Chapter- 15

Biodiversity and Conservation

- Large and diverse communities of biota occupy distinct climatic zone forming ecosystems.
- The term biodiversity was first coined in 1980 by W.G. Rosen. It is the shortened and combined version of two words- “biological” and “diversity”.
- Biodiversity or biological diversity can be defined as the vast diversity of species and varieties of all the life forms existing on earth. They include the species of micro-organisms, algae, fungi, plants, animals, occurring on the earth in various habitats and the ecological complexes and niches of which they are a part.
- Whether or not a species can survive and colonize an area depends on the environmental conditions of the area as well as the range of tolerance of the species.

MAGNITUDE OF BIODIVERSITY

- India has approximately 45,000 species of plants and nearly twice as many species of animals. India, therefore, is one of the 12 mega diversity countries of the world.
- Numerous species that are yet to be identified are believed inhabit tropics and coral reefs.
- The number of species present in tropics can be estimated by comparing species richness between tropics and temperate areas. Inventories are nearly complete for most groups of organisms in the temperate areas.
- Scientists have in this manner calculated the total number of species in the world to be approximately 5.50 million.
- The most intriguing aspect of biodiversity is that more than 70% of all species are animals while plants account for only 22%.
- Among the animals, insects are the most numerous (about 70%) with present estimate of 7 out of 10 animals.
- Further the knowledge about protists, archaebacteria and viruses is quite less. With that information the magnitude of biodiversity will further increase.

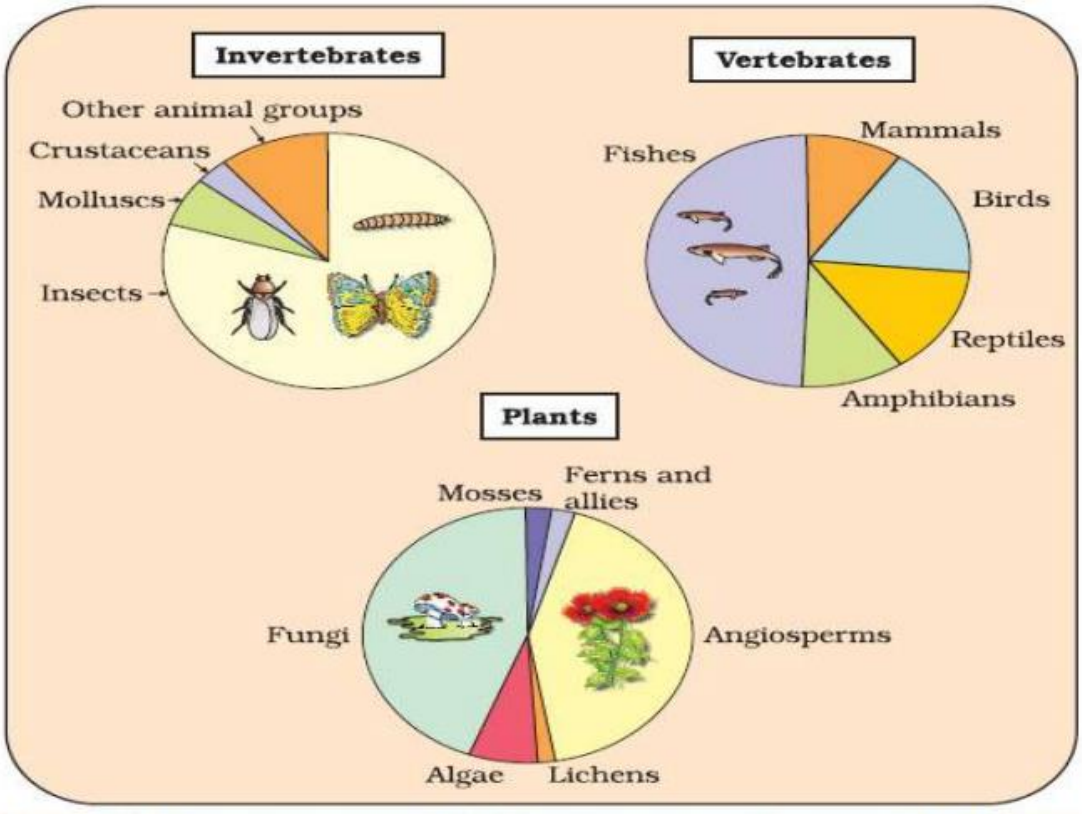

Figure [redacted] Representing global biodiversity: proportionate number of species of major taxa of plants, invertebrates and vertebrates

