4- BIODIVERSITY

Biodiversity, or Biological Diversity, is the sum of all the different species of plants, animals, fungi and microbial organisms that live on Earth, including the various ecosystems in which they live on. It also includes the genetic information that these organisms contain.
Biodiversity is usually explored at three levels -**genetic diversity, species diversity and ecosystem diversity**. These three levels work together to create the complexity of life on Earth. Recently new aspects - '**Molecular diversity**' and '**Functional Diversity**' have also been added. **Molecular biodiversity** is the richness of molecules found in life, without which evolution cannot occur, either in the origin of a new species, its survival and development, or its eventual extinction. The way species behave, obtain food and use the natural resources of an ecosystem is known as **functional diversity.**

4.1 GENETIC DIVERSITY:

Genes are the basic units of all life on Earth. They are responsible for both the similarities and the differences between organisms. The variety of genes within a species is Genetic diversity. It is the total genetic information contained in the genes of all the species. It also refers to the variation in genetic information between species as well as the variations between individuals of the same species.
Example: Species diversity in human beings, animals and plants.
The species must constantly adapt to the changes in the physical, chemical and biological environments over the time or face extinction. This ability of the species is directly related to amount of genetic diversity available to natural selection. More genetic diversity in a species or population means a greater ability for some of the individuals in it to adapt to changes in the environment. The maintenance of genetic diversity is a key for long term survival of most species as serves as a way for populations to adapt to changing environments.

4.2 SPECIES DIVERSITY:

Species are the basic units of **biological classification**.

Species diversity is the variety of species within a habitat or a region. It is measured in relation to a given area - from a small field to the entire planet. It can be assessed in terms of the number of species or the range of different types of species an area contains. Every ecosystem contains a unique collection of species which is described as Species Richness. Environments that can support large numbers of species, such as tropical areas, tend to have greater species richness. There is approximately 1.8 million different species classified on Earth, however their distribution is uneven. Tropical rainforests comprise only 7% of all land on Earth yet are home to nearly 50% of all the species on Earth. Species diversity is the highest in the equatorial region and gradually decline towards the polar region.

Species diversity is crucial for ecosystem health. Each species, no matter how small, all have an important role to play. Greater species diversity ensures natural sustainability for all life forms. If a species disappears, an entire ecosystem can start to unravel.

4.3 ECOLOGICAL DIVERSITY:

An ecosystem is made up of organisms from several different species living together in an environment and their connections through the flow of nutrients, energy. Ecosystems are varied in form and structure. It can be as small as a drop of pond water or can be as large as an ocean. The enormous range of terrestrial and aquatic environments on earth has been classified into a number of ecosystems such as forests, deserts, grasslands, mangroves etc.

Ecological or ecosystem diversity is the variety of ecosystems in an area. It is the variation in the ecosystems found in a region or the variation in ecosystems over the whole planet. This relates to the variety of habitats, biotic communities and ecological processes in the biosphere. It is difficult to measure ecological diversity because every ecosystem on earth merges into the surrounding ecosystems. Regions containing a great variety of ecosystems are rich in biodiversity, but individual ecosystems containing endemic species also make a significant contribution to global biodiversity. Diversity in the ecosystem is significant to human existence for a variety of reasons. For Example the availability of oxygen, regulate water cycle, increase plant varieties for consumption etc.

4.4 BIODIVERSITY HOTSPOT:

Biodiversity Hotspot is a biogeography region characterized both by exceptional levels of plant endemism and by serious levels of habitat loss. The concept 'Biodiversity Hotspot' was given in 1988 by British biologist Norman Myers. According to (Conservation International) CI, to be called a hotspot, a region has to fulfill two strict criteria including

- **Endemism:** It should contain at least 1500 species of vascular plants i.e. more than 0.5% of the world's total plants as endemics.
- **Loss of Habitat:** It should have lost at least greater than or equal to 70% of its original habitat. Around the world, 36 areas qualify as hotspots. They represent just 2.4% of Earth's land surface, but they support more than 50% of the world's plant species as endemics and nearly 43% of bird, mammal, reptile and amphibian species as endemics. Overall, Hotspots have lost around 86% of their original habitat and additionally are considered to be significantly threatened by extinctions induced by climate change.

