Unit: BIODIVERSITY

(Reading material exclusively for students of IDC ES 541)

Content
- Definition
- Biodiversity principles, values and threats
- Protecting biodiversity: legal and non-legal bindings
- Biodiversity of NE India

WHAT IS BIODIVERSITY?
- the sum of total of life forms at all levels of organization in biological system.

Biodiversity is defined as "***the intrinsically-inbuilt plus the externally-imposed variability in and among living organisms existing in terrestrial, marine and other ecosystem at a specific period of time***".

- Article 2 of the CBD defines "*Biological diversity 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 biological diversity within species and ecosystems*".

- "*Biodiversity includes assemblages of plant, animals and micro-organisms, their genetic variability expressed and populations, their habitats, ecosystems and natural areas, the mosaic of which constitutes the landscape which gives the richness to the natural environment*" (Denny, 1997).

- For the assessment of global biodiversity, it is defined as the total diversity and variability of living organisms and of the systems of which they are a part. This covers the total range of variation and variability among systems and organisms at the bioregional, landscapes, ecosystem, habitat (levels), and organismal level down to species, populations, individuals and genes (genetic diversity) [Heywood, 1995].

According to Edward Wilson "Biodiversity is the combined diversity at all the levels of biological organization."

History of Biodiversity

The term 'diversity' is not new, rather has a long history, but 'biological diversity' came into use in scientific literature only in the 1980s. The term was first coined by Lovejoy who, however, did not provide any formal definition to it, but considered it as only the number of species (Lovejoy, 1980). Rosen in 1985 used the term 'biodiversity' in the first planning conference of the 'National Forum on Biodiversity', Washington D. C., on Sept. 1986. Wilson (1988) edited the proceedings of the conference titled Biodiversity, and this popularized the concept.

      Convention on Biological Diversity in June 1992, constituted a historical commitment by all (many) nations of the world. For the first time, biodiversity was comprehensively addresses in this global treaty. At the same time the genetic diversity was considered and conservation of biodiversity was accepted as the common concern for the cause of human welfare (Gatson, 1998).

How Many Species are there on Earth and How Many in India?

Since there are published records of all the species discovered and named, we know how many species in all have been recorded so far, but it is not easy to answer the question of how many species there are on earth. According to the IUCN (2004), the total number of plant and animal species described so far is slightly more than 1.5 million, but we have no clear idea of how many species are yet to be discovered and described. Some extreme estimates range from 20 to 50 million, but a more conservative and scientifically sound estimate made by Robert May places the global species diversity at about 7 million.
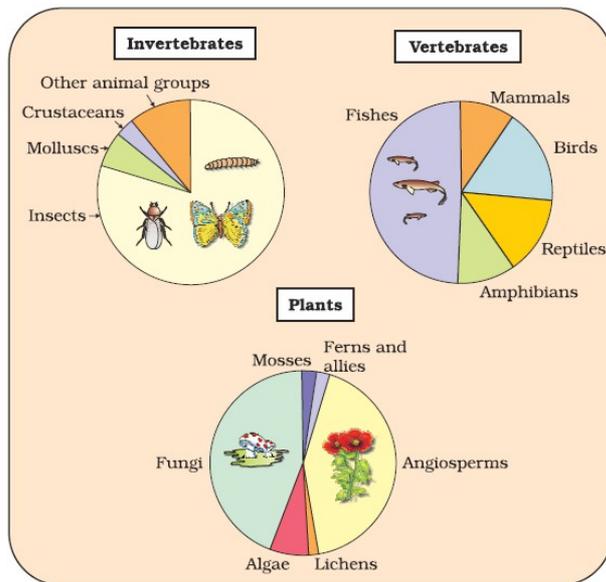
Although India has only 2.4 per cent of the world's land area, its share of the global species diversity is an impressive 8.1 per cent. That is what makes our country one of the 12 mega diversity countries of the world. Nearly 45,000 species of plants and twice as many of animals have been recorded from India. How many living species are actually there waiting to be discovered and named? If we accept Robert May's global estimates, only 22 per cent of the total species have been recorded so far. Applying this proportion to India's diversity figures, we estimate that there are probably more than 1,00,000 plant species and more than 3,00,000 animal species yet to be discovered and

Figure 15.1 Representing global biodiversity: proportionate number of species of major taxa of plants, invertebrates and vertebrates

described. Would we ever be able to complete the inventory of the biological wealth of our country? Consider the immense trained manpower (taxonomists) and the time required to complete the job. The situation appears more hopeless when we realize that a large fraction of these species faces the threat of becoming extinct even before we discover them. Nature's biological library is burning even before we catalogued the titles of all the books stocked there.

Global Biodiversity Gradient

Biodiversity is not distributed evenly across the planet:
Biodiversity is not distributed evenly across the planet but shows a rather uneven distribution, certain ecosystems and regions contain far more species than others. Tropical rain forests, coral reefs, the deep sea, and large tropical lakes appear to be the most species rich ecosystems on the planet (WCMC 1992; Heywood 1995; Levin 2001). For most groups of terrestrial plants and animals, species diversity is lowest near the poles and increases toward the tropics, reaching its peak in tropical rain forests. These forests, occupying only 6 percent of the earth's land surface, are believed to contain more than half the species on earth.

Evolution of Biodiversity

Biodiversity is a product of the numerous biological and geophysical events that have occurred over the history of life on Earth.

- Life on Earth is 3.7 - 3.85x10^9 years old
- Evolutionary history shapes contemporary physical and biological environment
- Current diversity of species is a product of the processes of extinction and speciation

Extinction

Extinction is an important part of the process of evolution of biodiversity and does not occur at a constant pace. It is the complete disappearance of a species from Earth. Thus, extinction is the final and irreversible event of species loss. In contrast, *extirpation* is the local or regional disappearance of a species from only a part of its range.

There have been at least five periods when there was a sudden increase in the rate of extinction – to at least double – affecting many different types of plants and animals.

