

Class: 2nd semester

Subject: Environmental Science

Unit III: Biodiversity and its Conservation

3.1 Introduction

The word "biodiversity is a short form of the term "biological diversity. The term Biodiversity originates from the word "Bios" means life and the word "Diversitis" means variety or difference. Hence, the word biodiversity means variety of life on Earth. The term biodiversity was coined by Walter Rosen in 1986. The UN Convention on Biological Diversity defines biodiversity as the “ the variability among living organism from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part, this includes diversity within Species, between species and of ecosystems." Thus Biodiversity simply refers to all the variety and variables of life forms on earth.

It has taken millions of years for life forms to evolve to this diverse state that we witness today. Earth's rich biodiversity is essential to sustain all life forms. Resources essential for the survival of life forms like food, fuel, shelter, medicines and the ecosystem services like the production of oxygen, absorption of CO₂, water, energy and other intangible resources are available to us through biodiversity. The United Nations declared May 22, as International Day for Biological Diversity to promote greater understanding and awareness of biodiversity issues.

Levels of Biodiversity

Biodiversity can be studied at three hierarchical levels to understand the interrelations and interplay of life forms that exist in nature. These levels are distinct from each other and include genetic, species and ecosystem diversity.

1. Genetic diversity

This refers to the diversity in the genetic composition (genes) among individuals within a species. The genes are the basic units of hereditary information and are transmitted from one generation to another. According to the latest knowledge of molecular biology, the genes are nothing but DNA strands with nucleotides, which when combined in different sequence and combinations cause variations in the individuals and different varieties of that species are formed. Each species consists of individuals with their own particular genetic composition. When the individuals interbreed, the produced offsprings have new combinations of the genes, resulting in new combinations of the characteristics of the species. For example, there are approximately more than 5000 rice varieties available in India belong to the same species known as *Oryza sativa*. They have different flavors, shapes, sizes and colors, and pest resistance depending on their genetic makeup: all of them originated from the original species. All these varieties of the species show variations at the genetic level.

2. Species diversity

The species diversity is the variability within a population or among the species of community. It means the variety of species found in a given area or place or region. It is the sum of the variety of all living organisms at the species level, i.e. it refers to the variety of species within a geographical area. Currently, scientists have identified and recorded about 1.7 million species. The species diversity can be measured in two types.

(i) Species Richness: The term is used to indicate the total number of species per unit area. For example, Amphibian diversity in the Western Ghats is greater than that of Eastern Ghats.

(ii) Species Evenness: It means the relative abundance or diversity of species in a given area.

3. Ecosystem diversity

It refers to the presence of different types of ecosystems or simply means variations in the ecosystems. Thus, the ecosystem diversity encompasses the broad differences between ecosystems and the diversity of the habitats and ecological processes occurring within each ecosystem type. India has very diverse terrestrial and aquatic ecosystems ranging from the cold Himalayas to deserts, from arid scrubs to grasslands to wetlands and tropical rainforests, from coral reefs to the deep sea. Each of these comprises a great variety of habitats and interactions between and within biotic and abiotic components. Such variations at the ecosystem level are termed as ecosystem diversity. The diversity of ecosystem is due to the nature of the physical environment, its geography, climate and soil etc.

MEASUREMENT OF BIODIVERSITY

The biodiversity can be measured in three different methods:

(i) Alpha diversity: It is measured by counting the number of species in a particular ecosystem. It is the diversity that exists within a community, which is also called local diversity and refers to the diversity of organisms that share the same community or habitat.

(ii) Beta diversity: It is the species diversity between two adjacent ecosystems and is obtained by comparing the number of species unique to each of the ecosystems. It is the relative richness of different species along a gradient from one habitat to another habitat within a community, which is mainly because of variations in physical conditions of habitats.

(iii) Gamma diversity: It is the measure of overall diversity for different ecosystems within ecological region with characteristic flora and fauna bounded by natural boundaries. Thus, it is the diversity of habitat over the total landscape or geographical area. It refers to the richness of different species in a range of habitats within a geographical area.