LEVELS OF BIODIVERSITY

1. Genetic diversity

- It is the diversity in the number and type of genes as well as chromosomes present in different species and the variations in the genes and their alleles in the same species.
- On average a bacteriophage has 100 genes, Drosophila melanogaster 13000 genes and Homo sapiens 30,000 – 40,000 genes.
- Variation in the genes of a species increase with increase in size and environmental parameters of the habitat.
- Genetic diversity is useful in adaptation to changes in environmental conditions.
- It helps in speciation or evolution of new species.
- Lower genetic diversity within a species or variety may be useful for uniformity in yield as well as higher yield. However it is more susceptible to degradation and prone to mass scale destruction at the hands of fungal or insect attacks.

2. Species diversity

- It is the diversity and variety in the number and richness of the species of a region.
- The number of species per unit area is called **species richness**.
- Number of individuals of different species in a given area represents species **evenness or species equitability**.
- Communities where species are represented by more or less the same number of individuals exhibit evenness.
- Communities where one or more species have more individuals than other, show **dominance or unevenness**.
- Species diversity is the **product of species richness or evenness or equitability**.
- Odum *et al* (1960) calculate species diversity as number of species per thousand individuals while Menhinick (1964) calculates it as number of species in relation to square root of total number of individuals.
- **Diversity index commonly used in ecological studies is Shannon index**.

3. Community and Ecosystem diversity

It has three types

(i) Alpha diversity (within community diversity) It is a species diversity. α – diversity is dependent upon species richness and evenness. There is a lot of competition, adjustments and inter relationships amongst members of the same community. Variations are limited.

(ii) Beta diversity (Between communities diversity). It is diversity which appears along a gradient of habitat within geographical area. Due to differences in microhabitat, niches and in environmental condition there could occur change in communities that could lead to replacement of species.

(iii) Gamma diversity.

- It is diversity present in ranges of communities as represented by diversity of habitats/ ecosystems over a total landscape geographical area.
- Ecosystem diversity is the variety of forms in the ecosystem due to diversity of niches, trophic levels and ecological processes like nutrient recycling, food webs, energy flow, role of dominant species and various biotic interactions.
- Diversity helps in achieving more productive and stable ecosystems which can tolerate various environmental stresses like prolonged drought

INDIA AS MEGADIVERSITY REGION

- India has attained a unique distinction as it has been assigned the status of mega diversity nation.
- The country has 10 biogeographical regions. They are: **Trans Himalaya, Himalaya, Desert, Semi-arid, Western Ghats, Deccan peninsula, Gangetic Plain, Coasts, North-East and Islands**.

- India has 89 national parks, 492 wild life sanctuaries, 14 biosphere reserves, 6 wetlands and 5 world heritage sites. The country has also 27 tiger reserves.
- Deccan peninsula is the largest biogeographical region and the Western ghat and north-east are regions richest in biodiversity.
- 33% of flowering plants, 10% of mammals, 36% reptiles, 60% of amphibians and 53% fresh water fish are endemic. The richest regions are the Himalayas, Western Ghats. Indian Islands and North-Eastern Hills

PATTERNS OF BIODIVERSITY LATITUDINAL AND ALTITUDINAL GRADIENTS

(i) Latitudinal gradient

- There is little biodiversity at the poles. Biodiversity is more in temperate areas but is maximum in tropical rain forests. This is because the tropical rain forests have more favourable conditions for more varieties of organisms and with less or no catastrophes. This has allowed for stability in the environment allowing more species to develop.
- In temperate areas harsh conditions exist only during the cold season. However, very harsh conditions prevail for most of the year in arctic regions.
- Number of vascular species is 118-236/0.1 ha in tropical forests and 21-48 species 0.1 ha in temperate forests. Their number would 10/0.1 ha in arctic regions.