Major Five Extinction events include:
Cretaceous-Tertiary Extinction Event (75% of all species including the dinosaurs) about 75 million years ago.
Triassic–Jurassic Extinction Event (60% of all species including most Achosaurs, Therapsids, and large Amphibians) about 205 million years ago.
Permian–Triassic Extinction Event (96% of Aquatic Species including most of the sessile species; and 70% of land species including most Synapsids) 251 million years ago.
Late Devonian Extinction Event (70% of all species including most Brachiopods and Trilobites) 360 million years ago.
Ordovician–Silurian Extinction Event (80% of all species, mostly brachiopods, bivalves, echinoderms, bryozoans, and corals) 450 million years ago.
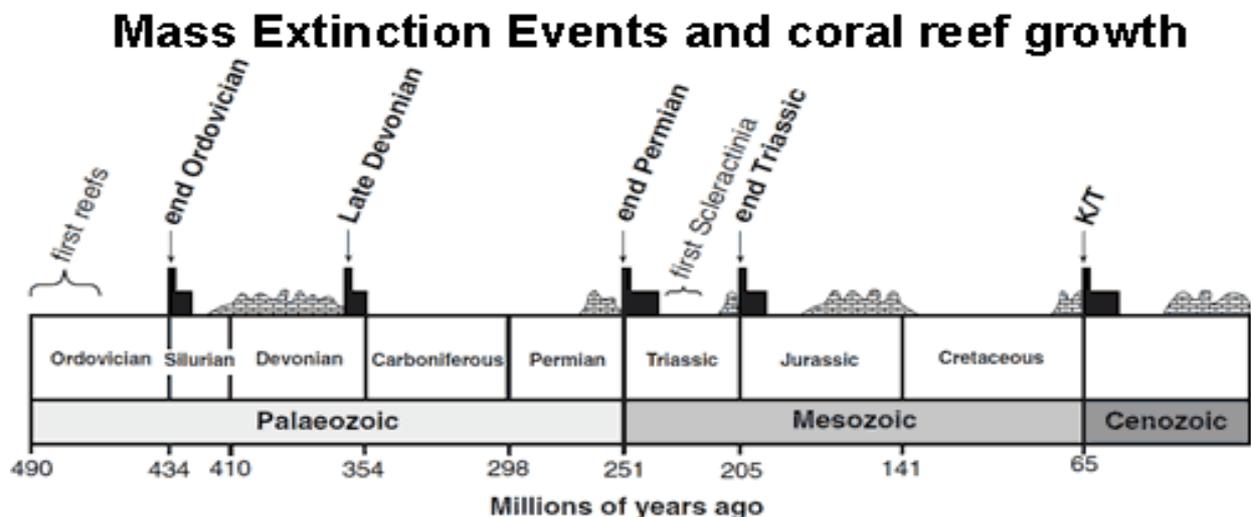

Figure 1: Timeline of mass extinction events. The five named vertical bars indicate mass extinction events. Black rectangles (drawn to scale) represent global reef gaps and brick-pattern shapes show times of prolific reef growth (Veron 2008).

6th extinction crisis
The world has begun, relatively recently, to lose species and habitats at an ever-increasing and alarming rate. This is often referred as **6th extinction crisis**, after the 5 known extinction waves in geological history.

So what is the Sixth Extinction? When is it coming? And what is its cause?
"It's the next annihilation of vast numbers of species. It is happening now, and we, the human race, are its cause," explains Dr. Richard Leakey, the world's most famous paleoanthropologist.

- Extinction of species that is currently occurring as a result of human activities of various kinds.

From a study of the history of life on earth through fossil records, we learn that large-scale loss of species like the one we are currently witnessing have also happened earlier, even before humans appeared on the scene. During the long period (> 3 billion years) since the origin and diversification of life on earth there were five episodes of mass extinction of species. How is the 'Sixth Extinction' presently in progress different from the previous episodes? The difference is in the rates; the current species extinction rates are estimated to be 100 to 1,000 times faster than in the pre-human times and our activities are responsible for the faster rates. Ecologists warn that if the present trends continue, nearly half of all the species on earth might be wiped out within the next 100 years.

Humans endanger the existence of species in *three* principal ways. The first is through direct *exploitation*, such as hunting. Second is the *biological havoc* that is occasionally wreaked following the introduction of alien species to new ecosystems, whether deliberately or accidentally. The third, and by far the most important, mode of human-driven extinction is the *destruction and fragmentation of habitat*, especially the inexorable cutting of tropical rainforests. The forests, which cover just 7 percent of the world's land surface, are a cauldron of evolutionary innovation and are home to half of the world's species. The continued growth of human populations in all parts of the world daily encroaches on wild habitats, whether through the expansion of agricultural land, the building of towns and cities, or the transport infrastructure that joins them. As the habitats shrink, so too does the Earth's capacity to sustain its biological heritage.

How a 6th mass extinction might differ from previous mass extinctions

- causes - apparently human induced (human population, pollution, global climate change, over hunting, etc.)
- rate - possibly greater
- possible breadth of taxonomic groups affected
- it can be stopped or at least slowed!

Dimensions of biodiversity

Biodiversity is the variety of life on Earth at all its levels, from genes to ecosystems, and the ecological and evolutionary processes that sustain it.

Genetic component	Spatial component	Functional component	Temporal component
within individuals	communities	e.g. reproductive behavior, predation, parasitism	daily
within populations	ecosystems		seasonal
between populations	landscapes		annual
between species	ecoregions biogeographic regions		geological or evolutionary

A comprehensive definition of biodiversity takes into account several dimensions, often overlapping. For example, genetic diversity exists over a hierarchy from individuals to populations to species.
          Collections of different populations and species form communities and ecosystems, which can vary over spatial scales from the local level to the global level. Spatial patterns of biodiversity are affected by climate, geology and physiography. Temporal dimensions of

biodiversity range from daily to seasonal to annual, and evolutionary. Another dimension is Functional biodiversity, that is, the role that a group of organisms plays in the web of life. So, biodiversity is a large subject that can be studied from a variety of angles.

Levels of biodiversity

Biodiversity is commonly considered at three different levels:
1. Within species (intraspecific) diversity; usually measured in terms of genetic differences between individuals or populations.
2. Species (interspecific) diversity, measured as a combination of number and evenness of abundance of species.
3. Community or ecosystem diversity, measured as the number of different species assemblages.

