Chapter 1

Introduction

1.1 What are Angiosperms?

Life seems to have originated some 3000 million years ago. The first life, it is believed, was formed in water, with a rare combination of inorganic substances under very special conditions of temperature and pressure. The first formed life, known as Protista, contained a miniature unit of protoplasm, which is the basis of all life. While still retaining the basic nature of life, the protista soon after its formation, appears to have given rise to two different forms of life. One set comprised mobile forms, i.e. animals and the other consisted of mostly immobile forms, i.e. plants. When the plant life migrated from water to the land it underwent a series of successive changes in its structure, both external and internal. These changes, known as evolution, resulted in bringing up highly developed types of plants, which bear flowers and have covered seeds. It is mainly this group of plants, known as angiosperms (Ashok Kumar, 2001).

1.2 Basic Understanding of Origin of the Word

Biodiversity is the abbreviated word for Biological Diversity. The latter usage appears to have come into prominence around 1980, when Norse and McManus (1980) first defined it. Its abbreviation into ‘biodiversity’ was apparently made by Walter G. Rosen in 1985 during the first planning meeting of the ‘National Forum on Biodiversity’ held at Washington DC in September 1986 (UNEP, 1995). The published proceedings of this meeting in a book entitled Biodiversity (Wilson and Peters, 1988) introduced the nature of biodiversity and popularized this word among the scientific community as well as the public. Since then, not only the number of publications on biodiversity, but also of people interested in the subject for one reason or the other has steadily increased (Harper and Hawksworth, 1994). The United Nations conference on Environment and Development (UNCED) held in 1992 at Rio de Janeiro has also substantially elevated the status of Biodiversity.

According to Wilson (1988), “Biological diversity is the key to the maintenance of the world as we know it”. Biodiversity is the variety of species, their genetic make-up and the natural communities in which they occur. It includes all of the native plants and animals.

Biodiversity is a basic property of life, which manifests itself at all levels of biological organization from cell to ecosystems and thus includes all types of variability among all living organisms from all sources. The diversity is a concept, which refers to the range of variations on differences among some set of entities: biological diversity thus refers to variety within the living world. The most prevalent usage of the term ‘biodiversity’ is as a synonym for the ‘variety of life’ (Wilson and Peter, 1998). From times immemorial, vegetation in any part of
the world has remained a matter of great curiosity for both the taxonomist and the ecologist. The major scientific discipline that emphasis's field studies of plant community includes plant taxonomy, plant ecology and forestry. For any of these studies, the basic requirement is the study of biodiversity.

1.3 History of Biodiversity

The history of biodiversity during the Phanerozoic (the last 540 million years) starts with rapid growth during the Cambrian explosion – a period during which nearly every phylum of multicellular organisms first appeared. Over the next 400 million years or so, global diversity showed little overall trend, but was marked by periodic, massive losses of diversity classified as mass extinction events.

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. However, not all – scientists support this view, since there is considerable uncertainty as to how strongly the Fossil record is raised by the greater availability and preservation of recent geologic sections. Some (Alroy et. al. 2001) argue that corrected for sampling artifacts, modern biodiversity is not much different from 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.

Most biologists agree however that the period since the emergence of humans is part of a new mass extinction, the Holocene extinction event, caused primarily by the impact human are having on the environment. At present, the number of species estimated having gene extinct as a result of human action is still for smaller than are observed during the major mass extinctions of the geological past. However, it has been argued that the present rate of extinction is sufficient to great major mass extinction in less than 100 years. Others dispute this and suggest that the present rate of extinctions could be sustained for many thousands of years before the loss of biodiversity matches the more than 20% losses seen in past global extinction events.

New species are regularly discovered and many, though discovered are not yet classified. Most of the terrestrial diversity is found in tropical forests.

1.4 Distribution of Biodiversity

Biodiversity is not distributed evenly on Earth. It is consistently richer in the tropics and in other localized regions such as the California Floristic Province. As one approaches polar regions are generally finds with fewer species. Flora and Fauna diversity depends on climate, altitude, soils and the presence of other species. In the year 2006, large numbers of the Earth's species were formally classified as rare or endangered or threatened species; moreover, many
scientists have estimated that there are millions more species actually endangered which have not yet been formally recognized. About 40 percent of the 40,177 species assessed using the IUCN Red List criteria, are now listed as threatened species with extinction – a total of 16,119 species (Kumar & Asija, 2005).

Biodiversity is most frequently quantified as the number of species. Estimates of the number of species currently living on Earth range widely, largely because most living species are microorganisms and tiny invertebrates, but most estimates fall between 5 million and 30 million species. Roughly 1.75 million species have been formally described and given official names. Insects comprise over half of the described species and ~ ¾ of known animal species. The number of undescribed species is undoubtedly much higher, however. Particularly in inaccessible environments and for inconspicuous groups of organisms, collecting expeditions routinely discover many undescribed species. Estimates of the total numbers of species on Earth have been derived variously by extra polling from the ratios of described to previously unknown species in quantities samples, from the judgment of experts in particular taxonomic groups and from patterns in the description of new species through time. For most groups of organisms other then vertebrates, such estimates the wide range in estimates of global species diversity. Since insects are essentially absent from the sea, the species diversity of the oceans is generally considerably lower than terrestrial ones (Kumar & Asija, 2005).

Species can be grouped on the basis of shared characteristics into hierarchical groups or taxa, reflecting their shared evolutionary history. As the highest level of classification organisms are divided into three domains: (1) the Bacteria which microorganisms lacking a cellular nucleus or other membrane – bound organelles; (2) the relatively recently discovered Archaea, microorganisms primarily extreme environments such as hot springs, which are superficially similar to Bacteria but fundamentally different at biochemical and the Eukaryotic, which include all other organisms based on nucleated cells. The Eukaryotic includes the four “Kingdoms”, the protista, animals, plants and fungi. Each of the eukaryotic kingdoms in turn is divided into a number of phyla. At this higher taxonomic level, the oceans are for more diverse than those on land, likely reflecting the marine origins of life on Earth nearly half the phyla of animals occur only in the sea, whereas only one is restricted to land.

