

Biodiversity Conservation in India

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Abstract

Biodiversity refers to the variety of living organisms and ecosystems in which they live. Biodiversity sustains life on earth. The global concern to conserve biodiversity stems from its enormous significance and inestimable value to mankind. The motive behind conservation is to preserve biodiversity, maintain essential life supporting ecological processes or ecosystem functions and preserve genetic resource along with the utilization of commercially important species in a sustainable way. The objectives of the present paper are following: (i) to define biodiversity; (ii) to highlight the significance of biodiversity; (iii) to identify the causes of biodiversity depletion; (iv) to list the legislative measures of biodiversity conservation in India and (v) to describe the in situ and ex situ measures of biodiversity conservation in India.

I. INTRODUCTION

Biodiversity refers to the variety of living organisms and ecosystems in which they live. It represents the ensemble and interactions of the genetic, species and ecological diversity in a given place and time. Biodiversity became a familiar term to general public with the United Nations Conference on the Environmental and Development (UNCED) held at Rio de Janerio (Brazil) in 1992. The Conference laid special focus on the biological diversity and the need to preserve it for posterity. The Rio conference focused on the significance and conservation of biological diversity for the future prosperity.

‘Biodiversity 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 diversity within species, between species and of ecosystems.’ This is the single legally accepted definition of biodiversity adopted

by the UN Convention on Biological Diversity (CBD). India has a great variety and variability of ecological complexes. At world level, India falls in the category of mega-diversity nation.

Genetic diversity refers to the variation of genes among the population and the individuals of the same species. For example, the number of genes is ~35,000 in Homo sapiens. It has a key role in the maintenance of biodiversity at species levels. Basically the stability and sustainability of species depends on genetic diversity. Species diversity refers to the variety of species within a region, i.e. the number of species per unit area at the site (species richness). Species are the primary focus of evolutionary mechanisms and therefore the origin and evolution of species are principle agents in maintenance of global biodiversity. The stability and sustainability of ecosystem depends on species diversity. In comparison to genetic and species diversity the quantitative assessment of ecosystem diversity is not easy. The boundaries of the communities which exist as different sub-ecosystems overlap.

Ecosystem diversity could best understand if one studies the communities in various ecological niches within the given ecosystem; each ecosystem is associated with defined species complexes. These complexes are related to composition and structure of the ecosystem. The stability and sustainability of biosphere depends on ecosystem diversity. It simply means that biodiversity sustains life on earth.

Ecologists use three different terms for various practical measures of biodiversity: (i) Alpha diversity - it refers to diversity within a particular area, community or ecosystem, and is measured by counting the number of taxa within the ecosystem (usually species); (ii) Beta diversity - it refers to species diversity between ecosystems and is measured by comparing the number of taxa that are unique to each of the ecosystems and (iii) Gamma diversity - it is a measure of overall diversity for different ecosystems within a region. Biodiversity, generally, decreases from equator to pole and also decreases with altitude.

II. SIGNIFICANCE OF BIODIVERSITY

The global concern to conserve biodiversity stems from its enormous significance and inestimable value to mankind. The values derived from biodiversity are classified into two broad categories – the direct use value and indirect use value. The benefits derived directly from biodiversity are numerous. Man depends on other animals, plants, fungi and micro-organisms for his food, fuel, fibre, fodder, medicine and many other raw materials as daily requirements. Direct use values derived from biological resources are essential marketable commodities. The biodiversity is perceived by majority persons as a potential storehouse of resources to provide raw material for food products, medicines and beauty products.

The biotic and genetic resources are the most significant resources of present and future. Who so ever controls the biotic resources will control the destinies of the world. As biodiversity is more in tropical ecosystems, they are prone to biopiracy by developed

countries of the temperate world. Biological weapons are a big threat to the humanity and life on earth.

Biodiversity provides base for subsistence and for value addition in manufacturing activities in different parts of the country. It also helps in sustaining cultural diversity. Therefore, farmers, pastorals, fishermen, forest dwellers, artisans, industrialists and service class all depend directly or indirectly on biodiversity. The country has a number of alternative medicines, like Ayurveda, Unani, Siddha and Homeopathic systems which predominantly depend on plant based raw materials. Herbal preparations for various purposes including pharmaceutical and cosmetic are part of traditional biodiversity uses in India. Recreation and eco-tourism are also emerging as the massive money spinning industry and have huge potential in India.