VALUES OF BIODIVERSITY

Humans derive many direct and indirect benefits from the living world. Biodiversity is the source of food, medicines, pharmaceutical drugs, fibers, rubber, timber and natural products that sustain global trade. The biological resources contain potentially useful resources as well. The diversity of organisms also provides many ecological services free of charge that are responsible for maintaining ecosystem health and human welfare. Thus biodiversity offers us enormous variety ranging from the physical needs to meta-physical needs. The multiple values of biodiversity have been classified as follows:

(i) Consumptive value

These are direct use value where the biodiversity product can be harvested and consumed directly such as fuel, food, drugs, fiber, wood etc.

Food: It is reported that there are about 80000 edible wild plant species which are consumed by human beings as food. The various food products produced from the biodiversity includes cereals, pulses, fruits, vegetables, oil seeds, spices, meat, eggs and milk. About 90% of present day food crops have been domesticated from the wild plants. Now the scientists are utilizing the genetic diversity to control the food production by several selections and breeding methods to fulfill the needs of the growing population.

Drugs and Medicines: According to the WHO over 75% of the world's population relies on traditional forms of medicine, largely plant based to meet primary health care needs. Mostly, the medicinal plant diversity provides several secondary metabolites namely alkaloids, flavonoids, aldehydes etc. from various plant species, which have vital value for therapeutic use, curing various health ailments. Isbagol a domestic herbal cure for bowel disorders is obtained from the husk of Plantago. The Pencillin is used as an antibiotic is derived from the fungus penicillium. Quinine the drug for malaria is obtained from the bark of cinchona tree. The phytochemical molecules present in the medicinal plants are providing solutions to the modern diseases like cancer, AIDS, diabetes etc. Vinblastin and vincristine are two anticancer drugs that have been obtained from Periwinkle (Catharanthus) plant, which possess anti-cancer alkaloids.

Fuel: Rural people throughout the globe depend on the fuel wood for the cooking of food. The fossil fuels coal, petroleum and natural gas are also products of fossilized biodiversity.

(ii) Productive Value

These are the commercially usable values where the product is marketed and sold. It includes timber, wild genes, animal products like tusks of elephant, musk from musk deer, silk from silkworms, wool from sheep, hides of many animals, lac from insects etc. all of which are traded in the market. Many industries are dependent upon the productive use values of biodiversity like paper and pulp industry, plywood industry, railway sleeper industry, silk industry, textile industry, leather industry, pearl industry etc.

Despite international ban on trade of products from endangered species, smuggling of fur, tusks, horns, hides, live specimen etc. worth millions of dollars are being sold every year.

(iii) Social value

These values are associated with the social life, customs, religion and psycho-spiritual aspects of the people. Biodiversity is a fundamental part of all religious thoughts. Man has always seen divinity in nature. Almost every religion has a sacred tree or plant and makes it a mandatory part of worship. The concept of Kalpavriksha is unique to Hinduism and refers to the divine tree with many powers. Pipal, Tulsi, Banyan are sacred for Hindus, Aurocarea (Christmas tree) for Christians and Date palm tree for Muslims, Sal tree is revered by Buddhists. Many animals like cow, snake, bull peacock, owl etc. also have significant place in our psycho-spiritual arena and thus hold special social importance. An indigenous community dependent on a forest takes inspiration from the forest and develops its customs and traditions based on the biodiversity available in the forest. The forest has a direct impact on the way they dress or eat or dance. In this manner biodiversity moulds our cultural beliefs, social relations, and community behavior. Biodiversity hence becomes intrinsic to our cultural heritage.

(iv) Ethical Value or moral value

This refers to the right to life of all living things. As the most evolved life form on Earth, it is the moral responsibility of man to see that all life forms continue to exist. The life form may not

have an obvious use or be productive but still it has a right to live. For example, a weed is as important as a mango tree, though it yields nothing. Every life form has a uniqueness that is irreplaceable and is essential for the sustenance of other life forms. The Earth is poorer today due to the extinction of the Dodo, the woolly mammoth, and the Sabre tooth tiger, the Chinese river dolphin and several others.

(v) Aesthetic value

Biodiversity is what makes the planet beautiful. The beautiful natural sights and sounds relax the mind and refresh the senses. The aesthetic value of biodiversity is being monetized in recent years in the form of ecotourism. Wildlife sighting, hiking, trekking, mountaineering, white water rafting, skiing, deep sea snorkeling are some of the adventure activities offered by nature. Worldwide, the revenues accrued from ecotourism totals to \$7 million and accounts for 5-7% of the travel and tourism industry. In India, ecotourism is a sunrise industry with tremendous growth potential.