1.5 Few Definitions of Biodiversity

The word Biodiversity is now very widely used not only by the scientific community, but also the general public, environmental groups, conservationists, industrialists and economists. It has also gained a very high profile in the national and international political arena. In fact, the term has become very fashionable with no clear understanding of what it means. Such loose usage has given the word so many different meanings, connotation and intentions that the actual concept of biodiversity has been lost in obfuscation (practice made intentionally to make something difficult) and confusion. Hence there is a real need to unequivocally define the
concept of biodiversity, which is today a recognized separate science with its own principles and facts, and to define the scope of this new science as well.

Biodiversity is generally considered an ‘Umbrella term’ referring to organisms found within the living world, i.e., the number, variety and variability of living organisms. It may thus be assumed to be a synonym for ‘Life on Earth’, ‘Variety of Life and its Processes’ (Keystone Center, 1991), ‘Condition of being different’ (Gove et. al. 1996), or what (Darwin, 1872) exclaimed as ‘Life’s endless Forms’. Taken in this general sense biodiversity is indeed ‘the essence of life’ (Frankelin, 1993). In reality, however, biodiversity is a very vast and complex concept and its ramifications extend deep into all spheres of human life an activity. Biodiversity is normally treated in terms of genes, species and ecosystems in correspondence with the three fundamental hierarchical levels of biological organization; these three diversities are respectively referred to as Genetic, Species and Ecosystem diversities. According to Harper and Hawskworth (1994), it was Norse et. al. (1980) who first expanded the traditional use of the term biological diversity to the three levels of biological organization. Diversity within species is genetic diversity, diversity between species is species diversity, and diversity at the ecological or habitual level is Ecosystem Diversity. Noss (1990, 1996), Szaro and Shapiro (1990), Szaro and Salwasser (1991) and Wilson (1988), among many others, have included a fourth form of biodiversity called Landscape Diversity. Landscape is a heterogeneous land area composed of a cluster of interacting ecosystems that is repeated in similar form throughout (Forman and Godron, 1986); it is also defined as ‘a mosaic of heterogeneous land forms, vegetation types and land uses’ (Urban et. al. 1987). Landscapes therefore have a pattern and this pattern consists of repeated habitat components. For example, a landscape may be interspersed with grasslands, meadows, ponds, streams, shrubby areas and forests. Thus, landscape diversity is Pattern Diversity (Scheiner, 1992). The inclusion of landscape diversity as a fourth form of diversity was emphasized by Odum (1992) when he listed the following as one of his 20 great ideas in Ecology: ‘An expanded approach to biodiversity, not just species diversity’. Ray (1996) is also very much in favor of including landscape diversity as the fourth category, based on his studies on coastal marine regions.

The complexity of the biodiversity concept is reflected in the existence of numerous definitions for this word, of which Jutro (1993) identified at least 14. Two among these 14 definitions are largely used, quoted and even officialised, since they have been approved by several countries based on worldwide negotiations, agreements and strategies. The first most used definition is sponsored by the United Nations (UN) and was included in the Convention on Biological Diversity (CBD) (UNEP 1992). According to this definitions Biodiversity refers to: ‘The variability among living, inter aling, terrestrial, marine and other aquatic systems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems’. The second most used definition of Biodiversity strategy (KIRI,
IUCN and UNEP, 1992) and is as follows: ‘The totality of genes, species and ecosystems in a region’.

According to di Castri and Younes (1996), biodiversity should not be construed as a ‘Simple umbrella covering a mosaic of heterogeneous activities’, but should represent a composite entity ‘shaped by the continuum of all its elements and the interactions’. These interactions, according to them, are of hierarchical nature and by interlocking the genetic, species and ecosystems diversities one can achieve the ‘Classical zooming effect of hierarchical theory’.

A slightly different composition of the various scales of biodiversity (Genetic, Organismal and Ecological) was suggested by UNEP (1995). It is interesting to find population as a common component/unit at all three scales of biodiversity. However, Heywood (1997a) stated that population is one of the most difficult to assess, whatever may be the scale. In addition, cultural diversity at all these levels. All these represent Culture Diversity, which therefore recognizes the pivotal role of sociological, ethical, religious and ethnic values in human efforts concerning biodiversity.

Heywood (1996) restate one of the earlier definitions of biological diversity as suggested by Norse and McManus (1980) which has only two major components: “Ecological diversity” and “Genetic Diversity”, the farmer being a combination of the “species” and “ecosystem” components used by authors. However, they subsequently categories biodiversity into four components, “ecological”, “genetic”, “organismal” and “cultural”.

di Castri and Younes (1996) provided the following definition: Biodiversity is “the ensemble and the hierarchical interactions of the genetic, taxonomic and ecological scales of organization, at different levels of integration”. Indeed, populations, species and ecosystems are respectively the cornerstones at the interaction points of the three scales. Noss (1994) suggested that each of these scales (genetic, species, ecosystems and landscape) should be further subdivided into compositional, structural and functional components.

<table>
<thead>
<tr>
<th>Table: 1.1 Composition And Scales of Biodiversity</th>
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<tbody>
<tr>
<td><strong>Genetic Diversity</strong></td>
</tr>
<tr>
<td>Populations</td>
</tr>
<tr>
<td>Individuals</td>
</tr>
<tr>
<td>Chromosomes</td>
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<tr>
<td>Genes</td>
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<tr>
<td>Nucleotides</td>
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<td></td>
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Source: UNEP, 1995
Thus, biodiversity is reframed by various authors in different manners and patterns but all these ultimately arrive at the same meaning.

### 1.6 Types of Biodiversity

Biodiversity is the totality of genes, species and ecosystems in a region. The wealth of life on Earth today is the product of hundreds of millions years of evolutionary history. Over the course of time, human cultures have emerged and adapted to the local environment, discovering, using and altering local biotic resources. Many areas that now seem “natural” bear the marks of millennia of human habitation, crop cultivation and resources harvesting. The domestication and breeding of local varieties of crops and livestock have further shaped biodiversity.