4.4.1 List of Biodiversity Hotspots:

1. **North Central America**: California Floristic Province, Madrean pine-oak woodlands, Mesoamerica
2. **The Caribbean**: Caribbean island
3. **South America**: Atlantic Forest, Cerrado, Chilean Winter, ainfall-Valdivian Forests, Tumbes-Choco-Magdalena, Tropical Andes
4. **Europe**: Mediterranean Basin
5. **Africa**: Cape Floristic Region, Coastal Forests of Eastern Africa, Eastern Afromontane, Guinean Forests of West Africa, Horn of Africa, Madagascar and the Indian Ocean Islands, Maputaland-Pondoland-Albany, Succulent Karoo
6. **Central Asia:** Mountains of Central asia
7. **South Asia:** Eastern Himalayas, Nepal, Indo-Burma, India and Myanmar, Western Ghats, India & Srilanka
8. **South East Asia and Asia-Pacific:** East Melanesian Islands, New Caledonia, New Zealand, Philippines, Polynesia Micronesa, Southwest Australia, Sundaland, Wallacea
9. **East Asia:** Japan, Mountains of Southwest China

10. **West Asia:** Caucasus, Irano-Anatolian

4.4.2 BIODIVERSITY HOT SPOTS OF INDIA

India is one of the richest countries in the world in terms of biodiversity. It lies within the Indomalaya ecozone and It hosts 4 of the 36 biodiversity hotspots in the world.

1. The Eastern Himalayas
2. The Western Ghats
3. The Indo-Burma region
4. The Sundaland (includes Nicobar group of Islands)

Out of the above four biodiversity hotspots, the Easter Himalayans and the Western Ghats completely lies in India. The third - Indo-Burma region lies partially Within the Indian North-East and the fourth the Sundalands includes Nicobar group of Islands and is shared by Indonesia, Malaysia, Singapore, Brunei, Philippines.

Due to the wide range of climate, topology and habitat in the country, **flora and fauna of India** is one of the richest in the world and is considered as one of the 17 Mega-diverse nations in the world. **India is home to** 2350 mammals which make up 7.6% of world species 21224 birds which make up 12.6% of the world species 2197 amphibians which make up 4.4% of the world species 2408 reptiles which make up 6.2% of the world species 22546 fishes which make up 11.7% of the world species 218,000 flowering plants which make up 6-7% of the world plant species.

4.5 THREATS TO BIODIVERSITY:

It is estimated that the current rate of species extinction is between 1,000 and 100,000 times more rapid than the average rate during the last several billion years. Some studies suggest that globally as many as one half of all mammals and bird species may become extinct within 200 to 300 years. The different factors threatening our planet's biodiversity are as follows:

1. Population Explosion
2. Habitat destruction
3. Habitat fragmentation
4. Invasion of Exotic species
5. Overexploitation and poaching

6. Pollution
7. Global Climate change
8. Control of Pests and Predators
9. Natural Calamities and
10. Other Factors

Population explosion: The core threat to biodiversity on the planet, and therefore a threat to human welfare, is the combination of human population growth and the resources used by that population. The exponential growth in the human population through the 20th century has had more impact on biodiversity than any other single factor. This growth eventually led to the alteration, conversion of the natural ecosystems to meet the increase in demand for land, food, water, energy and other resources.

Habitat destruction: Habitat loss is one of the biggest threats to biodiversity—it is the number one reason for species go extinct. The biggest threat to biodiversity loss is destruction or elimination of habitat whether it is a forest, wetland, coral reef, grassland, or flowing river which resulted due to the large industrial and commercial activities associated with agriculture, aquaculture, irrigation, construction of dams, mining, fishing etc. Deforestation, major cause of extinction of species has occurred in every part of the world. Internationally, there is half a hectare of natural habitat is converted to farmland every second. This directly affects future of agriculture as the species that are being destroyed for croplands may have been used for genetically enhancing crop products. Orangutans, tigers, elephants, rhinos, and many other species are increasingly isolated and their sources of food and shelter are in decline.

Habitat fragmentation: Habitat fragmentation is described as a 'habitat that is broken into smaller discontinuous segments of land for development'. With increased population, the habitats are fragmented into pieces for construction of roads, fields, canals, power lines, towns etc. Fragmentation can separate animals from one another and from their food sources. This happens both in water and on land.