(vi) Optional Value

This is the optional value of a biological resource existing in the biosphere that may be of use in the future. There are many plants and life forms that are as yet not fully understood. They need to be studied further and explored. Given the pace with which changes are taking place on the planet, there may be a scenario in the future when we may require newer sources of food, fuel or medicines. Oil is a fast depleting resource and we need some other forms of energy source much sooner than we realize. Jathropha, known as biodiesel plant, has been tried out as a substitute for fuel and is partially successful.

(vii) Ecosystem service value

It refers to the services provided by the different ecosystems. It includes soil formation, cycling of nutrients, prevention of floods, cycling of water, dilution of pollution, fixation of nitrogen, role of ecosystems as carbon sinks, maintenance of soil fertility, prevention of soil erosion, pollination of plants, decomposition of wastes etc.

All these are the supporting services rendered by the nature. If not, for these, the entire cycle of life can collapse. Food production depends on soil formation. Water cycle regulates the weather, which in turn, affects crop production. Fungi and bacteria help in decomposing waste and make nutrients available to the soil.

3.2 THREATS TO THE BIODIVERSITY

Human activities have greatly accelerated the global rate of species extinctions. Anthropogenic threats leading to extinction of species and consequent loss of biodiversity are habitat loss and fragmentation, poaching of wildlife, introduction of non-native species, overexploitation of natural resources, conflict between man and wild, deforestation, soil, water and atmospheric pollution, and intensive agriculture and forestry, and climate change.

1. HABITAT LOSS:

The destruction of habitats is the primary reason for the loss of biodiversity in terrestrial and coastal ecosystems. Habitat loss could be attributed to conversion, habitat degradation and fragmentation. When people cut down trees, fill a wetland, plough grasslands or burn a forest, the natural habitat of a species is changed or destroyed. These changes can kill or force out many plants, animals, and microorganisms, as well as disrupt complex interactions among the species. Habitat Loss and degradation is the most pervasive threat to birds, mammals and plants affecting 86% of all threatened birds, 86% of threatened mammals assessed and 88% of the threatened amphibians. Cutting of forest for agriculture and housing, construction of dams for electricity

generation and construction of roads which resulted in shrinkage and fragmentation of habitat. All these factors threaten biodiversity at gene, species and ecosystem level hampering the provision of key products and services.

2. Poaching of Wildlife:

Poaching is the unlawful hunting, killing and capturing of endangered animals. Hunting down animals for products, like furs, horns, tusks, hides is a major contributor to habitat loss. The illegal world trade in rare and endangered species of plants, birds and animals is estimated to be US\$ 8 billion per year, second only to arms smuggling. More than 37,000 plant and animal species are affected and these include rhinoceros, tiger, leopard, gorilla, butterfly, frog, tortoise, orchid, cactus, mahogany, etc. In addition, exotic pets and decorative plants are sold to collectors. The poachers, mostly poor people in developing countries, depend on this trade for their livelihood. They collect specimens indiscriminately, killing young and old, male and female, Often using very crude methods. On an average, for each animal captured alive, 50 other animals are killed. Mass killing of birds and animals for sport or for commercial purposes has driven some species to extinction. The passenger pigeon was prized for use of its feathers for the shuttle cock used in badminton. The whale is hunted for its meat and oil.

3. CONFLICT BETWEEN MAN AND WILDLIFE:

It is the interaction between wild animals and people and the resultant negative impact on people or their resources, or wild animals or their habitat. Today there are increasing instances of man animal conflict owing to habitat destruction. There are various root causes of man –wild animal conflict which are as follows:

- (i) Dwindling habitats.
- (ii) Man-eating tendency
- (iii) Scarcity of food
- (iv) Electric wiring
- (v) Lack of corridors
- (vi) Inadequate compensation

4. Introduction of Non-native species:

Introduction of non-native or invasive species may cause disappearance of native species through changed biotic interactions. Invasive species are considered second only to habitat destruction as a major cause of extinction of species. Alien Invasive Species are a significant threat to globally threatened Species affecting 326 bird species (30% of all), 212 amphibians species (11% of all), 760 mammals of all) and 361 plant species (15% of all threatened plants). Exotic species are having large impact especially in island ecosystems, which harbor much of the world's threatened biodiversity.