Biodiversity is usually defined in terms of genes, species and ecosystem: corresponding to three fundamental and hierarchically related levels of biological organization. The same is documented as three kinds of biodiversity i.e., genetic diversity, species or taxonomic diversity and ecosystem diversity (McAllister, 1991, Solbrig, 1991, Groom-bridge, 1992, Heywood, 1994, Norse, 1994). However, Harper and Hawksworth (1994) favour the terms referred as genetic, organismal and ecological diversity. In the context of conservation strategies, Soule (1986), distinguishes five divisions: genes; populations; species; assemblages (associations and communities) and whole system at the landscape or ecosystem level. Another classification distinguishes three interdependent sets of attributes: compositional levels, structural levels and functional levels (Noss, 1990). Nevertheless, different types of diversity can be stated as follows.

#### 1.6.1 Ecosystem Diversity

Ecosystem diversity is harder to measure than species or genetic diversity because the “boundaries” of communities – associations of species and ecosystem are elusive. Nevertheless, as long as a consistent set of criteria is used to define communities and ecosystem, their numbers and distribution can be measured. Until now, such schemes have been applied mainly at national and sub-national levels, though some coarse global classifications have been made. Besides ecosystem diversity, many other expressions of biodiversity can be important. These include the relative abundance of species, the age structure of populations, the pattern of communities in a region, changes in community composition and structure over time, and even such ecological processes as predation, parasitism and mutualism. More generally, to meet specific management or policy goals, it is often important to examine not only compositional diversity–genes, species and ecosystems – but also diversity in ecosystem structure and function. Human cultural diversity could also be considered as a part of biodiversity. Like genetic or species diversity, some attributes of human cultures represents “solutions” to the problems of survival in particular environments.
Ecosystems are the largest units generally considered in biodiversity, comprising some amalgam(combination) of habitats, the species within them and importantly the processes occurring within and between the biotic and abiotic components (Wilcove and Blair, 1995; Christensen et. al, 1996; Noss, 1996). It has been suggested recently that ecosystems form an appropriate unit for the management of large natural areas (Christensen et. al, 1996; Noss, 1996). However, the study of ecosystems and their use as management units has been frustrated by the looseness of definitions and the seeming inability to reach consensus on what they are in an operational sense, despite over 60 years of debate, Tansley first introduced the term (Tansley, 1935). Tansley explicitly linked the term ‘biome’ with ‘ecosystem’, defining the farmer as comprising the complex of organisms and the latter the complex of organisms plus all inorganic factors. However, subsequent usage has obscured the meaning of the term and has since been applied at broad and very fine scales. Additionally, the term “landscape” has become more frequently used in the past decade but it too suffers from definitional and usage problems.

Ecosystem diversity encompasses the broad differences between ecosystem types and the diversity of habitats and ecological process occurring within each ecosystem type. Since the ecosystem concept is dynamic and thus variable, it can be applied at different scales, though for management purposes it is generally used to group broadly similar assemblages of communities, such as temperate rainforests or coral reefs. A key element in the consideration of ecosystems is that in the natural state, ecological processes such as energy flows and water cycles are conserved.

The measurement of ecosystem diversity is still in its infancy. Nevertheless, ecosystem diversity is an essential element of total biodiversity and accordingly should be reflected in any biodiversity assessment. The quantitative assessment of diversity at the ecosystem, habitat or community levels remains problematic. While it is possible to define what is meant by genetic and species diversity and to produce various measures thereof, there is no unique definition and classification of ecosystems at the global level and it is thus difficult in practice to assess ecosystem diversity other than on a local or regional basis and that too only in terms of vegetation. Ecosystem further differs from genes and species in that they explicitly include abiotic components, being partly determined by soil parent material and climate.

1.6.2 Species Diversity

Species diversity refers to the variety of living species. The species level is generally regarded as the most appropriate for considering the diversity between organisms because species are the primary focus of our understanding of evolution and are therefore relatively well defined.

In terms of readily measurable field entities and as units of evolution, species are the fundamental unit of organization in ecology. They are essential for the evolution of ecological
and evolutionary patterns and process as well as generally being considered the most appropriate units for the management and conservation of natural areas (Spellerberger, 1996). Biodiversity is very commonly used as a synonym of species diversity. In particular, the term is substitute for the quantification of the species ‘richness’. As such, species diversity can be measured in a number of ways. Most of these ways can be classified into three groups of measurement: species richness, species abundance and taxonomic or phylogenetic diversity (Magurran, 1988). The measures of species richness count the number of species in a defined area, while species abundance measures the sample of the relative numbers among species. A typical sample may contain several very common species, a few less common species and numerous rare species. In fact, the measures of species diversity simplify information on species richness and relative abundance into a single index (Magurran, 1988; Spellerberg, 1992).

Species diversity is also a conventionally accepted measure of diversity. There are effective ways to assess the composition of assemblages using species as units of distinction, and to consider the relative phylogenetic similarity between groups of interest, using species or higher taxonomic distinctions (Williams et. al., 1996; Lee, 1997).

Measuring biodiversity using species diversity involves a complex combination of values such as species richness, species composition and taxonomic range (Gaston, 1996; Williams et. al., 1996). Species richness alone, as a measure of biodiversity has been used in several experimental studies investigating the functional significance of biodiversity on ‘ecosystem processes’ (Naeem et. al., 1994; Tilman et. al., 1996). The approach has been criticized as being inappropriate because it does not account for differences between component species. Species richness alone is consequently a poor measure of diversity, although it must be recognized that biologists have historically assessed species diversity in more complex ways (Ghilarov, 1996).

1.6.3 Genetic Biodiversity

Genetic diversity refers to the variation of genes within species; that is, the genetic information contained in all the individual plants, animals and micro organisms. New genetic variation is produced in populations of organisms that can reproduce sexually by recombination and in individuals by gene and chromosome mutations. The pod of genetic variation is shaped by selection. Selection leads to certain genetic attributes being preferred and results in changes to the frequency of these genes within this gene pool.