(ii) Altitudinal gradient

- A decrease in species diversity occurs as we ascend high mountains due to drop in temperature and greater seasonal variability.

SPECIES – AREA RELATIONSHIP

- German geographer and naturalist Alexander von Humboldt observed that species richness within a region increases with increasing area but only up to a certain limit.
- The relationship between species richness and area is a rectangular hyperbola for a wide variety of taxa whether they are birds, bats, fresh water fishes or flowering plants.
- On a logarithmic scale it is a straight line.
- Here S is species richness, Z is slope of line or regression coefficient, C is y-intercept while A is area.
- Regression coefficient is generally 0.1-0.2, regardless of taxonomic group or region e.g. plants in Britain birds in California or mollusks in New York.
- However, when the species area relationship is considered for a very large area like whole continent, retrogression coefficient or slope of the line comes to have Z value of 0.6 – 1.2, e.g. frugivorous birds and mammals of tropical forests of different continents with a steeper line of 1.15.

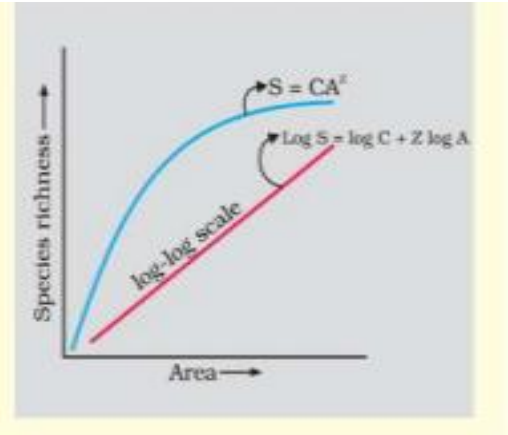

Figure 1.3 Showing species area relationship. Note that on log scale the relationship becomes linear

IMPORTANCE OF BIODIVERSITY

1. Source of food

- Of over 3000 species of food plants only 150 species have been commercialized. It can be seen that 85% of the food output is produced by less than 20 species.
- Two third of food is being produced by only three crops rich in carbohydrates -wheat, corn (maize) and rice.
- Utilisation of more and more food plants has to be made.

2. Source of fats and oils

- The major oil seed plants are soybean, coconut, cotton seed, peanut and sunflower, sesame, safflower, mustard and oil palm.
- Some newer species of oil are being investigated for obtaining high performing lubricants. E.g. Bitter colocynth, jojoba seed.

3. Fibres

The major sources of fibre are cotton, jute, flax, hemp, sun hemp, rosella, coir and agave. Search is continually on for new superior fiber yielding plants.

4. New varieties

- Domesticated commercial species are improved for various traits, especially disease resistance by crossing them with wild relatives.
- Rice has been made resistant to four main diseases by crossing it with wild species (*Oryza nivara*) from India.
- Potato has been made resistant to late blight (trait from *Solanum demissum*), Potato Mosaic Virus Y (trait from *Solanum stoloniferum*), *Fusarium* and five races of cyst nematodes (trait from *Solanum spegazzini*)

5. Drugs and medicines

- A number of drugs are based on plant products.
- Rosy periwinkle (*Charanthus roseus* = *Vinca rosea*) yields alkaloids (Vincristine and vinblastine) which are useful for treatment of leukaemia. The same are now being synthesized chemically.
- Other drugs derived from plants are Morphine (Papaver *somniferum* for pains), quinine (from bark of *Cinchona ledgeriana* for malaria), taxol (from bark of Yew; *Taxus brevifolia* and *Taxus baccata* for treating cancers), reserpine (from *Rauvolfia serpentine* for treating blood pressure and schizophrenia) etc.
- 25% of all drugs are currently sourced from 120 species of plants.
- Traditional systems of medicine world over use thousands of local/ wild plants for treating various maladies. It is possible to manufacture innumerable synthetic products from plant chemicals. These are called botano-chemicals.