5. Pollution:

Growing pollution of all types is increasing the pressure on ecosystem as well as the vulnerable sections of the society. Pesticides, DDT, dioxins, etc., damage the health of man and animals. Residual pesticides on food crops and horticulture crops directly impact our health. The water polluted by industrial effluents and discharges contain chemicals that affect all life forms. Soil pollution due to the chemicals or altering of the soil environment reduces fertility, which, in turn, impacts crop production. Air pollution originates from automobiles and industries which lead to acid rain and global warming which in turn affects the biodiversity of the planet earth.

6. Climate change :

The increase in the levels of green house gases in atmosphere by natural and anthropogenic causes lead to the rise in the temperature, resulting in the global warming which ultimately led to the climate change.

The forests are sensitive to climate change and even a little change in the temperature say 1°C can modify the functioning and composition of forests. The negative impact of the climate change induces altering of growth, reproduction and host-pathogen relationships in both plants and animals. It poses a great threat to the biodiversity, ecosystems, and the goods and services they provide.

7. Deforestation:

The country's forest wealth is always under tremendous pressure. India's total forest cover now stands at 6, 97,898 sq km or 21.23% of the country's area. (Forest Survey of India, 2013) That is well short of the official goal to get cover up to 33% of land area. We are losing our quality forest to human and animal demands, which are way above sustainable levels 78% of our forests, are heavily grazed and 50% is susceptible to forest fires Timber demands are way above sustainable levels. Exploitation of forest wealth is tipping the balance against a viable future. The main causes which are leading to deforestation are growing human population, urbanization and developmental projects.

CONCEPT OF THREATENED SPECIES

Threatened species are those which are under threat due to various natural and anthropogenic activities. If not protected all the species may become extinct if these casual factors continue operating. The International Union for Conservation of Nature and Natural Resources (IUCN) is maintaining a Red Data Book which contains a data of animals which are known to be in danger. The classification is based on the following factors:

1. The present and the past distribution of the species.
2. The decline in the population of the species
3. The biology and potential of the species and
4. The availability and quality of natural habitat of species.

The three categories depending upon the degree of danger to them includes the vulnerable, endangered and rare species as given below:

(i) **Vulnerable (VU):** Species is vulnerable when it is not endangered but facing high risk of disappearance. Some of the common vulnerable animal species in India are: Golden langur, Leopard cat etc.

(ii) **Endangered (EN):** Species whose number has been reduced critically or whose natural habitats have been adversely affected by natural and artificial means. These are near to extinction. The important ones from these are: Hanglu, Snow leopard, Nilgiri langur Red panda, Musk deer, Peacock, Himalayan monal peasant etc.

(iii) **Rare (R):** Species which are less in number but are scattered throughout the world. These do not satisfy the criteria for endangered or vulnerable but they are at risk. Some Indian rare species are: Indian Desert cat, Wild yak, Markhor etc.

3.3 CONCEPT OF ENDEMISM

Endemism is the occurrence of a certain plant or animal species in a particular area alone. It is an isolated distribution of a species. The species which are found in a particular area or region and are not found anywhere else in the world are known as endemic species. India is richly blessed with rare plant and animal species that are endemic to the country and not found anywhere else in the world. About 60% of the endemic species of India are found in the Himalayan and the western Ghats. Lion tailed macaque, Nilgiri langur, Brown palm civet and Nilgiri tahr are endemic in the western Ghats.

CONCEPT OF EXOTIC SPECIES

These species are also called as introduced species or alien species or non-indigenous species. Exotic species are those species which live outside their native distributional range and which has arrived either accidentally or intentionally. These exotic species causes immense harm and loss to the biodiversity. These species when introduced in a new ecosystem with no threats, predators, competitors it grows vigorously and increases in number. The exotic or introduced alien species invades into the natural habitat, suppressing and wiping out the local native species from the ecosystem. Examples are Water Hyacinth, lantana, Congress grass etc.