Genetic diversity is clearly an important component of biodiversity (Gaston 1996, Mallet 1996); the ‘Fine Scale’ level of biodiversity is measured in the variety of expressed genes or characters among organisms (Williams et. al. 1996). However, as a basic unit for measuring and assessing biodiversity it has previously been dismissed as too difficult and costly to use (Moritz, 1994).
The conservation of genetic diversity can be considered a subset of the nation of conserving species diversity by conserving species across their range. This would alleviate apparent problems with fine taxonomic distinction (Mallet, 1996), notwithstanding the clear need to incorporate studies of genetic variation in key species as part of overall strategies (Baur et al., 1996).

Genetic diversity refers to the variation of genes within species. This covers genetic variation between distinct populations of the same species. Genetic diversity can be measured using a variety of DNA based and other techniques (WCMC, 1992). New genetic variation is produced in populations of organisms that can reproduce sexually by recombination and in individuals by gene and chromosome mutations.

The large differences in the amount and distribution of genetic variation can be attributed in part to the enormous variety and complexity of habitats and the different ways in which organisms obtain their living. This represents the heritable variation within and between populations of organisms. One estimate is that there are 109 different genes distributed across the world’s biota, though they do not all make an identical contribution to overall genetic diversity (WCMC, 1992). In particular, those genes, which control fundamental biochemical processes are strongly conserved across different species groups or taxa and generally show little variation. Other more specialized genes display a greater degree of variation. This pod of genetic variation presents an inter-breeding population that is acted upon by selection. Differential survival results in changes of the frequency of genes within this pod and this is equivalent to population evolution. This signification of genetic variation thus is clear: it enables both natural evolutionary change and artificial selective breeding to occur.

### 1.6.4 Agro Biodiversity

A strong reason prompted a separate note on the diversity of cultivated taxa. Cultivated taxa have influenced human life and civilization more than wild species. Diversity of cultivated taxa is distinct from diversity of wild taxa and is now increasingly termed agro biodiversity, to distinguish it from general biodiversity (Virchow, 1998). Agro biodiversity can be broadly defines as ‘that part of biodiversity which nurtures people and which is nurtured by people’ (FAO, 1995; Virchow, 1998). Although there are similarities between biodiversity and agro biodiversity, the differences are greater. A very important international conference for the specific issue of agro biodiversity was held in Leipzig in 1996, where the first report on the state of the World’s Plants Genetic Resources for Food and Agriculture (PGRFA) was presented.

Agro biodiversity represents the agro ecosystems in which man has deliberately selected specific crop plants to replace the natural vegetation. Therefore, it is an artificial ecosystem. The artificiality and biodiversity seen in these systems vary enormously depending on the intensity of human intervention.
Agro ecosystems include shifting cultivation, home and kitchen gardens, pastures, mixed farming (all classified under low intense intervention), multiple cropping, horticulture, alley farming (all classified under middle intense intervention) cereal and pulse, cropping orchards and plantations (all classified and high intense intervention). All high intense agro ecosystems are monospecific and usually composed of genetically uniform plant stands.

Although extremely poor in species diversity (and almost nil in high intense systems), agro systems also have weeds, escapes, parasitic microbes (pests and soil organisms).

1.6.4.1 Origin and Evolution of Cultivated Species Diversity

Domestication or cultivation can be defined as the ‘Forceful’ inclusion of wild populations of useful species, wholly or in part, into human society. Harris and Hillman (1989) defined domestication as ‘human intervention in the reproductive system of the plant’, which resulted in genetic and/or phenotypic changes. Cultivation grew out of food gathering by our ancestors, which imperceptibly let to elements of domestication (Harris, 1969). Yen (1986) considers this transition from wild to cultivation as a ‘form of intensification of plant gathering’, involving a slow/gradual ‘domestication of the environment’. Therefore, all cultivated plants were evolutionarily derived, directly or indirectly from wild species through human imposed unwitting/deliberate selections for desirable traits. The ancestors for many cultivated taxa have been identified, although those of some important crops, such as maize and common wheat, are still subject to research and argument.

In some cultivated taxa, the plants underwent more or less drastic morphological, physiological and other changes during the act of domestication, thus creating vast differences between the wild ancestors and the derived domesticates. In other words, they underwent changes related to the domestication syndrome. In yet others, the demarcating line between wild and cultivated taxa is extremely thin and diffuse. This is especially true of many forest and pasture species and tropical fruit trees such as oil palm. In many cases, there is an evolutionary continuum connecting the wild taxa with the present day cultivars; there is also an ecological link connecting wild and cultivated taxa through semi cultivated ones. The ecological and evolutionary continuum and relationships between wild progenitor and derived cultivar are very important in two respects:

i. Wild species are subjected to continual domestication, especially in a world where land use has intensified and pressure for new industrial raw materials increased.

ii. Wild relatives of domesticates are increasingly gaining importance as vital genetic resources for improvement of the derived cultivars, either for better yield and performance or for combating various stresses, including diseases.

Thus, agro biodiversity represents not only crop pattern but interlinked with wild taxa also.
### Table: 1.2 Comparison of Biodiversity and Agro Biodiversity