Indirect use value of biodiversity refers to the benefits derived from nature through ecological functions and various services provided by the ecosystem. Readily recognised services include purification of air and water, nutrient cycling, waste decomposition, soils formation and protection from soil erosion, pollination of crops, regulation of climate and other organisms. For example, many non commercial species of planktons and mollusks may not be used directly in industries but they contribute as essential food source for economically important fish species and other organisms. The value of these organisms is thus indirectly immense, as they help to sustain food webs of the ecosystems. Similarly, butterflies, bees and birds have indirect value as plant pollinators and seed dispersers, helping in crop yield. Forests in addition to direct benefits like timber, medicinal plants and minor forest products provide indirect benefits like climate stabilization, nutrient cycle and purification of air and water. However, indirect value is more difficult to assess in the economic terms than the direct use value.

Further, other values of biodiversity include intrinsic value, aesthetic value, bequest value, knowledge value and cultural value which includes religious and spiritual values. The intrinsic or inherent value of biodiversity is the pleasure of that man derives from interactions with nature and other organisms which cannot be expressed in economic terms. The intrinsic value of biodiversity takes us beyond the circle of science and technology, in the aesthetic world of arts, language, history, religion and philosophy. The aesthetic value represents the pleasure that man derives from the boundless beauty and serenity of nature. Bequest value stands for transfer of gift of biodiversity from generation to generation. Biodiversity is a great reservoir of knowledge base. All living beings are unique, have the right to exist and owe respect. Religions all around the world consider each biotic component of the nature as sacred. So they need conservation and unlawful killing of animals or destruction of forests is often punishable. Biodiversity is part of many cultural and religious beliefs. In many Indian villages and towns, plants like *Ocimum sanctum* (Tulsi), *Ficus religiosa* (Pipal), and *Prosopis cineraria* (Khejri) and various other trees are considered sacred and worshipped by the people. Several birds, animals and even snake have been considered sacred. Also, we recognize several animals as national symbols and heritage.

III. CAUSES OF BIODIVERSITY DEPLETION:

Species extinction is the most common way for depletion of biodiversity. This results into total gene pool loss of that species. This loss directly or indirectly affects other organisms and the balance of the ecosystem is also disturbed. It is evident that this invaluable heritage is being destroyed at an alarming rate due to several reasons. The main causes of biodiversity depletion are – natural disasters (floods, droughts, volcanic eruptions and cyclones), climate change, population explosion, land use changes, invasion of exotic species, over exploitation of natural resources, deforestation, hunting, environmental pollution and pressures of economic development. Biodiversity depletion is the result of natural as well as anthropogenic factors.

3.1 Listing of Threatened Biodiversity:

To highlight the legal status of rare species for the purpose of conservation, the International Union for Conservation of Nature and Natural Resources (IUCN) has established the following five main conservation categories: (i) **Extinct** species that are no longer known to exist in the wild. Searches of localities where they were once found and of other possible sites have failed to detect the species; (ii) **Endangered** species that have a high likelihood of going extinct in the near future; (iii) **Vulnerable** species that may become endangered in the near future because populations of the species are decreasing in size throughout its range; (iv) **Rare** species that have small total numbers of individuals often due to limited geographical ranges or low population densities and (v) **Insufficiently known** species that probably belong to one of the conservation categories but are not sufficiently well known to be assigned to a specific category.

These categories were named as Red list categories. The IUCN Red List is the catalogue of taxa that are facing the risk of extinction. This list aims to impart information about the urgency and scale of conservation problems to the public, environmentalists and policy makers. On the global level, the IUCN published Red Data Book, name given to the book dealing with threatened plants and animals of any region. The IUCN, now known as World Conservation Union (WCU), in 2001 recognized nine Red List Categories as Extinct (Ex), Extinct in wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD) and Not Evaluated (NE). The main purpose of the IUCN RED List is to catalogue and highlight those taxa that are facing a higher risk of global extinction (i.e. those listed Critically Endangered, Endangered and Vulnerable).