6. Aesthetic value

Biodiversity has a lot of value in terms of aesthetics and attraction of people towards a particular place. Aesthetic value of biodiversity can be utilized for ecotourism, bird watching, wildlife, pet keeping and gardening.

7. Cultural benefits

- Historically people have associated themselves with certain specific plants and animals.
- Many Indian homes have varieties of *Ocimun sanctum* (Tulsi) growing in the gardens and pots.
- Trees of *Ficus religiosa* (Peepal) and *Prosopis cineraria* (Khejri) are considered sacred. They are worshipped.
- Many birds are believed to be sacred. Snakes are also worshipped.
- Every country and state recognizes a particular plant and particular animal as symbol of national and state pride and cultural heritage.

8. Ecosystem services

- To maintain and utilize products and services of various ecosystems and individual species biodiversity is required.
- Forest and oceanic systems control climate and maintain gaseous composition of atmosphere.
- Amazon rain forest are considered lungs of planet earth as they give out 28% of total oxygen.
- Biodiversity is essential for natural pest control and maintenance of populations of various species. It is also important for pollination by insects and birds, nutrient cycling, conservation and purification of water, formation and protection of soil etc. The services are valued at 16-54 trillion dollars per year.

THREATS TO BIODIVERSITY

i) Habitat loss and fragmentation: -

The world is facing accelerated rate of species extinction, largely due to human interference. There are four major causes (**the evil quartet**):

- Overpopulation, urbanisation and industrialization require additional land every year.
- It can come through destruction or fragmentation of natural habitat through filling wetlands, ploughing grasslands, cutting down trees, burning a forest and clearing some area of vegetation.
- Animals requiring large territories are badly affected.
- Migrating animals would go astray and get killed.

ii) Over –exploitation:-

- Excessive exploitation of a species, whether a plant or animal reduces size of its population so that it becomes vulnerable to extinction.
- Three subspecies of Tiger, dodo, stellar sea cow and passenger pigeon have become extinct in the last 500 years due to overexploitation by humans.
- Many marine fish populations are declining around the world.
- **Alien species invasions:-**
  Non-native or alien species are often introduced inadvertently for their economic and other uses. Many times they become invasive and inhibit growth and survival of local species.
- **Island ecosystems are the most vulnerable. This is mainly because of their small size and small number of species.**
- **Water hyacinth (Eichhornia crassipes) was introduced with intent to reduce pollution in Indian waters.**
- **It has led to clogging of water bodies including wetlands at many places. This has resulted in death of several aquatic plants and animals.**
- **Nile perch (a predator fish) was introduced in Lake Victoria of South Africa. It has since then killed and eliminated ecologically unique diversity of over 200 native species of small Cichlid fish.**
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iii) o-extinctions:-

- Certain obligatory mutualistic relationship exist in nature e.g. Yucca moth and Yucca flower.
- Extinction of one will automatically cause extinction of other.
- If the host fish becomes extinct, all the parasites exclusively found on it will also become extinct.

WILDLIFE CONSERVATION

Wildlife conservation is necessary for lot of reasons.

i) Balance of nature:

- There is a balance of nature in an ecosystem. The different living organisms live in equilibrium.
- The food web consists of an interlocking system of food chain, the destruction of any species of wildlife in an ecosystem can disrupt the entire balance of nature.

ii) Commercial value of wildlife:

- We have a rich variety of wild life. Government established national parks and sanctuaries attract many tourists from abroad. This is valuable source of foreign exchange.
- Surplus animals are exported to foreign zoos and parks, also earning foreign exchange.

iii) Biological studies: Naturalists, zoologists and behavior biologists can study the ecology, physiology and behavior of the various forms of wildlife in their natural habitats. This contributes to our knowledge of biology.

iv) Sports and recreation:

The sport of hunting is restricted to a great extent because of the rapidly declining number of animals. Good recreation can be provided in form of camping, trekking and other adventure activities by wildlife centres.