Biodiversity, therefore, is usually considered at three hierarchical levels i.e.
Genetic, *Species* and *Community and Ecosystem* levels.

1. **Genetic diversity**
   Genetic diversity refers to any variation in the nucleotides, genes, chromosomes, or whole genomes of organisms. This is the "fundamental currency of diversity" (Williams and Humphries, 1996) and the basis for all other organismal diversity.
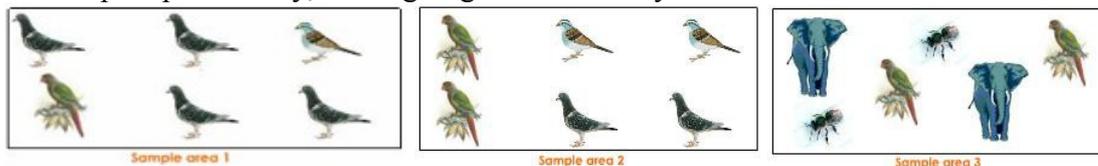
   ➤ Genetic diversity is the sum total of genetic information, contained in the genes of individuals of plants, animals and microorganisms that inhabit the earth.
   ➤ It is needed by any species in order to maintain reproductive vitality, resistance to disease and the ability to adapt to changing conditions.
   ➤ It enables a population to adapt to its environment and to respond to natural selection.
   ➤ The amount of genetic variation is the basis of speciation.
   ➤ Genetic diversity within a species often increases with environmental variability.
   ➤ Such genetic variability has made it possible to produce new breed of crops plants and domestic animals, and in the world allowed species to adapt to changing conditions.

2. **Species diversity**:
   • A group of organisms genetically so similar, that they can interbreed and produce fertile offsprings is called a **species**.
   • The species diversity is usually measured in terms of the total number of species within discrete geographical boundaries.

Species diversity - "species are groups of actually or potentially interbreeding natural populations that are reproductively isolated from other such groups" (Mayr 1963)
   • Species are distinct units of diversity each playing a specific role in the ecosystem.
   • In nature, both the number and kind of species, as well as the number of individuals per species vary, leading to greater diversity.

The different sample areas showing species richness (sample area 1), Species evenness (sample area 2) and diversity due to taxonomically unrelated species (sample area 3).

3. **Community-level diversity**:

It is defined by the species that occupy a particular locality and the interactions between them. It represents the collective response of species to different environmental conditions. Biological communities such as deserts, grasslands, wetlands, and forest support the continuity of proper ecosystem functioning by providing ecological beneficial services to people.
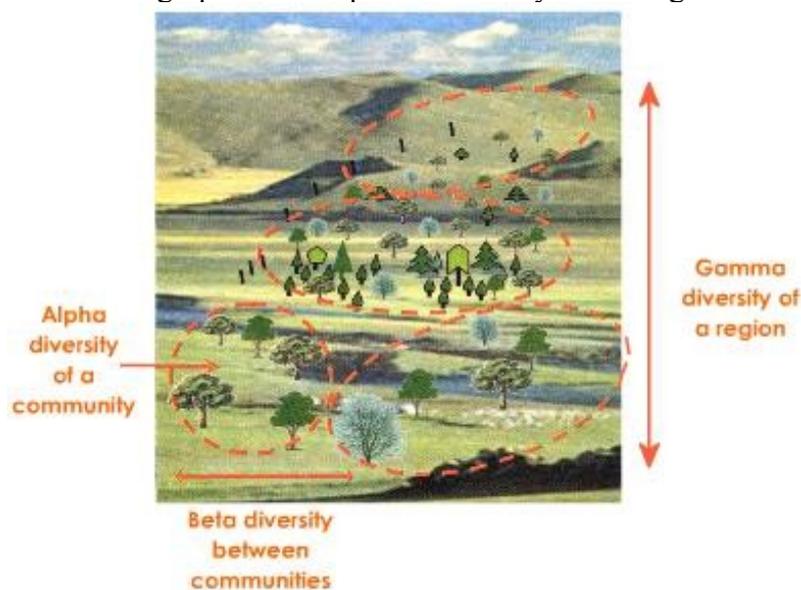
Diversity at the level of community and ecosystem exists along 3 levels.

- It could be within-community diversity (alpha diversity),

- between-communities diversity (beta diversity) or

- diversity of the habitats over the total landscape or geographical area (gamma diversity).

Alpha, Beta, and Gamma Diversity

Whittaker (1972) described three terms for measuring biodiversity over spatial scales: alpha, beta, and gamma diversity.

- *Alpha Diversity* refers to the diversity within a particular area or ecosystem, and is usually expressed by the number of species (i.e., *species richness*) in that ecosystem.

- *Beta diversity:* a comparison of diversity between ecosystems, usually measured as the amount of species change between the ecosystems .

- *Gamma diversity:* a measure of the overall diversity within a large region. Geographic-scale species diversity according to Hunter (2002)

BIODIVERSTY PRINCIPLES

1. Go native - Native areas (wetlands, aquatic areas, riparian areas, forests/woodlands, and grasslands) provide the most important contribution to biodiversity on land.
2. Semi-natural is valuable -Semi-natural areas (e.g., shelterbelts, hedgerows, pastures and haylands, buffers, road margins) also contribute to the conservation of biodiversity.
3. Location - The location, pattern, and seasonal availability of habitat influences the type and amount of biodiversity present.
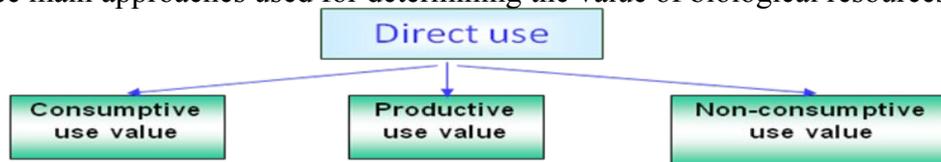
4. Connection - Connecting native and semi-natural areas of land and with neighbouring landscapes is important to biodiversity.

5. Achieving structural diversity- The variation in physical structure of both native vegetation and crops—on the land provides an important contribution to biodiversity.