Invasion of Exotic species: Invasive species are 'alien' or 'exotic' species which are introduced accidentally or intentionally by man. Invasive species are identified as the second greatest threat to native wildlife after habitat loss. When a new animal, plant, or microbe is introduced into an ecosystem, it may not have any natural predators or controls. Hence It can breed and spread quickly, by preying on native species and outcompeting their resources. They even bring unfamiliar diseases, modify habitats, or disrupt important interactions thus prevent native species from reproducing or killing a native species' young, thus they are capable of causing extinctions of native plants and animals, reducing local biodiversity, Globally, around 42% percent of threatened or endangered species are at risk due to invasive species. Ex. Parthenium, Eicchornia, Catfish.

Overexploitation of resources and poaching: Overexploitation, also called **overharvesting,** refers to harvesting a renewable resource to the point of diminishing returns. Overhunting, overfishing and over-harvesting contribute greatly to the loss of biodiversity, killing off numerous species over the past several hundred years. Poaching has been defined as the illegal hunting or capturing of wild animals, usually associated with land use rights. Poachers kill several animals for their meat, organs, skin, bones etc. Elephants are hunted for their ivory tusks, tigers for their skins and bones, rhinos for horns, turtles for shell, Gorillas for meat, pangolins for scales, snakes for meat and skin, musk deer for musk, bears for their organs, Gharial and crocodile for skin and jackal for fur trade whales for blubber. Slaughtered animals, on the other hand, have commercial value as food, jewelry, trophy, decor, or traditional medicine.

Pollution: Pollution is the release of chemical, physical, biological or radioactive contaminants into the environment. All forms of pollution pose a serious threat to biodiversity as they alters the natural habitat. Burning of fossil fuels, release sulfur dioxide (SO_2) and nitrogen oxides (NOx) into the atmosphere. These air pollutants react with water, oxygen, and other substances to form airborne sulfuric and nitric acid. When acid rain reaches Earth, it flows across the surface in runoff water, enters water systems, and sinks into the soil. Acid rain makes such waters more acidic, which results in more aluminum absorption from soil, which is carried into lakes and

streams. That combination makes waters toxic to crayfish, clams, fish, and other aquatic animals. The nutrients mainly Phosphorous and Nitrogen come from animal wastes, fertilizers and sewage, are washed by rain or irrigation into the water bodies through surface runoff. This nutrient load enriches the water body and makes it Eutrophic. This leads to dense growth of toxic algal blooms and plant life such as the water hyacinths in the aquatic environments. Bioaccumulation is an important concept connected with pollution. This is the process of chemicals becoming increasingly concentrated in animal tissues as they move up the food chain. Many agricultural and industrial chemicals are persistent organic pollutants (POPs) these POPs move up the food chain and get concentrated in the animals present in the higher trophic level. At higher concentrations, these POPs have been shown to cause disruptions to hormone levels and immune systems, and increase birth defects.

Global Climate change: Due to increasing world population and industrial development there is an increased emission of Greenhouse gases (GHGs) due to the use of fossil fuels, deforestation, burning and decay of biomass, etc. Greenhouse gases trap heat in the Earth's atmosphere and heat up the Earth, a process known as the Greenhouse effect. This effect leads global warming aka Climate change. Global warming is projected to have a number of effects on the oceans. Ongoing effects include rising sea levels due to thermal expansion and melting of glaciers and ice sheets, and warming of the ocean surface, leading to increased temperature stratification.
Climate change is causing huge changes to biodiversity, and it will continue to threaten species and their habitats for the predictable future. There is a two-way relationship between biodiversity and climate: biodiversity is threatened by climate change is already forcing biodiversity to adapt either through shifting habitat or changing life cycles. The polar region is home to a number of species which have adapted themselves to the cold conditions that exist there. If average global temperature continues to rise, the polar climate will also change, and that in turn, will trigger a series of changes in the polar ecosystem. It will become difficult for animals like the red fox, Arctic fox, polar bear, Adélie penguin, snow owl, etc., to adapt.

Control of Pests and Predators: Chemical pollutants such as pesticides generally kill predators that are a component of balanced ecosystem They remain in the crop field for a longer time and may also indiscriminately kill non-target species like microflora, and micro and macrofauna of soil, bird and frog diversity and also natural predators.

Natural Calamities: Natural calamities such as floods, prolonged draught, landslides, forest fires, earth-quakes, tsunamis, volcanic eruptions, dust storms, epidemics etc. Sometimes take a heavy toll of plant and animal life of various ecosystems. Disasters occur all over the world at different magnitudes. Epidemics sometimes destroy large portions of a natural population. The eruption of volcanoes and subsequent lava flow at times completely destroys plant and animal life in its surrounding areas. Forest fires in densely wooded localities often reduce to ashes a large number of plant and animal species and so do earthquakes. Tsunamis and tropical cyclones bring about considerable damage to coral reefs, mangrove vegetation and coastal ecosystems. Massive floods reduce the level of biodiversity, habitat potential and food present in the ecosystem, creating long-term impacts for surviving wildlife.