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Criteria</th>
<th>Biodiversity</th>
<th>Agro biodiversity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Definition of diversity</td>
<td>Species diversity as variation of diversity between species</td>
<td>Genetic diversity as variation of diversity in one species</td>
</tr>
<tr>
<td>2</td>
<td>Common quantification of diversity</td>
<td>Number of species per defined area</td>
<td>Number of varieties of a given crop per defined area</td>
</tr>
<tr>
<td>3</td>
<td>Centres of diversity</td>
<td>Majority in tropical humid areas</td>
<td>Majority in tropical semi arid and arid areas</td>
</tr>
<tr>
<td>4</td>
<td>Driving force of diversity</td>
<td>Evolutionary process</td>
<td>Breeding process</td>
</tr>
<tr>
<td>5</td>
<td>Expansion</td>
<td>Unsystematically by humankind</td>
<td>Systematically by humankind</td>
</tr>
<tr>
<td>6</td>
<td>Extinction characterized by</td>
<td>Mainly species</td>
<td>Mainly varieties</td>
</tr>
<tr>
<td>7</td>
<td>Main causes of extinction</td>
<td>Human destruction, fragmentation, modification of habitats</td>
<td>Abandonment of land races</td>
</tr>
<tr>
<td>8</td>
<td>Prioritized conservation methods</td>
<td>In situ</td>
<td>Ex situ</td>
</tr>
<tr>
<td>9</td>
<td>General in situ conservation strategy</td>
<td>Reducing activities of humankind in areas of high diversity (habitat/protected area approach)</td>
<td>Promoting the use of agro biodiversity by farmers (on farm management)</td>
</tr>
<tr>
<td>10</td>
<td>Polluter pays principle</td>
<td>Applicable</td>
<td>Non applicable</td>
</tr>
<tr>
<td>11</td>
<td>Operational utility value</td>
<td>Pharmacologically active compounds (genetically coded information)</td>
<td>Desirable traits (genetically coded function)</td>
</tr>
<tr>
<td>12</td>
<td>Supply for</td>
<td>All biotechnology industries including plant breeding industries</td>
<td>Conventional and biotechnology plant breeding industries</td>
</tr>
<tr>
<td>13</td>
<td>Companies involved</td>
<td>Mostly private</td>
<td>Public and private companies</td>
</tr>
<tr>
<td>14</td>
<td>Genetic sources for new products</td>
<td>Single component</td>
<td>Various component</td>
</tr>
<tr>
<td>15</td>
<td>Research and development system</td>
<td>Private</td>
<td>Public &amp; private</td>
</tr>
<tr>
<td>16</td>
<td>Transaction chains between collection and ultimate producer</td>
<td>Short</td>
<td>Long</td>
</tr>
<tr>
<td>Sr. No.</td>
<td>Criteria</td>
<td>Biodiversity</td>
<td>Agro biodiversity</td>
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<td>--------------------------------------------------------------------------</td>
<td>----------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>17</td>
<td>Revenue-gene-rating potential of products</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>18</td>
<td>Redistribution of sales as 'benefit sharing' to the providers of genetic resources</td>
<td>Effective</td>
<td>Ineffective</td>
</tr>
<tr>
<td>19</td>
<td>Genetic resources exchange system</td>
<td>Bilateral contracts</td>
<td>Multilateral system</td>
</tr>
<tr>
<td>20</td>
<td>Overlap</td>
<td>Wild relatives of plant genetic resources for food and agriculture</td>
<td></td>
</tr>
</tbody>
</table>

Source: Virchow, 1998

### 1.7 Diversity at Different Scales

At its simplest level, diversity can be defined as the number of species found in a community, a measure known as species richness. Diversity is “a single statistic in which the number of species and evenness are compounded”. Many methods of calculating diversity have been proposed that combine these two types of information. Mathematical indices of biodiversity have also been developed to connate species diversity at different geographical scales as follows (Sharma, 2009).

#### 1.7.1 Alpha Diversity

This refers to number of species in a single community. This diversity comes closest to the popular concept of species richness and can be used to compare the number of species in different ecosystem types.

#### 1.7.2 Beta Diversity

This refers to the degree to which species composition changes along an environmental gradient. Beta diversity is high for example, if the species composition of moss communities changes at successively higher elevations on a mountain slope, but is low if the same species occupy the whole mountain side.

#### 1.7.3 Gamma Diversity

This applies to larger geographical scales and defined as “the rate at which additional species are encountered as geographical replacements within a habitat type in different localities. Thus gamma diversity is a species turnover rate with distance between sites of similar habitat or with expanding geographic areas".
1.8 Conservation Categories of Species

To highlight the legal status of rare species for purpose of conservation, the IUCN (1984) has established the following five main conservation categories.

**Extinct**
Species that are no longer known to exist in the wild. Searches of localities where they were once found and of other possible sites have failed to detect the species.

**Endangered**
Species that have a high likelihood of going extinct in the near future.

**Vulnerable**
Species that may become endangered in the near future because populations of the species are decreasing in size throughout its range.

**Rare**
Species that have small total number of individuals often due to limited geographical ranges or low population densities.

**Insufficiently**
Species that probably belong to one of the conservation categories but are not sufficiently well known to be assigned to a specific category. Male and Lande (1991) have proposed a three level system of classification based on the probability of extinction(Kumar & Asija, 2005).

(e1) **Critical**
Species with a 50% or greater probability of extinction within 5 years or 2 generations whichever is longer.

(e2) **Endangered**
Species with a 20% probability of extinction within 20 years or 10 generations.

(e3) **Vulnerable**
Species with a 10% or greater probability of extinction within 100 years.

1.8.1 Threatened Taxa and Families

The IUCN (cf. Walter and Gillett, 1998) revealed that 12.5 percent or 34,000, of the world's plant species are threatened. There are 511 families of vascular plants currently recognized as per the classification system of Brummitt (1992). According to the IUCN Red List (1997), 372 of these contain globally threatened and/or extinct species. Not surprisingly, the largest families also contain the largest number of threatened species. Excluding nineteen threatened monotypic families (only one species in the family and thus 100 percent threatened), there are 20 plant families with at least 50 percent of their species threatened. Of these, eight are
gymnosperm families. In contrast the ferns as a group appear to face relatively low level of threat. This may be due in part to the efficiency with which fern spores are dispersed. At the same time, fern species have not been fully assessed, so their status as a group is not entirely clear.

In India, nearly 450 plant spp. have been identified as endangered, threatened or rare while in Gujarat, there are 4 plant spp. involving in the same categories. Total 134 plant spp. belonging from 68 families are in risk at the different part of the country. In Gujarat, mainly there are 4 plant spp. belonging from the families like Burseraceae, Asteraceae, Arecaceae and Papaveraceae are in risk, which are as under (Krishnamurthy, 2007).