6. Healthy ecosystems - The health of native and semi-natural areas, all other farmland, and soil and water influences the type and amount of biodiversity present.

7. Variety - The number and mix of species present, including crops and livestock, influences the type and amount of biodiversity present.

8. Aliens - Invasive alien species are generally detrimental to the conservation of biodiversity.

THE VALUES OF BIOLOGICAL DIVERSITY

- Human society depend on biological diversity for almost all the <u>food</u> supply, half of its medicines, much of its <u>clothing</u> and in some region virtually all of its fuel and <u>building material</u> and as well as, of course, an important part of its mental and spiritual welfare.
- Ecological services

Biological diversity as a resource

The three main approaches used for determining the value of biological resources.

- **Consumptive use value:** The biological resources are consumed directly, without passing to the market. Assessing the value of nature's products - such as fire wood, fodder, game meat, etc.
- **Productive use value:** The resource comes through market or trading. Assessing the value of products that are commercially harvested, such as timber, fish, game meat sold in a market, ivory, and medicinal plants.
- **Non-consumptive use value**: The resources meant for the future potential uses of biodiversity (tourism, scientific research) and ecological balance.

Indirect use - **Ecological services**

Benefits of biodiversity

- **Economical benefits –**

    a) Food value – providing food to the human population on this earth for thousands of years. In the process of development of human civilization, man has unfolded many plant and animal life forms which are directly or indirectly helpful for him in solving his food problem. Due to the scientific advancement many new taxa have been discovered which are high yielding.

    b) Commercial value –timber which is a major component of material used for providing shelter to man. Natural fibres like cotton and silk are still used for clothing by human population.

    c) Medicinal value –Medicines, drugs and pharmaceuticals. Many plant genetic resources are used from derivation of basic drugs. These plant resources vary from actinomycetes and fungi to large trees.

    Traditional knowledge of indigenous people still keeps an edge over the scientific knowledge in this field.

    This benefit of biodiversity is still unexplored as the scientists could assess a small fraction of biodiversity for their potential for medicine and agriculture.

- **Aesthetic value** – Man has always been fascinated by the natural beauty and nature has inspired him resulting in development of his moral and ethical values.
  This intrinsic value of plants and animals are independent of their economic and commercial value. Wonderful plants and animals of this planet not only reflect their aesthetic value but they can make us think of the creator. This opens doors for spiritually which envisages to live in harmony with the nature.

- **Ecological benefits/services (Indirect use value)** – Biodiversity supplies the buffering capacity and stability to life on the planet by maintaining the interactive dynamics of the ecosystems of the world.

THREATS TO BIODIVERSITY
> Growing human population
  - specific types of human actions that threatened biodiversity and ecosystems and causes to extinction of many species are:
  - Over-hunting/over-exploitation
  - **Habitat loss/ degradation/fragmentation**
  - Deforestation
  - Invasion of non-native species
  - Pollution
  - Climate change
  - Cultural impacts

Over-exploitation: Humans have always depended on nature for food and shelter, but when 'need' turns to 'greed', it leads to over-exploitation of natural resources.

Habitat loss/degradation/fragmentation is an important cause of known extinctions. As deforestation proceeds in tropical forests, this promises to become the cause of mass extinctions caused by human activity. All species have specific food and habitat needs. The more specific these needs and localized the habitat, the greater the vulnerability of species to loss of habitat to agricultural land, livestock, roads and cities. In the future, the only species that survive are likely to be those whose habitats are highly protected, or whose habitat corresponds to the degraded state associated with human activity.

The Amazon rain forest (it is so huge that it is called the 'lungs of the planet') harbouring probably millions of species is being cut and cleared for cultivating soya beans or for conversion to grasslands for raising beef cattle. Besides total loss, the degradation of many habitats by pollution also threatens the survival of many species. When large habitats are broken up into small fragments due to various human activities, mammals and birds requiring large territories and certain animals with migratory habits are badly affected, leading to population declines.

Habitat fragmentation is a further aspect of habitat loss that often goes unrecognized. The forest or other habitat that remains generally is in small, isolated bits rather than in large, intact units. Environmental fluctuations, disease, and other chance factors make such small isolates highly vulnerable to extinction. Any species that requires a large home range, such as a grizzly bear, tiger, etc will not survive if the area is too small. Moreover, small land units (fragments) are strongly affected by their surroundings, in terms of climate, dispersing species, etc. As a consequence, the ecology of a small isolate may differ from that of a similar ecosystem on a larger scale.

Alien species invasions: When alien species are introduced unintentionally or deliberately for whatever purpose, some of them turn invasive, and cause decline or extinction of indigenous species. E.g. environmental damage caused and threat posed to our native species by invasive weed species like carrot grass (Parthenium), Lantana and water hyacinth (Eicchornia). The recent illegal introduction of the African catfish Clarias gariepinus for aquaculture purposes is posing a threat to the indigenous catfishes in our rivers.

Pollution: Chemical contaminant certainly poses a further threat to species and ecosystems. While not commonly a cause of extinction, it likely can be for species whose range is extremely small, and threatened by contamination.

Climate changes: A changing global climate threatens species and ecosystems. The distribution of species (biogeography) is largely determined by climate, as is the distribution of ecosystems and plant vegetation zones (biomes) [GCI,11/8]. Climate change may simply shift these distributions but, for a number of reasons, plants and animals may not be able to adjust. The pace of climate change almost certainly will be more rapid than most plants are able to migrate. For these reasons, some species and ecosystems are likely to be eliminated by climate change. Agricultural production likely will show regional variation in gains and losses, depending upon crop and climate.

Based on the degree of threats face by the species, species are categories into different conservation category i.e. Extinct, Endangered, Vulnerable and Risk. Therefore, it is pertinent to protect and conserve the existing biodiversity for the socio-economic development and ecological balance. Every species have its role in the environment.

