of the natural defects in wood is the manufacture of so-called “built up” stock or plywood. The plywood is made by gluing together from three to nine thin veneers. The grain of each successive layer is at an angle to the next, so that the strength is redistributed. With the result the finished product becomes very strong and stable and does not warp or twist like ordinary wood. The plywood does not split when the nails and screws are driven close to its edge. The plywood is extensively used in the home for doors, walls, flooring, cabinets, shelves, partitions, furniture and interior trim. A large quantity of plywood is utilized in making concrete forms, boats, prefabricated houses, airplanes, railroad cars and the body making of station wagons.

Laminboards: Laminboards are usually made up with cheap inferior woods for the cores, and better quality decorative good for the faces. Such timber as pine, spruce, fir, *Bombax ceiba*, *Ailanthus grandis*, *Tetrameles nudiflora* and *Kydia calycina* are very suitable for core work, while better class timbers such as teak, rosewood, sissoo and toon make excellent face veneers. The laminboards are used for making doors and cabinets.

Cork: Most commercial cork is obtained from the cork oak (*Quercus suber*). Cork or "corkwood" consists of the outer bark of the tree. This can be removed without injury to the tree. At the age of about 20 years, when the tree is about 40 cm in circumference, this outer layer, known as virgin cork, is removed by stripping. The operation consists of making vertical and horizontal cuts with knives or saws, and then prying off large pieces of the bark. After stripping the pieces of cork are dried for several days and then boiled in large copper vats. The rough edges are then trimmed off and the flat pieces are sorted and baled.

The natural cork is used to make stoppers, hats, helmets, cigarette tips, handles of golf clubs, pen holders, fishing rods, floats, life preservers, life jackets, base balls mats, tiles, and several other such products. Composition of cork is utilized for the lining of crown caps, the metal tops for sealing bottles, gaskets, toes, counters and innersoles for shoes. (Pandey, 2006).

4.8 Summary

The production and distribution of plant and its products have a profound influence on the economic and social life of the nations of the world, affecting both domestic conditions and international relations, and even changing the course of history. Conservation of those significant plant species is imperative and its loss may result in grave consequences for times to come. Careful and sustainable utilization of them require integrated efforts for policy makers to the end user.

Life as we know today, would not be possible without plants. The complete importance of plants and trees could not be enumerated in a single article, but to summarise, they are the foundation of life on this planet, and the human race should be more woke and do their bit to save the extinguishing green flame that forms the biosphere.

4.9 Questions and Answers

A. Multiple Choice Questions:

1. **How much forest resources contribute in the Net Domestic Product of the Country.**

   a. 3.9% b. 2.4% c. 2.9% d. 3.4%

   Answer : c. 2.9%

2. Which one of the below is an avenue tree in Kolkata?

a. *Ocimum sanctum* b. *Alstonia scholaris*

c. *Oldenlandia paniculata* d. *Phyllanthus amarus*

Answer : b. *Alstoniascholaris*

3. Match the following:

A. *Ficus religiosa*	**i. Bakul**
B. *Mimusops elengi*	**ii. Simul**
C. *Delonix regia*	**iii. Aswattha**
D. *Bombax ceiba*	**iv. Gul mohor**

a. A(i), B(ii), C(iii), B(iv) b. A(iv), B(iii), C(ii), D(i)

c. A(ii), B(iv), C(i), D(iii) d. A(iii), B(i), C(iv), D(ii)

Answer : d. A(iii), B(i), C(iv), D(ii)

4. Beverage produced by top fermentation having pale in colour, tart in taste, and high in alcohol content is known as –

a. Ale b. Porter c. Lager beer d. Stout

Answer : a. Ale

5. Distilled beverages produced from sugarcane syrup or sugarcane byproducts is known as –

a. Whisky b. Rum c. Brandy d. Wine

Answer : b. Rum

6. Porus woods are found in –

a. Conifers b. Pteridophytes

c. Angiosperms d. None of the above

Answer : c. Angiosperms

B. Short answer type questions:

1. Write the name of two avenue trees of Kolkata with their family and common name.

   Answer : 4.3

2. Define Ornamental plant? Give example.

   Answer : 4.4

3. Write the name of two white coloured ornamental plants found in our surroundings.

   Answer : 4.4

4. Write the differences between fermented and distilled beverages.

   Answer : 4.5

5. What are the uses of Apricot and Mulberry?

   Answer : 4.6.1

6. What are the differences between ring porus and diffuse porus woods?

   Answer : 4.7.0

7. Define Heart wood.

   Answer : 4.7.0

8. What is a Cork? From which plant it is obtained?

   Answer : 4.7.1

C. Long answer type questions:

1. Write the commercial and ecological uses of forestry.

   Answer : 4.2

2. How forest products are useful in our daily life?

   Answer : 4.2

3. Write a short note about the Avenue trees in Kolkata.

   Answer : 4.3

4. Write a short note on the red and yellow flower coloured ornamental plants in Kolkata.

   Answer : 4.4

5. What is fermented beverages? What kind of fermented beverages are available commercially? Give a brief idea about them.

   Answer : 4.5.1 & 4.5.2

6. What kind of tropical fruits are found in India. Write their scientific name, common name, and uses.

   Answer : 4.6.0

7. Write a short note on temperate fruits of India.

   Answer : 4.6.1

8. Describe the different feature and uses of wood.

   Answer : 4.7.0 & 4.7.1

4.10 References and Further Readings

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