3.2 Conservation of Biodiversity:

Measures are being taken up at national and international levels to address this issue of depletion of biodiversity. In Indian traditional knowledge and practice the conservation and sustainable use of biological resources is part and parcel of ethical way of living. The objective of conservation is to preserve biodiversity, maintain essential life supporting ecological processes or ecosystem functions and preserve genetic resource along with the utilization of commercially important species in a sustainable way. To achieve these goals, the three main components of biodiversity, such as ecosystem

diversity, species diversity and genetic diversity are to be fully protected. There exists a wide range of varied national policies and legal measures for conservation of biological diversity. Various strategies have been applied to conserve and manage biodiversity. These are described under – legislative, in-situ and ex-situ conservation measures in the following section.

3.2.1 Legislative Measures

Formal policies and programmes to conserve and manage the biological resources of the country were introduced from the very beginning in independent India.

The concept of environmental protection is enshrined in the Indian constitution in articles 48a and 51a (g). The article 48 of the Constitution of India specifies that, ‘the state shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country.’ Article 51-A of the Constitution states that ‘it shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures.’ This way, the conservation of wildlife is enshrined in Indian Constitution. The Indian Board for Wildlife (IBWL) was constituted in 1952 to suggest means of preservation, conservation and management of wildlife to the government. India has long history for conservation of biodiversity through legislative measures. The major Central Acts and Rules related to conservation and management of biodiversity are list below:

1. Madras Wild Elephants Preservation Act, 1873.
2. Elephants Preservation Act, 1879.
3. Fisheries Act, 1897.
4. Wild Birds and Animals Protection Act, 1912.
5. Destructive Insects and Pests Act, 1914.
6. The Indian Forest Act, 1927.
7. Bengal Rhinoceros Preservation Act, 1932
8. Agricultural Produce (Grading and Marketing) Act, 1937.
9. Indian Coffee Act, 1942.
10. Import and Export (Control) Act, 1947.
11. Rubber (Production and Marketing) Act, 1947.
12. Tea Act, 1953.
13. Assam Rhinoceros Preservation Act, 1954
14. Mining and Mineral Development (Regulation) Act, 1957.
15. Prevention of Cruelty to Animals Act, 1960.
16. Customs Act, 1962.
17. Cardamom Act, 1965.
18. Seeds Act, 1966.
19. The Patents Act, 1970.
20. The Wildlife (Protection) Act, 1972.
21. Marine Products Export Development Authority Act, 1972.
22. Water (Prevention and Control of Pollution) Act, 1974.

23. Tobacco Board Act, 1975.
24. Territorial Water, Continental Shelf, Exclusive Economic Zone and Other Maritime Zones Act, 1976.
25. Water (Prevention and Control of Pollution) Cess Act, 1977.
26. Maritime Zones of India (Regulation and Fishing by Foreign Vessels) Act, 1980.
27. Forest (Conservation) Act, 1980.
28. Air (Prevention and Control of Pollution) Act, 1981.
29. Agricultural and Processed Food Products Export Development Authority Act, 1985/86.
30. Environment (Protection) Act, 1986.
31. Species Board Act, 1986.
32. National Dairy Development Board, 1987.
33. Rules for the Manufacture, Use/Import/ Export and Storage of Hazardous Microorganisms/ Genetically Engineered Organisms or Cells, 1989.
34. Foreign Trade (Development and Regulation) Act, 1992.
35. Protection of Plant Varieties and Farmers' Rights (PPVFR) Act, 2001.
36. Biological Diversity Act, 2002.
37. Plant Quarantine (Regulation of Import into India) Order, 2003.
38. Biological Diversity Rules, 2004.
39. The Food Safety and Standards Act, 2006.
40. National Environment Policy, 2006.
41. Scheduled Tribes and Other Traditional Forest Dwellers (Regulation of Forest Rights) Act, 2006.

3.2.2 Protection of Flora:

The conservation of flora has a rather low priority. Following four different types of measures have been used in India:

- (1) **Collection and possession** – it represents the legislative measures that prohibit collection, damage to plants and their parts that are mainly listed as threatened species.
- (2) **Trade Restriction** – these are laws which restrict trade related activities like possession, transportation, exhibition, sale and purchase of plants.
- (3) **Prohibition on destruction** – destruction of protected flora is prohibited.
- (4) **Controlling introduction of exotic species** – introduction of exotic species in any country negatively affects the native biotic communities and so control of these invasive species is generally regulated by laws. Import of exotic species is permitted only for purposes such as for zoological or botanical gardens or for scientific research and that too after ascertaining that the species is free of pathogens. Import of endangered exotic species is banned following the Convention on International Trade in Endangered Species (CITES).