The IUCN Red List (2004) documents the extinction of 784 species (including 338 vertebrates, 359 invertebrates and 87 plants) in the last 500 years. Some examples of recent extinctions include the dodo (Mauritius), quagga (Africa), thylacine (Australia), Steller's Sea Cow (Russia) and three subspecies (Bali, Javan, Caspian) of tiger. The last twenty years alone have witnessed the disappearance of 27 species.
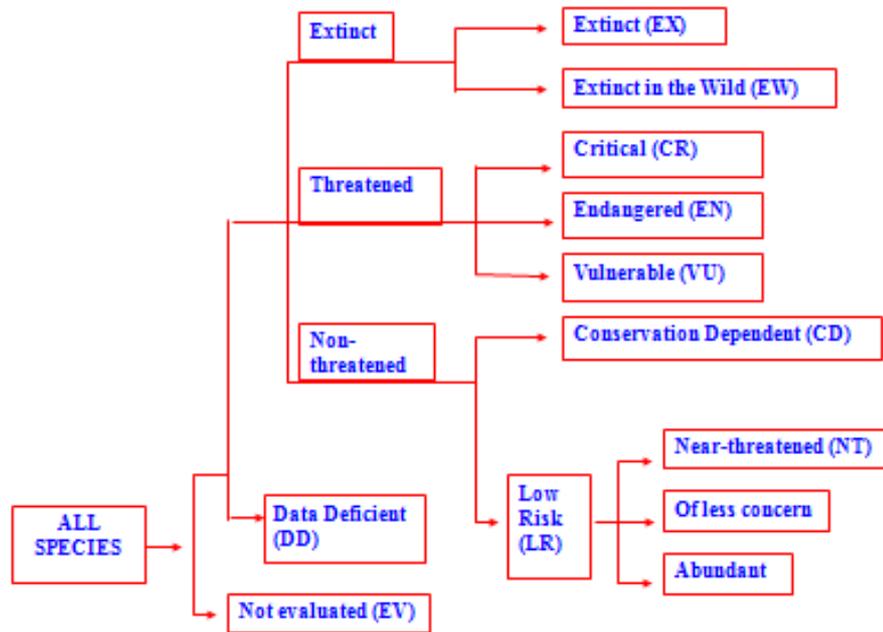
Threatened Species Categories (According to IUCN)	
Extinct (E)	A taxon is Extinct when there is no reasonable doubt that that the last individual has died.
Critically Endangered (CR)	A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future.
Endangered (EN)	A taxon is Endangered when it is not Critically Endangered but facing a very high risk of extinction in the wild in the near future.
Vulnerable (VU)	A taxon is Vulnerable when it is not Critically Endangered but facing a high risk of extinction in the wild in the medium-term future.
Lower Risk (LR)	A taxon is Lower Risk when it has been evaluated, does not satisfy the criteria for any of the categories CR, E, or VU.

Endemic species: Species restricted to a particular region or ecosystem due to various environmental factors or due to the barriers of dispersal.
Rare species: Some species are naturally rare due to presence in small numbers.

THREAT CATEGORIES

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Threatened species of India	
Taxonomic group	Number of threatened species
Mammals	86
Birds	73
Reptiles	25
Amphibians	3
Fish	3
Molluscs	2
Other vertebrates	21
Plants	244
Total	459
Source: IUCN 2000	

BIODIVERSITY CONSERVATION

Why Should We Conserve Biodiversity?
There are many reasons, some obvious and others not so obvious, but all equally important. They can be grouped into three categories: **narrowly utilitarian**, **broadly utilitarian, and ethical.**

The **narrowly utilitarian** arguments for conserving biodiversity are obvious; humans derive countless direct economic benefits from nature food (cereals, pulses, fruits), firewood, fibre, construction material, industrial products (tannins, lubricants, dyes, resins, perfumes) and products of medicinal importance. More than 25 per cent of the drugs currently sold in the market worldwide are derived from plants and 25,000 species of plants contribute to the traditional medicines used by native peoples around the world. Nobody knows how many more medicinally useful plants there are in tropical rain forests waiting to be explored. With increasing resources put into 'bioprospecting' (exploring molecular, genetic and species-level

diversity for products of economic importance), nations endowed with rich biodiversity can expect to reap enormous benefits.

The **broadly utilitarian** argument says that biodiversity plays a major role in many ecosystem services that nature provides. The fast dwindling Amazon forest is estimated to produce, through photosynthesis, 20 per cent of the total oxygen in the earth's atmosphere. Can we put an economic value on this service by nature? You can get some idea by finding out how much your neighborhood hospital spends on a cylinder of oxygen. Pollination (without which plants cannot give us fruits or seeds) is another service, ecosystems provide through pollinators layer – bees, bumblebees, birds and bats. What will be the costs of accomplishing pollination without help from natural pollinators? There are other intangible benefits – that we derive from nature–the aesthetic pleasures of walking through thick woods, watching spring flowers in full bloom or waking up to a bulbul's song in the morning. Can we put a price tag on such things?

The **ethical** argument for conserving biodiversity relates to what we owe to millions of plant, animal and microbe species with whom we share this planet. Philosophically or spiritually, we need to realise that every species has an intrinsic value, even if it may not be of current or any economic value to us. We have a moral duty to care for their well-being and pass on our biological legacy in good order to future generations.

Biodiversity knows no political boundaries and its conservation is therefore collective responsibilities of all nations.

PROTECTING BIODIVERSITY: LEGAL AND NON-LEGAL BINDINGS

Conservation of biodiversity
- Conservation of biodiversity is essential for the human survival, notably through health, food and industry.
- All forms of life-human, animal and plants are so closely interlinked that disturbance in one gives rise to imbalance in the others.
- If species of plants and animals become endangered they signify degradation in the environment, which may threaten man's own existence.
- The maintenance of biodiversity at all levels is fundamentally the maintenance of viable population of species or identifiable populations.
- Approaches of biodiversity conservation should be concise with due consideration of national problems.
- Priority should be given first to conserve those species which have vital resource which benefit to mankind at shorter duration and also to conserve threatened, endangered and rare species of the nation.
- *In situ* and *ex situ* conservation of biodiversity should be done for those species which are threatened, rare, endangered as well as species expenditure.
- Extraction of timber from the forest areas should be based on ecological planning by taking into the consideration of stability of ecosystem.
- The scientific knowledge of biodiversity conservation should not be restricted on paper that should be spread among the people through the mass communication, training, awareness programmes at the grassroots level.
- An approach of sustainable harvest or exploitation of the species will be helpful for the conservation of biodiversity, offering all the basic necessities for the subsistence of man's life.
- Therefore, sustainable use of resources and sustainable development are highly needed in order to save the loss of biodiversity.