Other Factors: Other Ecological Factors that may also contribute to the extinction of Plant and Animal Diversity is as follows:

- **Distribution range** – The smaller the range of distribution, the greater the threat of extinction,
- **Degree of specialization** – The more specialized an organism is, the more vulnerable it is to extinction,
- **Position of the organism in the food chain** – The higher the organism in food chain, the more susceptible it becomes,
- **Reproductive rate** – Large organisms tend to produce fewer off springs at wide intervals.

4.6 CONSERVATION OF BIODIVERSITY (INSITU & EX SITU):

Biodiversity conservation is about saving life on Earth in all its forms and keeping natural ecosystems functioning and healthy. Conservation of biodiversity is conservation of all living beings including their habitat, heredity and ecosystem at large.

Why Biodiversity should be protected?

Conservation of biological diversity leads to conservation of essential ecological diversity to preserve the continuity of food chains.

1. The genetic diversity of plants and animals is preserved.
2. It ensures the sustainable utilization of life support systems on earth.
3. It provides a vast knowledge of potential use to the scientific community.
4. A reservoir of wild animals and plants is preserved, thus enabling them to
   be introduced, if need be, in the surrounding areas.
5. Biological diversity provides immediate benefits to the society such as
6. Recreation and tourism.

4.6.1 Methods of Biodiversity conservation

There are two types of conservation methods namely **In-situ** and **Ex-situ** conservations. Let us discuss the different conservation methods along with their importance.

- **In-situ conservation:** Conserving the animals and plants in their natural ecosystem or natural habitats is known as **In-situ conservation** or **On-site conservation.** It is considered the most appropriate way of conserving biodiversity as all the constituent species (known or unknown) are conserved and benefited in their natural surroundings.
- **Advantages :**
  This method of conservation allows animals flourish in their natural habitat and food chain and offers more mobility to the animals. Provides protection to endangered species against predators. Helps maintain the ongoing process of evolution and adaptation within the natural environment of the species. The protection and management of biodiversity through in situ conservation involve certain specific areas known as **Sacred areas** and **Protected areas.**

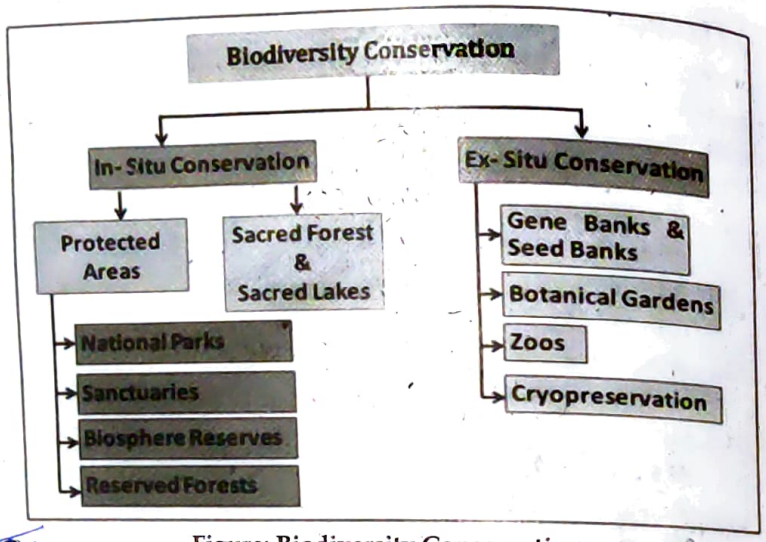

Figure: Biodiversity Conservation

4.6.1.1 Sacred Grooves & Sacred Water bodies

A **sacred grove** or **sacred forests** are any grove of trees that are of special religious importance to a particular culture."Sacred Groves is an age - old tradition where a patch of forest or water body is dedicated to local deities and none is allowed to cut plants or to kill animals or any form of life. These sacred forests consists of tracts of virgin forest with rich diversity and they are protected by the local people for centuries for their cultural and religious beliefs and taboos that the deities reside in them and protect the villagers from different calamities. The famous sacred grooves of the world are Atsuta-jingu Shrine in the Atsuta Forest, Shimogamo Jinja shrine in Tadasu-no-mori forest; The Mijikenda Kaya sacred Forests in Kenya; the Buoyem Sacred Grove in Ghana; Lumbini groove in Nepal are few examples. In india, **14,000** sacred groves have been reported, which act as reservoirs of rare fauna, and more often rare flora, amid rural and even urban settings.