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name of Species</th>
<th>Name of Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Commiphora wightii (Arn.) Bhandari</td>
<td>Burseraceae</td>
</tr>
<tr>
<td>2</td>
<td>Helichrysum cutchicum (Clarke) R.Rao.</td>
<td>Asteraceae</td>
</tr>
<tr>
<td>3</td>
<td>Hyphaene dichotoma (White) Furt.</td>
<td>Arecaceae</td>
</tr>
<tr>
<td>4</td>
<td>Meconopsis betonicifolia Franch.</td>
<td>Papaveraceae</td>
</tr>
</tbody>
</table>

**1.8.2 Extinct Species**

The IUCN Red List (cf. Walter and Gillett, 1998) shows that 380 species have become extinct in the wild, with an additional 371 species listed as Extinct/Endangered (Ex/E). There are at least an additional 6,522 species listed as Endangered (E). Without a concentrated effort to safeguard them, many of these species might be added in future to the Extinct list.

A species is considered extinct when no member of the species remains alive anywhere in the world. If individuals of a species remain alive only in captivity or other human controlled conditions, the species is said to be extinct in the wild. In both of these situations, the species would be considered globally extinct. A species is considered locally extinct when it is no longer found in an area it once inhabited but is still found elsewhere in the wild. There may also be an ecologically extinct species if it persists at such reduced members that its effects on other species in its community are negligible. Thus, the most serials aspect of the loss of biodiversity is the extinction of species.

**1.9 Global Biodiversity Strategy**

Biodiversity conservation is increasingly being recognized as a fundamental component of sustainable development. The goal of biodiversity conservation is to support sustainable development by protecting and using biological resources in ways that do not diminish the world’s variety of genes and species or destroy important habitats and ecosystems.
In recent years major international studies have emphasized the link between development and conservation including world conservation strategy. The world conservation strategy (1980) developed by the world conservation union (IUCN), the United Nations Environment Programme (UNEP) and World Wildlife Fund (WWF), Our common Future (1987) – a report by the world commission on Environment and Development and also caring for Earth a strategy for sustainable living (1991) by IUCN, UNEP and WWF. In addition biennial world resources and environmental data reports have been providing authoritative and disturbing overviews of the State of the planet. The Global Biodiversity Strategy was published in 1992, at a time when it could be used by both governments and NGOs preparing for the UN conference on Environment and Development the “Earth Summit” as well as the negotiation of international Biodiversity Convention. Looking beyond the Earth summit and the proposed convention, the strategy was also designed to be on outline for the diverse actions that governments and NGOs groups should take in support of and as an adjunct to the convention (Kumar and Asija, 2005).

1.9.1 Present Status of Global Floristic Diversity

The Earth’s total biological diversity is currently estimated at between 5 and 30 million species. It comprises all forms of life and is a part of the ecosystem. The diversity of living things is crucial to humanity. More than one out of every ten plant species worldwide is at risk of extinction, according to the most comprehensive scientific assessment ever assembled on the status of the world’s plant (IUCN, 1995). Of all the estimated 1.4 million known to inhabit the earth, one fourth to one third is likely to become extinct within the next few decades (Spellerberg, 1992). According to Myers (1979), these exponential species extinction rates have increased dramatically in the last 50,000 years from one extinction per 1000 years to about 1000 extinction’s per year and may reach 40,000 per year until the end of this century, so that one species will be lost every hour.

Nevertheless, species extinction is an integral part of evolution. It is of a subtending character on the one hand and a composite of transformation and speciation on the other hand (Nixon and Wheeler, 1992). The projections for species extinction over the next few decades greatly exceed the formerly documented observations in recent geological history (Wilson, 1985). It is estimated that tropical forests covered approximately 1500 million ha. in pre agricultural time and that by 1988 the tropical forests had been reduced to 300 million ha. in the early 21st century (Myers, 1990). The US National Science Board (1989) had predicted that as many as 25% or more the Earth’s living species may become extinct within the next quarter century. This threat to species diversity and to the only evidence, that exists with regard to the history of the evolution of life on our planet thereby, imposes an external timetable on the enterprise of making an inventory of our species and indeed substantial progress and development is required in the next 25 years.
According to the IUCN Red List of Threatened Plants (Walter and Gillett, 1998), there are an estimated 2,50,000 known species of vascular plants, which include ferns, fern allies, gymnosperms (including conifers and cycads) and flowering plants. Of these species assessed, 33,798 species, or at least 12.5% of all known vascular plants are threatened with extinction on a global level. These plants are found in 369 families and are scattered throughout 200 countries to a single country – which links their potential for extinction to national economic and social conditions. These islands or island groups, which often have high rate of infelicity, face particular high level of threat to their flora. Indeed, seven of the top ten areas listed according to percentage of threatened flora are islands viz., St. Helena, Mauritius, Seychelles, Jamaica, French Polynesia, Pitcairn.

A great number of plant species known to have medical value are at list of disappearing, leaving their human healing potential unfulfilled. For instance, 75 percent of the species from the yew (Taxaceae) family a source of important cancer – fighting compounds, are threatened. The willow (Onagraceae) family, from which aspirin is derived, has 12 percent of its species threatened. The Dipterocarpus (Dipterocarpaceae) a family of trees that includes some valuable timber species in South-East Asia, have 32.5 percent of their close relatives threatened. With the loss of each species, we loss access to critical genetic material that may have contributed to producing hardier, healthier crops for human and animal consumption. Close relatives to many familiar plants are at list of extinction. For instance, 14 percent of the rose family, 32 percent of the lily family and 32 percent of the iris family are threatened.

Using the IUCN categories (1997), the World Conservation Monitoring Centre (WCMC) has evaluated and described threats to about 60,000 plants species in its series of Red Data Books. The great majority of the species on these lists of Red Data Books are plants. The plant list includes the giant Rafflesia of Sumatran rain forest and the African violet, now occurring wild only in Central Tanzania. On a global basis, the IUCN have estimated that about 10% of the world’s vascular plant species totaling to about 20,000 - 25,000 species are under varying degrees of threat. Due to pressure on account of environmental changes, 11,406 species of plants and animals are facing high risk of extinction (IUCN, 2000). While plant species are declining rapidly in South America, Central and West Africa and South-East Asia, mammals and birds are disappearing faster in Brazil, India and China. In India, all the eight species of vultures are declining fast.