How do we conserve Biodiversity?

In situ conservation - In India, ecologically unique and biodiversity-rich regions are legally protected as biosphere reserves, national parks and sanctuaries. India has also a history of religious and cultural traditions that emphasized protection of nature eg. Sacred groves.

Ex situ Conservation– In this approach, threatened animals and plants are taken out from their natural habitat and placed in special setting where they can be protected and given special care and protective maintenance. Examples; zoological parks and botanical gardens, in vitro fertilisation, tissue culture propagation and cryopreservation of gametes.

Forests and wildlife
The Forest (Conservation) Act, 1980
This Act was adopted to protect and conserve forests. The Act restricts the powers of the state in respect of de-reservation of forests and use of forestland for non-forest purposes (the term ?non-forest purpose? includes clearing any forestland for cultivation of cash crops, plantation crops, horticulture or any purpose other than re-afforestation).

The Wildlife (Protection) Act, 1972, Amendment 1991
The WPA (Wildlife Protection Act), 1972, provides for protection to listed species of flora and fauna and establishes a network of ecologically-important protected areas. The WPA empowers the central and state governments to declare any area a wildlife sanctuary, national park or closed area. There is a blanket ban on carrying out any industrial activity inside these protected areas. It provides for authorities to administer and implement the Act; regulate the hunting of wild animals; protect specified plants, sanctuaries, national parks and closed areas; restrict trade or commerce in wild animals or animal articles; and miscellaneous matters. The Act prohibits hunting of animals except with permission of authorized officer when an animal has become dangerous to human life or property or so disabled or diseased as to be beyond recovery (WWF-India, 1999). The near-total prohibition on hunting was made more effective by the Amendment Act of 1991.

National Parks
Definition: An area dedicated by statute for all time, to conserve the scenery and natural and historical objects of national significance, to conserve wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations, with such modifications a local conditions may demand". (IBWL 1952)

Wildlife Sanctuary
Definition: It is an area where killing and capturing of any species of birds or animals is prohibited except under orders of competent authority and whole boundaries and characteristics should be sacrosanct (free from outrage) as far as possible". (IBWL 1952)

Aims of establishment of National Parks and Wildlife Sanctuary
The sanctuaries and national parks (Protected areas) are established with the view to:-
1. Adequate representation of bio-geographic diversity.
2. Proper geographic distributions of PAs across prominent wilderness belts.
3. Setting-up new PAs rationalizing boundaries of existing ones so as to meet the imperative in the above 1 & 2.
4. Overcoming management deficiencies in PAs.

5. Promoting corridor values (conducive to movement of major mammals and long terms, long ranging gene-travel of all species of flora and fauna) through forests and multiple-use areas that lie between PAs in a given wilderness belt.
6. Establishing a monitoring mechanism to access the viability of network of PAs.

Difference between NP and WLS

-   National park is declared by the state government under section 35(1) of the Wild Life (Protection) Act, 1972; whereas sanctuary is declared under section 18(1) of the Act.

-   In NP, the boundary is well-defined and accurate at the time of its declaration; while the boundary is demarcated approximately at the time of its declaration in sanctuary.
-   The claim of right of land of the people is settled before its declaration in NP; whereas in case of sanctuary the same is settled after its declaration.

-   No alternation of the boundaries of the NP shall be made except on a resolution passed by Legislative Assembly of the State Government; but on contrary, in sanctuary, such alternation may be done by the order of the state Government.

-   In NP grazing is not permissible while in sanctuary grazing and movement of the cattle may be permitted for the benefit of wild animals.

-   In sanctuary, the Chief Wildlife warden may pass his/her order after getting concurrence of the state Government to kill or catch the certain wild animal for the welfare of wild community and he/she is also empowered to dismiss the order; but in case of NP, such order is governed by the state Government itself and then the Chief Wild Life warden issues the concerned order which cannot de dismissed by him/her.

The status and degree of permanency and protection is, therefore, much higher in NP than in a sanctuary.

Biosphere Reserve

Biosphere reserves are areas of terrestrial and coastal ecosystems promoting solutions to reconcile the conservation of biodiversity with its sustainable use.
 They are internationally recognized, nominated by national governments and remain under sovereign jurisdiction of the states where they are located.

Biosphere reserves serve in some ways as 'living laboratories' for testing out and demonstrating integrated management of land, water and biodiversity.
Collectively, biosphere reserves form a World Network. Within this network, exchanges of information, experience and personnel are facilitated. There are over 480 biosphere reserves in over 100 countries.

To prevent loss of biodiversity, the Government of India is setting up 17 biosphere reserves in different parts of the country. (Ministry of Environment and Forests: "Annual Report 2010-2011")

-   These are multipurpose protected areas to preserve the genetic diversity in different ecosystems.

-   Seven of the seventeen biosphere reserves are a part of the World Network of Biosphere reserves, based on the UNESCO Man and the Biosphere (MAB) Programme list. Namely, Nilgiri, Gulf of Mannar, Sundrbans, Nanda Devi, Nokrek, Pachmarhi, and Similipal Biosphere Reserves

Functions of Biosphere Reserve

Each biosphere reserve is intended to fulfill 3 basic functions, which are complementary and mutually reinforcing:
- **a conservation function** - to contribute to the conservation of landscapes, ecosystems, species and genetic variation;
- **a development function** - to foster economic and human development which is socio-culturally and ecologically sustainable;
- **a logistic function** - to provide support for research, monitoring, education and information exchange related to local, national and global issues of conservation and development.

Sacred groves

❖ Sacred groves are the tract of virgin forest harbouring rich biodiversity, protected by the local people based on the ground of beliefs of culture, religion and taboos of indigenous people.

❖ They are the repositories of rare and endemic species and can easily be thought of as remnants of primary forest left untouched by the local inhabitants and protected by them due to the consideration that deities resides in these forests.

❖ It is one of the oldest form of conservation of nature, practiced by the indigenous communities and rural people.