Hotspots of Biodiversity

A biodiversity hotspot is a bio-geographic regions which are rich in endemic, rare and threatened species found in a relatively small areas but facing significant threats of habitat loss. Norman Myers developed the concept of biodiversity hotspot in 1988. The biodiversity hotspots are the richest and the most threatened reservoirs of plant and animal life on earth.

Criteria of Biodiversity Hotspot

1. It must contain at least 1500 species of vascular plants or 0.5% of world's total as endemics.
2. It should have lost at least 70% of its original habitat.
3. Biodiversity hotspots are areas that also support high diversity of locally endemic species, which are unrepresented in other parts of the world.

In the beginning only 12 hotspots were identified as per the criteria; but, after detailed study by Myers et al, (2000), they proposed 25 biodiversity hotspots across the globe. These areas held endemics, which were 44% of the world's plants and 35% of terrestrial vertebrates in an area that formerly covered only 11.8% of the planet's land surface. The periodical assessment of the biodiversity hotspot is essential due to changes occur over a period of time, because, a hotspot may become more vulnerable and threatened or sometimes it may recover also.

Conservation International, an organization based in the USA, published a book known as "Hotspots revisited" (2004), according to which, 34 global biodiversity hotspots" were recognized, by introducing quantitative thresholds for designation of biodiversity hotspots. Among these spots, each has lost at least 70% of their original habitat and each contains more than 1500 endemic vascular plant species. These sites support nearly 60% of the world's plants and vertebrate animals, with a very high share of endemic species. The habitat extent of this land area has reduced by 87.8% of its original extent. These hotspots cover only 2.3% of Earth's land surface, and support over 50% of the world's vascular plants and 42% of all terrestrial vertebrate species (amphibians, reptiles, birds and mammals) as endemics. At present there are 36 hotspots around the world they represent 2.4% of the earth's land surface, but they support more than half of the world's plant species as endemic and nearly 43% of bird, mammal, reptile and

amphibian species as endemic. Out of the 36 hotspots of biodiversity 4 are present in India represented by Eastern Himalayas, Indo-Burma region, Western Ghats and Sundaland.

Some of the important global biodiversity hot spots are:

- 1) Brazil's Cerrado.
- 2) Central Chile.
- 3) California floristic province.
- 4) Madagascar.
- 5) West African forests.
- 6) Cape floristic province.
- 7) South central China.
- 8) Eastern Himalaya of India.
- 9) Western Ghats of India.
- 10) Coastal forests of Tanzania/Kenya.

HOT SPOTS IN INDIA

Out of 36 identified hot spots, 4 are found in India. These are:

(i) Eastern Himalaya: This region comprises of Northeast India, Bhutan, and southern, central and eastern Nepal. The Himalayan hotspot is home to the world's highest mountain, including Mt. Everest and K2. Some of the major rivers in the world originates from the Himalayas. The Eastern Himalayan hot spot is rich in endemic plants and the temperate forests are found at the height of 1780-3500 meters above sea level.

(ii) Western Ghats: This region is internationally recognized as a region of immense global importance for conservation of biological diversity, besides containing areas of high geological, cultural and aesthetic values. Western Ghats covers the evergreen forests in the states like Karnataka, Maharashtra and Kerala that lies at height of about 500-1500 meters above sea level. It contains at least 325 globally threatened species. The two main centers of biodiversity are Agasthyamalai hills and Silent valley.

(iii) Indo-Burma: It includes entire North-Eastern India except Assam and Andaman group of Islands, Southernmost china, most of Myanmar except Northern part, Thailand except southern tip, Cambodia, Laos and Vietnam. This hotspot encompasses more than 2 million km² of Tropical Asia. Of the 13,500 vascular species found in this region 52% are Endemic to this region. Six large mammal species have been discovered in the last 12 years.

(iv) Sundaland: It includes Nicobar group of Islands, Indonesia and Malaysia with their tropical rainforest and coral reefs. Sundaland consists of 17000 islands that cover just 1% of the earth's land surface, with Borneo and Sumatra two of the world's largest island are also found within this hotspot. it is host of 10% of the world's flowering plant species, 12% of the world's mammal, 17% of the world's bird and more than 25% of the world's fish species. Sundaland has a high of biological which can be attributed to its unique geology and geography. About 60% of the 25000 species of vascular plants found here are endemic.