1.10 India’s Floral Biodiversity - in a Global Context

India is one of the twelve mega biodiversity countries of the world. Each of the ten biogeographic zones of the country has characteristic biota and broadly represents similar climatic conditions and constitutes the habitat for diverse species of flora and fauna. An account of the dominant species of flora, based on survey of about two-third of the geographical area of the country, the Ministry of Forest and Environment reported that,
India have at present about 45,000 plants representing 7% of the World Flora (GOI, 1994) respectively, representing about 6.5% of the global biodiversity.

The floristic diversity of India is well known. The Indian region with a total area about 3029 million ha. is considered to be one of the twelve centers of origin and diversity of several plant species in the world (Takhtajan, 1969). India is a tropical country and is recognized as one of the mega diversity centers today. Of the 1.4 million species of identified organisms, 0.2 million (13%) are known from India. This is remarkable as India covers just 2.0% of the earth's land area. As with rest of the earth’s surface this biodiversity is however dumped within the warm and wet regions of India. Thus, the humid Western Ghats and the Eastern Himalayas – Assam provinces are the richest in biological species (Gadgil, 1996).

The origin of cultivated plants was first accounted by De Candolle (1883). Further, the work was extended by Vavilov (1926) and he gave an account on the centers of diversity of crop plant genetic resources of the world. Vavilov (I.C.) identified these on the basis of anatomy, genetics, cytology, varietal diversity, homologous variations, endemism and dominant allele frequencies and disease resistance. These have also been referred to as Germplasm Treasures (Khoshoo, 1991). There is today general unanimity about 12 centers of diversity and India is one of the very important centers that has contributed to the world agriculture of at least 167 plant species. Within the overall all mega Indian centre of diversity as recognized by Vavilov (I.C.), there are at least 9 sub-centers of diversity, where wild relatives of cultivated plant occur (Arora and Pandey, 1996).

There are also secondary centers of genetic diversity, which are environmentally different from the primary centers, where the crops were developed further by human ingenuity. Thus India is a secondary centre of diversification for several species, which are very old introductions into the country. Such crops are grain Amaranthus, maize, red pepper, soyabean, potato, oil palm etc. Even, Hooker (1872-1897) has remarked “the Indian Flora is more varied than that of any other country of equal area in the Eastern Hemisphere, if not in the globe”. Not only this, the presence of a large number of primitive flowering plants in India has led Takhtajan (1969) to render the region as “a Cradle of Flowering Plants”. As many as 131 species are stated to be primitive.

**1.10.1 Present Status of Floristic Diversity- in Indian Context**

India occupies a unique position among global biodiversity as a mega biodiversity nation. A large number of species are native to India. It is stated among the top ten or fifteen nations of the world for its great diversity of plant life, especially flowering plants, a source of new drugs being discovered during recent past. About 5,000 species of flowering plants belonging to 141 genera and 47 families had birth in India. Many of these are endemic to India, found nowhere else in the world. India is a source of traditional crop varieties ranking first amongst the 12
regions of biodiversity of crop plants and seventh so far in the contribution of agricultural species. India is the origin place of 166 species of crop plants and 320 species of wild relatives of cultivated crops.

Out of the total number of flowering plant species known (17,500) in India, there are more than 4,000 species used is medicines about 3,000 for food, nearly 700 as traditional religious and social purposes, about 500 yield fibre, 400 as fodder, 300 yield gum and about 100 species are used to extract essential oil and scents (Kumar & Asija, 2005).

India is rich in marine biodiversity among the coastline of 7500 km with exclusive economic zone of 202 million km², supporting the most productive ecosystems such as mangroves, coral reefs, estuaries, lagoons and backwaters. There are about 45 species of mangrove plants over 342 species of coral reefs belonging to 76 genera have been reported and about 50% of the global reef building corals are found in India. In Western Ghats and North-East Himalayas about 1500 plants respectively are endemic. About 33% of Indian endemic species belong to flowering plants (Envis NEWS letter, 2010).

India harbors about 45,000 plant species representing about 7% of the World's Flora. These are categorized in different taxonomic divisions including 15,000 to 17,500 flowering plants, about 315 families and 2250 genera are known to occur in India in different ecosystems from the humid tropic of Western Ghats to Alpine zones of the Himalayas and mangroves of Sunderbans to dry desert of Rajasthan. The Indian region has approximately half of the World’s Aquatic Flowering plants. Estimates for the lower plants are shown in this table.

Table No.: 1.4  India’s Floral Biodiversity in a Global Context

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Division</th>
<th>No. of Species in the world</th>
<th>No. of Species in the India</th>
<th>No. of Species in Gujarat</th>
<th>% World Flora</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Algae</td>
<td>40,000</td>
<td>6,500</td>
<td>1,933</td>
<td>16.30%</td>
</tr>
<tr>
<td>2</td>
<td>Fungi</td>
<td>70,000</td>
<td>14,500</td>
<td>164</td>
<td>20.7%</td>
</tr>
<tr>
<td>3</td>
<td>Lichens</td>
<td>13,500</td>
<td>2075</td>
<td>-</td>
<td>15.0%</td>
</tr>
<tr>
<td>4</td>
<td>Bryophytes</td>
<td>14,500</td>
<td>2,850</td>
<td>8</td>
<td>19.7%</td>
</tr>
<tr>
<td>5</td>
<td>Pteridophytes</td>
<td>10,000</td>
<td>1200</td>
<td>16</td>
<td>12.0%</td>
</tr>
<tr>
<td>6</td>
<td>Gymnosperms</td>
<td>650</td>
<td>48</td>
<td>4</td>
<td>7.4%</td>
</tr>
<tr>
<td>7</td>
<td>Angiosperms</td>
<td>2,500,000</td>
<td>17,500</td>
<td>2,198</td>
<td>7.0%</td>
</tr>
</tbody>
</table>

Source: ENVIS NEWSLETTER (Seshaiyana Envis Newsletter, 2010)
1.11 Present Status of Floristic Diversity in Gujarat

Gujarat, located in the western region of India, has a variety of climatic and edaphic conditions. In spite of continuous onslaught on the biological resources, the overall range of biodiversity of Gujarat is still unmatched. Gujarat has many kinds of natural ecosystems due to varied environmental, climatic and edaphic conditions. Some important ecosystems in this state are deserts, grasslands, scrublands, wetlands, forests, marine ecosystem etc.