❖ The inextricable link between present society to the past in terms of biodiversity, culture, religious and ethnic heritage has been found in sacred groves.

❖ It is believed that sacred virgin forest dates back to several thousands of years when human society was in the primitive state.

❖ Historical links of the sacred groves has been traced from pre- agricultural, hunting and gathering stage of societies and believed to be pre-Vedic in origin.

❖ The groves have evolved under different socio-ecological and cultural situations. Every sacred grove carries its own legends, lore and myths which form the integral part of the oral traditions of local people.

❖ This unique community-linked forest conservation concept is still followed in many tribal and agrarian regions of the world. For example, a number of human societies in Asia, Africa, Europe, America and Australia had long preservation sections of their natural environment as sacred groves.

❖ The protection and conservation of groves depends entirely on the control of the community over the forest and the people.

❖ They have been survived for many hundreds of years and today they serve as reservoir of much local biodiversity. Groves provides many ecological, environmental and socio-cultural functions to the society.

❖   In the context of the recent concern over the high rates of deforestation and natural resource use, the sacred groves offer a potential tool and model to revisit and explore the possibilities of conservation of biological diversity.

Classification of sacred groves

Traditional Sacred Groves – It is the place where the village deity resides, who is represented by an elementary symbol.

Temple Groves – Here a grove is created around a temple and conserved.

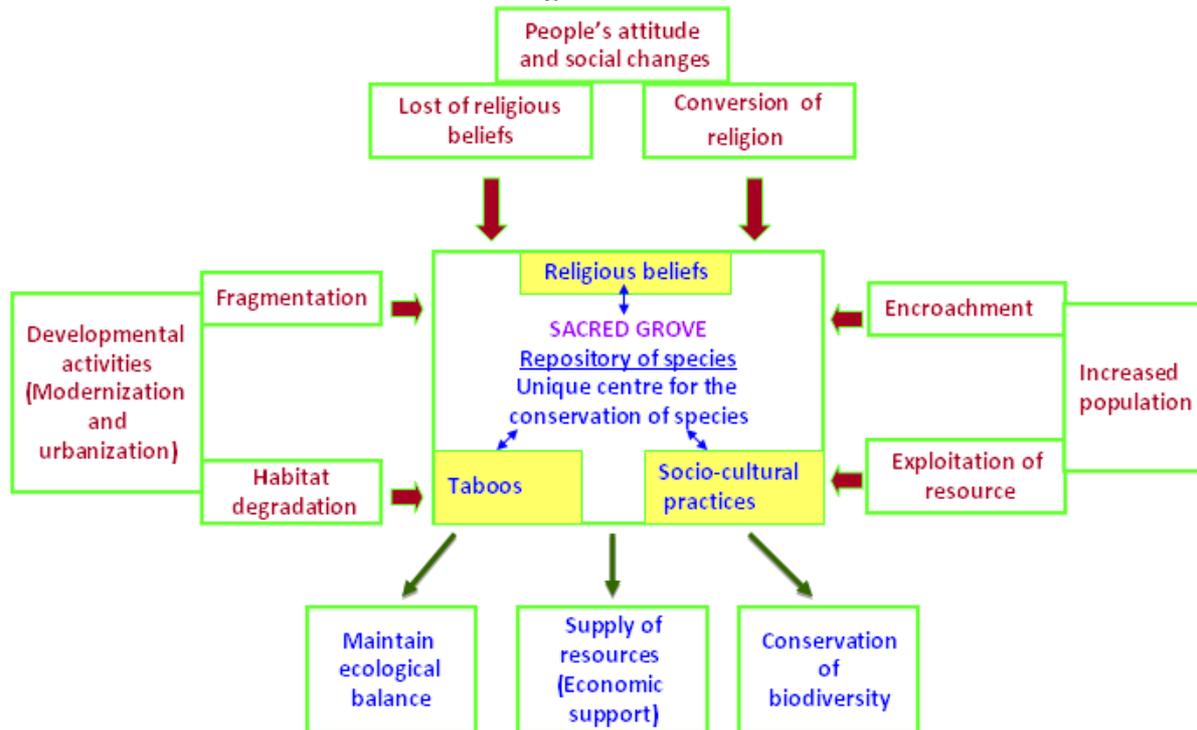**Groves around the burial or cremation grounds.**

Figure . Diagrammatic representation of sacred grove: it's benevolent to human and nature, and fortune due to human impacts.

(Source: Khumbongmayum, et al 2004)

BIODIVERSITY OF NORTHEAST INDIA

- Northeast India is blessed with a wide range of physiography and ecoclimatic conditions. It represents the transition zone between the Indian, Indo-Malayan and Indo-Chinese biogeographic regions and a meeting place of the Himalayan Mountains and Peninsular India.
- The region is one of the richest in biological values. It is in this lowland-highland transition zone that the highest diversity of biomes or ecological communities can be found, and species diversities within these communities are also extremely high.

FLORA

The vegetation of the northeastern region is fairly well known. With about 1,67,000 sq.km. area under forest, this region accounts for approximately 7500 species of angiosperms. The State of Sikkim alone holds about 5000 species of flowering plants. Out of 315 families of Angiosperms in India, more than 200 are represented in Northeast India and this region

accounts for nearly 50% of the total number of plant species in India as a whole. Though the flora of this region exhibits an Indo-Malayan affinity, the floral elements of other parts of India, and of neighbouring and far off countries, have also contributed to its richness and diversity. It is of interest to note that about one third of the flora of Northeast India is endemic to this region.

- The NE region accounts for nearly 50% of the total number of plant species in India as a whole.
- The region has at least 7,500 flowering plants, 700 orchids, 58 bamboos, 64 citrus, 28 conifers, 500 mosses, 700 ferns and 728 lichen species. Some of the important gene pools of citrus, banana and rice have been reported to be originated from this region (Anonymous 1996).
- Out of the 315 families of Angiosperms in India, more than 200 are represented in NE India.
- It is of interest to note that about one third of the flora of NE India is endemic to this region.

The carnivorous/ Pitcher plant (*Nepenthes khasiana*) is endemic to Meghalaya and is listed in Appendix I of CITES and placed in Schedule VI of the wildlife (Protection) Act, 1972.