3.4 CONSERVATION OF BIODIVERSITY

Conservation is the act of protecting, preserving and scientific management of biodiversity so as to maintain it at its threshold level and derive sustainable benefits for the present and future generation. Protecting all forms of life present on earth is the core activity in the conservation of biodiversity. It involves keeping the natural ecosystems functioning and in a healthy state, thus maintaining the equilibrium of the ecosystem.

Methods of Biodiversity Conservation

It can be done in an integrated manner by following two types of conservation methods:

1. In-situ conservation
2. Ex-situ conservation

In-situ conservation: this means conservation of biodiversity in their natural habitat, where they occur naturally. It can be done in many ways either by protecting an area, or cleaning up the area of pollutants that disturb the natural ecosystem or adopting other intensive measures to protect a plant or animal species. The main advantage of this method is that it preserves the area in its distinctive and characteristics form, as it occurs naturally. In-situ conservation is being mainly done by declaring area as protected area which includes:

1. National parks: National parks come under Category-2 of IUCN Protected Areas Management Categories. Under Section 35 of Wildlife Protection Act, 1972, the National Park is declared for the purpose of protecting, propagating or developing wildlife or its environment. It is an area having adequate ecological, faunal, floral, geomorphological, natural or zoological significance, and is preserved as a national heritage for future generations. A national park is an area which is totally prohibited for human activities like forestry, grazing, cultivation etc. and is reserved for the betterment of wildlife. National park is an area to preserve for all times which contains an object of geographical, historical, and biological importance as a national heritage for the benefit of education and enjoyment of people. It is enacted or promulgated by central Legislation. As of May 2019, there were 104 national parks. All national park lands encompassed a total of 40,501 km², comprising 1.23% of India's total surface area.

2. Wildlife Sanctuaries: Wildlife Sanctuary comes under Category-4 of IUCN Protected Areas Management Categories. In India, Under Section 18 of Wildlife Protection Act, 1972, the Wildlife Sanctuary is declared for the purpose of protecting, propagating or developing wildlife or its environment. It is an area having adequate ecological, faunal, floral, geomorphological, natural or zoological significance. Wildlife Sanctuary is an area set aside for the preservation and conservation of wildlife where human activities like harvesting of timber, collecting minor forest products and private ownership rights are allowed as long as they do not interfere with the well being of wildlife, where man can visit as a privileged visitor without effecting wildlife. In this, quality of environment is managed or unproved by wildlife Management Techniques or practices. Boundaries of sanctuaries are not well defined and controlled biotic interference is permitted. It is enacted by the state Legislation. There are about 551 wildlife sanctuaries covering an area of 119775.80 km², comprising the total geographical area of 3.64% of India.

3. Biosphere Reserves: Biosphere Reserve includes natural, minimally disturbed, man modified and degraded ecosystem. These are meant for conservation of natural areas and the genetic material which is contained within them. Biosphere reserve programme was established in 1971 under MAB (man and biosphere) programme of UNESCO. Presently worldwide there are 651 biosphere reserves in 120 countries. Biosphere reserves have three interrelated zones that aim to fulfill three complementary and mutually reinforcing functions. The core zone comprises a strictly protected ecosystem that contributes to the conservation of landscapes, ecosystems, species and genetic variation. The buffer zone surrounds or adjoins the core areas, and is used for activities compatible with sound ecological practices that can reinforce scientific research, monitoring, training and education. The transition area is the part of the reserve where the greatest activity is allowed, fostering economic and human development that is socio-culturally and ecologically sustainable. Biosphere reserves are areas comprising terrestrial, marine and

coastal ecosystems. The first biosphere reserve of the world was established in 1979. In India presently we have 18 biosphere reserves. Nilgiri being the first one and Panna the latest one. Out of 18 biosphere reserves, 9 are part of the world Network of biosphere reserves on UNESCO Man and Biosphere Programme list. These are:-

- i. Nilgiri biosphere reserve
- ii. Gulf of Manar biosphere reserve
- iii. Sunderbans biosphere reserve
- iv. Nanda Devi biosphere reserve
- v. Nokrek biosphere reserve
- vi. Pachmari biosphere reserve
- vii. Simlipal biosphere reserve
- viii. Achanakmar-Amarkantak biosphere reserve
- ix. Nicobar Islands biosphere reserve