This state has got a large population of tribal dependent on the natural biological resources for their livelihood. The Southern and Eastern Gujarat are primarily tribal areas whereas in Saurashtra and Kachchh, there is large population of nomadic pastorals community called Maldharis, Whose migratory life style affect the floral and faunal diversity of the state.

This universe is the creation of the supreme power meant for the benefit of all his creations. Individual species must, therefore, learn to enjoy its benefits by forming a part of the system in close relation with other species.

The angiospermic flora of Gujarat is mostly varied in extent and composition. There are 2,198 species of higher plants belonging to 902 genera and 155 families, which represent 12.91% of the flora of the country. So far as the floristic explorations are concerned, the South Gujarat region has been intensively studied by several workers. By and large, the central part of the state, part of North Gujarat, West Saurashtra and Eastern Kachchh remain virtually unexplored. 62 species of Angiosperm and Gymnosperm plants have been given different rarity status. Majority of them is distributed in the semi-arid regions of Kachchh.

Perhaps the most interesting feature of the vegetation is that marks the dividing line between the Perso-Arabian Flora (to which the Flora of Sind belongs) and the Indo-Malayan Flora proper (Saxton and Sedgwick, 1918). Drude (1890), in the map of Handbuch Der Pflanzen geographic, makes the line of demarcation which passes through the gulf of Cambay northward along the Aravali Hills, thus, exactly traversing the area of Gujarat. It is well known from the evidence that Peninsular India is formed part of the gigantic continent of Godwana which broke up only after the evolution of flowering plants. Parts of which form the continents of South America, Africa and Australia.

1.12 Study Undertaken in North Gujarat Region

Several taxonomists did continue to survey the forest areas and many new records for the North Gujarat were added at regular intervals, such as, “Plants of North Gujarat” ( Saxton and Sedgwick, 1918 ; Saxton, 1922) and “ A contribution to the Flora of North Gujarat” (Yogi, 1970). The areas worked out by Saxton & Sedgwick are Ahmedabad, Prantij, Talod, Sonasan, Bavasar, Ghadi, Raipur, Raesan, Modasa, Dhansura, Kharaghoda etc. They made valuable contribution to the Flora of Gujarat. Their collection is preserved in the Herbarium at Gujarat
College, Ahmedabad. The areas explored by Yogi are Mansa, Mahudi, Lakroda, Pahada, Kadi and Keshani in Mehsana district and Himmatnagar, Idar and Khedbhramain Sabarkantha district. Two forest ranges such as Ambaji and Danta of District Banaskantha were explored for floristic study by Patel, R.S.(2003) and Patel K.C.(2003) respectively. Although the flora of some parts of North Gujarat is known, there are still many areas, which have yet, remained unexplored botanically. Banas River corridor in North Gujarat is one of them. Is covers large scales of different habitats along the corridors with various biodiversity.

1.13 Hypothesis
The river corridor of Banas is one of the longest corridors in Gujarat. There are different types of ecosystems which represents large scale of biodiversity along the river bank. A review of literature reveals that a very few number of publications/research works done on Banas river. There is no remarkable documentation available which can focus the entire biodiversity over the river corridor. The other important factor is that, Banas river is an important water source for the present study area. The river has undergone changes due to various developmental activities including dam, agriculture and sand mining. The dry and shallow river bed of Banas is a magnet for sand miners. Sand is indivisible part of riparian ecosystem. The removal of large quantities of sand from river bed is directly or indirectly affects on biodiversity which is dependent on this system. Therefore, it was hypothesized that habitat destruction, various human pressure, overexploitation of the biotic resources, mining pressure, and livestock grazing etc. might had caused a shift in the floristic composition of the Banas river corridor. It was thus presumed further that the possible shift on the floristic composition might have resulted in loss of some species at the expense of newly introduced species resulting in either decrease or increase in the total number of the floristic elements in the area. Therefore, the present status of flora might provide the necessary clues about the plant biodiversity of this region.

1.14 Aim & Objectives
The research work emphasizes on the angiospermic biodiversity of the Banas river corridor in Gujarat. Banas river is passing through from two major states, Rajasthan to Gujarat. In Gujarat, the river covered two major districts, Banaskantha and Patan and its end with the little Rann of Kuchchh in Santalpur taluka. It has covered a large scale corridor of 285 km, so the great variation in plant vegetation is occurred throughout the corridor. Because of the large flow of the river in Gujarat, it covered various ecosystems like agricultural ecosystems, forests, water bodies, wetlands, grassland, desert etc. climatic variations is the another remarkable factors for different diversity in the area.

The study demonstrates the value of ecosystems and biodiversity to the economy, society and individuals. It underlines the urgent need to transform our approach to natural capital,
and demonstrates how we can practically take into account the value of ecosystems and biodiversity in policy decisions to promote the protection of our environment and contribute to a sustainable economy and to the wellbeing of societies.

1.14.1 Objectives

- To enumerate and list out the plants occurring in the area.
- To analyze various plant community characters i.e. % Frequency, Density, Abundance, and % Composition.
- To determine Importance Value Index (IVI) of tree species.
- To determine various species diversity indices.
- Distribution of the recorded plant species.
- To list out the Rare/Endangered species of the area.
- Biodiversity as a biological resource.
- To find out the threats to the present biodiversity of the area.

1.15 Limitations of the Study

There are two noteworthy limitations of this study which are as following:

1. Secondary data which were collected for the study not updated with the relevant Departments/Institutes.

2. It has been taken care for covered the entire corridor for primary data collection though some patches of the area might be left where approach was difficult.