Siroy lily (*Lilium mackliniae*) a ground lily that produces beautiful flowers, is a narrow endemic found in the eastern border area of Manipur in Ukhurl district.

Agarwood (*Aquilaria malaccensis*) that occurs in the tropical forests of the NE regions is highly prized and is listed in Appendix II of CITES Schedule VI of the Wildlife (Protection) Act, 1972.

The yew tree (*Taxus baccata*) is a highly toxic plant that has occasionally been used medicinally, mainly in the treatment of chest complaints. Modern research has shown that the plants contain the substance 'taxol' in their shoots. Taxol has shown exciting potential as an anti-cancer drug, particularly in the treatment of ovarian cancers. *Taxus baccata* found in West Kameng and Tawang district of Arunachal Pradesh are cut down by the local people and exploit for commercial purpose. Due to the large scale destruction, the survival of species are threatened and immediate conservation is needed. Therefore, in Bomdila a nursery of *Taxus* baccata is set up and helping from the verge of extinction.

Rhododendron

The genus Rhododendron of Ericaceae is another remarkable group of showy plants with nearly 98% of the total Rhododendrons reported from India are confined to Himalayan region (Singh et al. 2003).
In total 72 species, 20 sub species and 19 varieties listed from India, eastern Himalaya region harbors 71 species. Out of 12 species, 2 sub species and 5 varieties of Rhododendron endemic to India, in north eastern region, Arunachal Pradesh has maximum number of endemic species with 9 species and 1 sub species, followed by Manipur and Sikkim with 3 species and 1 sub species and Mizoram with 2 species (Mao et al 2001).

Orchid

Orchidaceae, the most fascinating and highly evolved groups of plants with 1229 species belonging to 184 genera in India (Singh & Chauhan 1999), about 700 species have been reported from north eastern region of India.

Of these, 545 species belonging to 122 genera are reported from only Arunachal Pradesh (Chowdhery 1998). Of which 12 species are under endangered category, 16 species vulnerable and 31 species threatened.

FAUNA

The region is equally rich in faunal diversity. An estimated 3,624 species of insects, 50 molluscs, 236 fishes, 64 amphibians, 137 reptiles, 541 birds and 160 mammalian species have been so far described (Anonymous 1998b).

Primates
- Three families of primates' occur in India with 15 known species, nine of these species occur in North east India (Mohnot 1980 and Roonwal and Mohnot 1977).

- The Golden Langur (*Trachypithecus geei*) is a Schedule I animal and is also listed in the Appendix I of CITES.

The Slow Loris (*Nycticebus bengalensis*) is an inhabitant of tropical forests south of the Brahmaputra River in Northeast India. This highly endangered animal is listed as Schedule I animal, and in Appendix I of the CITES.

Carnivores
- Of the six largest cats of the world recorded from India, state of Arunachal Pradesh only sustain four of them - the Tiger (*Panthera tigris*), Leopard (*Panthera pardus*), Snow Leopard (*Uncia uncia*) and the Clouded Leopard (*Neofelis nebulosa*).

- Red Panda, protected under Schedule I of the Indian Wildlife (Protection) Act, 1972 and listed in Appendix I of CITES and as 'Endangered, by IUCN is also predominantly available in the region.

Ungulates
- The foothill grasslands and broadleaf forest harbor important population of Asian elephant, onehorned rhinoceros and wild water buffalo.
- In Northeast India Great Indian Rhinoceros (*Rhinoceros unicornis*) is now restricted to Kaziranga, Pabitora and Orang in Assam.
- The Brow-antlered Deer (*Cervus eldi eldi*), locally known as Sangai is endemic to Manipur and one of rarest and the most localized subspecies of deer in the world.
- The Pygmy Hog (*Sus salvanius*) is the smallest and the rarest wild suid in the world, and only a few isolated wild populations survive in Northeast India.

Birds
- From Arunachal Pradesh over 760 bird species have been reported (Borang 2004).
- Greater Adjutant (*Leptoptilos dubius*) is a globally threatened bird with the majority of the world's population now found in Assam.
- Spot-billed Pelican (*Pelicanus philippensis*), Blacknecked Stork (*Ephippiorhyncus asiaticus*), Lesser Adjutant (*Leptotilos javanicus*), and Pale-capped Pigeon (*Columba punicea*), are only to name a few of the globally threatened birds found in the region.
- Swamp Francolin (*Francolinus gularis*), found in Northeast India, is endemic to the Indian subcontinent.

Lower Vertebrates
- So far 137 species of reptiles have been recorded from Northeast India which has the greatest affinity to the Oriental, Indo – Malayan and Indo – Chinese regions.

- 20 lizard species from the State of Assam, and 18 species from the tiny state of which is profoundly influenced by the Indo-Chinese connection have been recorded so far.
- Of the three species of Monitor Lizards found in the region, *Varanus flavescens* is listed in Schedule I under Wildlife (Protection) Act, 1972 and listed in Appendix I of CITES.
- The Tokay Gecko (*Gekko gekko*) is the largest gecko alive today and is found in northeast India.
- Fifty eight species of snakes have been recorded in Assam, 34 from Manipur and 92 from Arunachal Pradesh. *Python reticulatus*, the largest snake in India, is found in northeast India and *Python molurus bivittatus* is the most commonly known in the region.
- So far 64 species of amphibians have been recorded from the Northeast India.

Invertebrates
- The Biodiversity Strategy and Action Plan for Northeast Ecoregion suggests that 3,624 species of insects and 50 molluscs are recorded from the region (Tripathi and Barik 2003).
- Butterflies and moths are by far the best-studied invertebrate organisms in Northeast India, and the region contributes the maximum number of species for the group in the country.

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Abbreviations used:
CBD: Convention on Biological Diversity
CITES: Convention on International Trade in Endangered Species of Wild Fauna and Flora
IBWL: Indian Board for Wildlife
IUCN- International Union for Conservation of Nature
UNESCO - United Nations Educational, Scientific and Cultural Organization
WCMC: World Conservation Monitoring Centre
WPA - Wildlife Protection Act
WWF- World Wide Fund for Nature

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