4.6.2 Protected Areas

The protected areas are biogeographical areas where biological diversity along with natural and cultural resources are protected, maintained and managed through legal and administrative measures. IUCN defines protected areas as "A clearly defined geographical space, recognized, dedicated and managed, through

legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values". Protected areas include National parks, Wildlife sanctuaries, Biosphere reserves, Reserved and protected forests, Conservation and community reserves, Communal forests, Private protected areas, Conservation areas, etc. The world's first national park, Yellowstone, was created in the USA. As on today there are around 3100 national parks in the world. India's first national park was established in 1936 as Hailey National Park, now known as **Jim Corbett National Park**, Uttrakhand. As of July 2018, there were 104 national parks in India (under protected areas category II). They encompass an area of 40,501 km2 (15,638 sq mi), comprising 1.23% of India's total surface area.

Some important national Parks of India are:

- Jim Corbett National Park, Uttarakhand
- Kaziranga National Park, Assam
- Gir Forest National Park, Gujarat
- Sundarban National Park, West Bengal
- The Great Himalayan National Park, Himachal Pradesh

Wildlife Sanctuaries

A Wildlife **sanctuary** is a protected area which is reserved for the conservation of animals only. Human activities like harvesting of timber, collecting minor forest products and private ownership rights are allowed as long as they do not interfere with well-being of animals. There are over 3,000 wildlife sanctuaries in the world. Important wildlife sanctuaries of the world are Lone Pine Koala Sanctuary - Australia, Sloth Sanctuary of Costa Rica, Tiritiri Matangi Open Sanctuary - New Zealand, Wechiau Community Hippo Sanctuary - Ghana, The David Sheldrick Wildlife Trust - Kenya, Black Jaguar White Tiger Foundation - Mexico.

Wildlife sanctuaries of India are classified as IUCN Category IV Protected areas. Between 1936 and 2016, 543 wildlife sanctuaries were established in the country that covers 118,918 km2 (45,914 sq mi) as of 2017.

Few wild life sanctuaries in India:

- Kutch Desert Wildlife Sanctuary (Greater Flemingo) - Gujarat,
- Dibang Wildlife Sanctuary- Arunachal Pradesh,
- Bhimbandh Wildlife Sanctuary (Tigers & Panthers) - Bihar,
- Kedarnath Wildlife Sanctuary (Himalayan musk deer)- Uttarakhand,
- Hastinapur Wildlife Sanctuary (Twelve horned deer & River Dolphins)

Wildlife sanctuaries in Telangana :

1. Pocharam Wildlife Sanctuary - Medak
2. Pakhal Wildlife Sanctuary – Warangal District
3. Eturnagaram Wildlife Sanctuary
4. Kawal Wildlife Sanctuary – Mancherial District
5. Kinnerasani Wildlife Sanctuary – Bhadradri Kothagudem District
6. Manjira Wildlife Sanctuary – Sangareddy District
7. Nagarjunsagar-Srisailam Tiger Reserve - Nalgonda District
8. Shivaram Wildlife Sanctuary - Manthani
9. Pranahita Wildlife Sanctuary – Mancherial District

4.6.3 Biosphere Reserve

Biosphere reserves are sites established by countries and recognized under UNESCO's Man and the Biosphere (MAB) Programme to promote sustainable development based on local community efforts and sound science. **Biosphere** reserves can be defined as 'areas of terrestrial and aquatic ecosystems promoting solutions to reconcile the conservation of biodiversity with its sustainable use, that are internationally recognized, nominated by national governments and remain under sovereign jurisdiction of the states where they are located'. The main aim of biosphere reserve is to preserve genetic diversity in representative ecosystems by protecting wild animals, traditional life style of inhabitant and domesticated plant/ animal genetic resources. These are scientifically managed allowing only the tourists to visit.

Functions : Each biosphere reserve is intended to fulfill three basic functions, which are complementary and mutually reinforcing

1. Conservation of Biodiversity : to contribute to the conservation of

landscapes, ecosystems, species and genetic variation.