EX-SITU CONSERVATION

Ex-situ method of conservation is the conservation of flora and fauna outside their naturally occurring habitat under controlled conditions. It has the advantage of preserving plant material and making it available for research purposes, without damaging the natural population. It is done by collecting samples in various forms and restoring them in specially created ecosystem for the purposes of preservation of the species. Samples may be seeds, eggs, pollens, tissue or cell cultures. The various ex-situ conservation methods are as follows:

1. Botanical gardens: A botanical garden is generally developed with the specific plan of collecting, preserving and sometimes demonstrating a repository of several varieties of plants including herbs, shrubs, trees, climbers, prostate plants, succulent plants, aquatic plants, gymnosperms, pteridophytes, etc. Plants are planted, classified and displayed with their botanical names and other details of use. A botanical garden is said to be well established if it has lakes, ornamental flower beds, glass houses, herbaria, libraries and laboratories associated with it. In botanical gardens under controlled conditions, those plants are grown which cannot grow normally. After the growth of these plants, they are reintroduced in the original area to grow and so help in plant introduction. This plan is very helpful in propagation of economically important plants like tea, coffee, rubber, etc. It may contain specialist plant collection in greenhouses, glasshouses and specially created environments suited for special plants. Botanical gardens have scientific as well as historical and cultural importance. In the sixteenth and seventeenth centuries medicinal plants were an essential part of botanical gardens and in later times their educational, horticultural and botanical roles gained importance and evolved into commercial plantations.

2. Zoos and zoological parks: Zoological Park is a place where animals, birds and aquatic creatures are kept for education, entertainment and a part of ecotourism. Zoos keep animals in enclosures and large open areas cut off by moats. The attempt is to try and replicate the animal's natural habitat. These enclosures also provide a sheltered area where the animal can rest away from the prying eyes of visitors and extreme weather conditions. Food provided to the animals in the zoo once again is as close as possible to the natural diet and is the responsibility of the zookeepers and staff. Maintenance of the enclosure, health of the animals, behavior observations are all part of their duties. Veterinary doctors attend to the animals in case of some ailments and disease.

3. Cryo-preservation: It may be defined as the conservation of seeds, pollen etc at freezing temperature or at ultra low temperature. By this method we can preserve pollen and seeds of a

plant which are the most essential material for the progeny. The conservation of sperms through Cryo-preservation is also done, not only sperms, but animal cells, ovarian and embryonic tissue and also the whole embryo is also used for livestock breeding programmes. Micro-organisms which are an important component of any ecosystem have received hardly any attention, particularly their association with the higher plants. These Micro-organisms constitute an important element in the establishment and this aspect needs to be looked into with holistic approach. A wide range of microbes, algae, insects and many other organisms are to be stored for any possible future use.

4. Tissue culture: Tissue culture technique is another scientific method to conserve plants. This technique has been developed recently and with the help of this technique, from a single cell we can get a complete plant. Each cell in a plant is able to grow is the main principle underlying some reasons like lack of pollinators, sterility or reproductive organs etc it can be made to grow through tissue culture. Preservation of gene, reproductive materials like seed, semen, etc also helps in conservation.

5. DNA banks: This is a technologically advanced way of ex situ conservation. Special labs are created for the preservation of endangered species through the use of biotechnological methods. In India Hyderabad houses the special lab called Lacones set up by Center for Cellular and Molecular Biology and the Government of India. It focuses on identifying the DNA of rare species and cloning it. The genetic variations are studied. The genes are stored in banks and in-vitro fertilization is taken up for conservation purposes. In China, the giant panda has been cloned in the lab. Lacones has attempted cloning leopard and lion, but have not met with success yet.

6. Gene banks: A gene bank is an institution where valuable plant and animal materials likely to be lost in the wild or in cultivation is preserved in a viable condition. National Bureau of Plant Genetic Resources (NBPGR) is the center for management of gene bank of plants. It is located in Hyderabad. This center plays a crucial role in the improvement of various crop plants and diversification and development of agriculture in India. Among other things, it undertakes the collection and introduction of germ plasm from foreign institutes. National Bureau of Animal Genetic Resources (NBAGR) is located in Karnal, Haryana. It has the mandate of identifying, evaluating, characterizing and utilizing genetic resources from livestock and poultry.