CONSERVATION OF BIODIVERSITY

Conservation of biodiversity is considered under three categories-

A. Narrowly utilitarian
B. Broadly utilitarian
C. Ethical

Narrowly utilitarian

- Human beings obtain innumerable direct economic benefits from nature.
- Food (cereals, pulses, fruits), firewood, fiber, construction material.
- Industrial products (tannins, lubricants, dyes, resins, perfumes).
- Products of medicinal importance.
- **Bioprospecting:** The process of exploring molecular genetics and species level diversity to obtain and develop products of economic importance.

Broadly utilitarian

- Amazonian forests alone produce nearly 20% of oxygen during photosynthesis.
- **Pollinator layer:** bees, bumblebees, birds and bat that pollinate the plant without which seed cannot be produced by plants.
- Aesthetic pleasure we get from the biodiversity.

Ethical:

- Humans owe their existence to all other organisms that inhabit and have inhabited this earth.
- Each species and variety has an intrinsic value.
- It is our ethical responsibility to protect and pass on the biological legacy that we have been blessed with.

Conservation of Biodiversity:

There are two types of conservation strategies – **in situ (on site) and ex situ (off site)**

IN SITU CONSERVATION

It is conservation and protection of the whole ecosystem and its biodiversity at all levels in order to protect the threatened species. It is however neither economically feasible nor possible to conserve all existing biological wealth and all the ecosystems.

Hot spots

These are areas with high density of biodiversity or megadiversity. These are also the most threatened ones.

Ecological hot spots are determined by four factors

(i) Number of species/ species diversity

(ii) Degree of endemism

(iii) Degree of threat to habitat due to its degradation and fragmentation

(iv) Degree of exploitation:

- Mayers (1988) initially identified 12 hot spots with 14% of plant species in an area of only 0.2%.
- Today the number of hotspots identified by ecologists is 34 covering an area less than 2% of land surface with about 20% of human population living there.
- India has three hot-spots: **Indo-Burma, Himalayas and Western ghats and Srilanka**.

Protected areas

- They are ecological / biogeographical area as where biological diversity along with natural and cultural resources is protected, maintained and managed through legal or other effective measures.
- They are defined and delimited on the basis of biological diversity e.g. cold desert (Thar), wetland (Assam) saline swampy area (Sundarbans) etc.
- Protected areas include national parks, sanctuaries and biosphere reserves.

National park

- They are areas maintained by government and reserved for betterment of wildlife cultivation. Grazing, forestry and habitat manipulation are not allowed.
- There are 89 national parks in India that occupy nearly 1.1% of geographical area

Sanctuaries

They are tracts of land with or without lakes where wild animals / fauna can take refuge without being hunted. Certain other activities like collection of forest products, harvesting of timber private ownership of land, tilling of land etc., are allowed.

Biosphere reserves

- They are protected areas which have been designed for multiple purposes. They are meant for preserving genetic diversity in representative ecosystems of various natural biomass and unique biological communities. This is done by protecting wild populations, traditional life style of tribal and domesticated plant and animals genetic resources.
- Creation of biosphere reserve was initiated in 1975 under MAB programme of UNESCO.
- Till 2002, 408 biosphere reserves had been established in 94 countries.
- In India, 17 biosphere reserve have been set up by now.

Each biosphere reserve has-

i) Core or Natural zone: No human activity is allowed. The area is undisturbed and legally protected ecosystem.

ii) Buffer zone: It surrounds the core area. Limited human activity is allowed like resource use, strategies research and education.

iii) Transition zone:

- It is the outermost or peripheral part of biosphere reserve where an active cooperation is present between reserve management and local people for activities like settlements, cropping recreation, forestry and other economic uses without disturbing ecology.
- Transition zone has different parts like forestry, agriculture, and tourism and restoration region.
- Restoration region is degraded area which is selected for restoration to near natural form.