2. Sustainable Development : to foster economic and human development which is socio-culturally and ecologically sustainable.

3. Support for Logistics : to provide support for research, monitoring, education and information exchange related to local, national and global issues of conservation and development

4.6.3.1 Structure of the Biosphere reserve

Biosphere reserves are traditionally organized into three interrelated zones, to carry out the complementary activities of biodiversity conservation and sustainable use of natural resources. The zones of a biosphere reserve are

- **Core Zone**
- **Buffer zone and**
- **Transition zone**

Few Biosphere reserves in India

1. Nilgiri 1986 Tamil Nadu, Kerala & Karnataka.
2. Nanda Devi 1988 Uttarakhand.
3. Nokrek 1988 Meghalaya.
4. Manas 1989 Assam.
5. Sunderban 1989 West Bengal.

4.6.4 Reserved & Protected Forests

A reserved forest (also called reserve forest) or a protected forest is a forest accorded a certain degree of protection. Land rights to forests declared to be Reserved forests or Protected forests are typically acquired and owned by the Government of India. Unlike national parks of India or wildlife sanctuaries of India, reserved forests and protected forests are declared by the respective state governments.

4.7 Ex- Situ Conservation

The conservation of all levels of biodiversity outside of their natural environments or ecosystems is known as ex-situ conservation or off-site conservation. It involves conservation of wild and cultivated species as well as genetic resources. In general, ex situ conservation is applied as an additional measure to supplement in situ conservation. Through Ex situ conservation, the target species is preserved outside their natural habitat, in the form of whole plants

or animals, seed, pollen, vegetative propagules, tissue or cell cultures, etc. The main purpose of ex-situ conservation is the rescue and preservation of genetic or reproductive material of a threatened target species, or take care of the living target species and reintroduce it if their continued survival in its native habitat is threatened.

Techniques for ex-situ conservation

- Ex-situ techniques applicable to animal populations include the storage of embryos, semen/ovule/DNA (Gene banks), Captive breeding, Zoos, aquaria, etc.
- Ex-situ collections of plants are established by storing seeds, field gene
- banking, conserving pollen, in vitro conservation of plant shoots, establishment of Botanical Gardens, etc.
- Germ plasm Banks or Gene Banks : Plant genetic resources like pollen, seed, branch, bulb, or tissues and animal genetic materials such as sperm, oocytes, embryos and somatic cells are preserved at ultra low temperatures (liquid nitrogen, -196°C) in gene banks. This is called 'cryopreservation' and this method has been recognized as a practical and efficient tool for the long-term storage of germplasm.

In India, the National Bureau of Plant Genetic Resources (**NBPGR**) has conserved over 64,829 traditional varieties in Gene Banks located in different states. National Animal GeneBank at Bureau has been established with the objective of conserving the indigenous livestock biodiversity. Presently a total of 1,29,174 deep frozen semen doses belonging to 311 breeding males (Bulls/Rams/Bucks/Stallions) from 44 breeds representing Cattle, Buffalo, Sheep,Goat, Camel, Yak and Equine have been collected and preserved at National Gene Bank for posterity.

India's first National Wildlife Genetic Resource Bank was established at Laboratory of Conservation of Endangered Species (LaCONES), Centre for Cellular and Molecular Biology's (CCMB) CCMB, Hyderabad in August, 2018. So far this bank has collected and preserved genetic resources of 23 species of Indian wild animals.

A seed bank is a type of gene bank where seeds of different crops and rare plant species are collected and stored for future use. Most of the seeds can be stored for centuries without damaging their genetic

properties. However, they should be replanted after a certain time period in order to avoid eventual DNA damage. The seeds are frozen at temperatures below -4 degrees centigrade and stored in seed vaults.

Captive breeding is the process of maintaining plants or animals in controlled environments, such as zoos, botanic gardens, aquaria, arboreta and other conservation facilities. It helps species that are being threatened by human activities such as habitat loss, fragmentation, over hunting or fishing, pollution, etc. and can save a species from extinction. Besides conservation it provides opportunities for education and research beneficial to the species concerned. Disadvantages of ex-situ conservation are:

1. The methods are highly costly.
2. Captive population have limited genetic diversity
3. Animals may not behave normally, making reproduction difficult
4. Though it prevents immediate extinction of the species, it may have serious evolutionary implications and consequently make reintroduction of the affected species into their natural habitats very difficult to achieve.