Importance of biosphere reserves includes:

i) Restoration – Biosphere reserve help in restoration of degraded ecosystems and habitat.

ii) Conservation – They are helpful in conserving genetic resources, species, ecosystems and landscapes without uprooting the local people.

iii) Development – They ensure sustainable economic development by maintaining cultural, social and ecological sanctity.

iv) Monitoring- Regular monitoring of development and conservation progress.

v) Education and Research – Each biosphere reserve supports education and research in various ecological aspects of the ecosystem / biome. There is also exchange of information about research, restoration, conservation and development aspects at the national and global levels.

MAB program

- Man and biosphere program is an international biological programme of UNESCO which was started in 1971 but was introduced in India in 1986.
- MAB has studied impact of human interference and pollution on abiotic and biotic components and develops conservation strategies for present as well as future.

EX SITU CONSERVATION

- These are means of conservation of any desired species or variety away from their natural habitats. They are offsite collections.
- They are live collections of wild and domesticated species in botanical gardens, zoos etc.
- Currently, there are more than 1500 botanical gardens and arboreta (gardens with trees and shrubs) with more than 8000 species.
- Many of them possess seed banks, tissue culture facilities and other ex-situ technologies.
- There are more than 800 zoological parks.
- Together they have about 3000 species of mammals, birds, reptiles and amphibians.
- Most of them also have a well-managed captive breeding programmes.
- Captive breeding is resorted to in those cases where the number of surviving individuals is so small that there is no realistic chance of in situ survival.
- As the number of surviving organisms increases, individuals are selectively released in the wild.
- Offsite collection can also be used to restore depleted populations, reintroduce species in the wild and restore degraded habitats.

Gene Bank

These are institutes that maintain stocks of viable seeds **(seed banks**), live growing plants **(Orchards)** , tissue cultures and frozen germplasm with the whole range of genetic variability.

(i) Seed banks: Seeds are of two types- **orthodox and recalcitrant.**

Orthodox seeds are those which can tolerate reduction in moisture content (up to 5%), anaerobic conditions and low temperature of -10^{o}C to -20^{o}C or even lower for prolonged periods e.g. cereals, legumes.

Seeds are allowed to germinate at intervals from plants and thus fresh seeds are developed for storage.

Recalcitrant seeds are those seeds which get killed on reduction of moisture and exposure to lower temperature e.g. Tea, cocoa, jackfruit, coconut.

They can be stored for shorter duration after treatment with fungicides in room having air and normal oxygen.

(ii) Orchards: Plants with recalcitrant seeds are grown in orchards where all possible strains and varieties are maintained e.g. Litchi, oil palm, rubber tree etc.

(iii) Tissue culture: It is carried out through callus formation, embryoids, pollen grain culture and shoot tip culture for those plants which are either seedless, have recalcitrant seed, variable seed progeny or where clone is to be maintained.

The method is useful in maintaining a large number of genotypes in a small area, rapid multiplication of endangered species and for hybrid rescue.

Shoot tip culture can be used to maintain virus free plants. It is used for international exchange of germplasm in cultures multiplied by vegetative methods.e.g. Banana, Potato.

(iv) Cryopreservation: Preservation at -196°C (liquid nitrogen) can maintain tissue culture, embryos, animal cell/tissue, and spermatozoa indefinitely.

The cryopreserved material is revived through special technique when required.

BIODIVERSITY ACT (2002)

For protection of India's rich biodiversity and associated knowledge against their use by foreign individuals and organizations without sharing the benefits arising out of such use and to check biopiracy.

Convention on Biodiversity

- **"The earth Summit"** held in **Rio de Janeiro in 1992** called upon all nations to take appropriate measures for conservation of biodiversity and sustainable utilization of its benefits.
- **World Summit** on Sustainable development **held in 2002 in Johannesburg, South Africa** and 190 countries pledged their commitment to achieve by 2010 a significant reduction in the current rate of biodiversity loss at global, regional and local level.