3.2.3 Protection of Wild Fauna:

Legislation for protection of wild fauna is almost similar to that of the flora.

(1) **Removing:** the oldest method of protection is restriction on removing wild animals from their habitat. In India, the principal legislation exists in the form of Wildlife Protection Act, 1972.

(2) **Possession and Trade:** the restriction on trade of wild species is a very common form of legislative protection. Convention on International Trade in Endangered Species of wild fauna and flora aims to control trade and export of plants and animals. CITES, is an international treaty for conservation of wildlife and to prevent biodiversity loss. Foreign Trade (Development and Regulation) Act (1992) framed policies on the export and import of materials related to body parts of plants and animals of trade. The Wild Animals and Birds Act advocates against cruelty to animals and prohibits killing animals and birds in captivity.

The Indian Wildlife Protection Act, 1972 is the first comprehensive act at the national level to preserve biodiversity and afford protection to wild flora, fauna and other natural resources. This act follows a two ways conservation strategy viz. protection of specified endangered species and protection of all species in National Parks and Sanctuaries. In 1991, the act also recognised plants as wild life and implemented conservatory measures for them. In 2002, the act was amended to include protected area outside the range of forest that gave rise to 'Conservation Reserve' and 'Community Reserve'.

The Convention on Biological Diversity (CBD) was opened for signature at the Earth Summit in Rio de Janeiro on 5th June, 1992 and came into force on 29th December, 1993. India ratified CBD and signed the convention in 1994 The main objectives of the CBD are following: (i) conservation of biodiversity, (ii) sustainable use of the biological resources, and (iii) equitable sharing of benefits arising out of utilization of genetic resources.

Following the convention, Biological Diversity Act, 2002 and the Biological Diversity Rules, 2004 were subsequently enacted in India. The main provisions of these are following:

1. Prohibition on transfer of Indian genetic material outside India, without prior approval of the Government.
2. Prohibition on anyone claiming an Intellectual Property Right (IPR), such as a patent, over biodiversity or associated knowledge, without permission of the Government.
3. Regulation of collection and use of biodiversity by Indian nationals, while exempting the local community from such restrictions.
4. Provisions for sharing of benefits arising from the use of biodiversity, including the transfer of technology, monetary returns, joint research and development or joint IPR ownership.
5. Measures to conserve and use biological resources sustainably, including habitat and species protection, environmental impact assessments of projects, integration of biodiversity into the plans, programmes and policies of various departments/sectors.
6. Provisions for local communities to have a moral right in the use of their resources and knowledge, and to charge fees for any access.

7. Protection of indigenous or traditional knowledge, through appropriate laws or other measures, such as the registration of aforesaid knowledge with the help of People's Biodiversity Register (PBR).
8. Regulation of the use of genetically modified organisms.
9. Setting up of national, state and local biodiversity funds to support conservation and benefit -sharing.
10. Setting up of Biodiversity Management Committee (BMC) at local, village and urban levels, State Biodiversity Boards (SBB) at the state level, and the National Biodiversity Authority (NBA) at the national level.

IV. IN-SITU CONSERVATION

In-situ conservation is an integral approach for protection of ecosystems supporting plants, animals, and microorganisms, including the atmosphere, hydrosphere and lithosphere. It is considered as the best method of protecting, propagating and developing species and their habitat along with ecological processes with which they have evolved. The in-situ conservation programme is cost effective and a convenient way in which all the population of a biotic community as well as the ecosystem types are conserved. To achieve this, different categories of lands have been designated as Protected Areas or Management Areas.

Protected Areas

According to the IUCN, a protected area is defined as "An area of land and /or sea especially dedicated for the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means". There are 103 national parks and 543 wildlife Sanctuaries, 18 biosphere reserves, 47 Conservation Reserves and 4 Community Reserves in the country, covering an area of 1,61,221.57 km² (4.90% of total geographic area). Protected areas include the following:

- (i) **National Park:** an area dedicated by statute (legislation) for all times to come, to conserve the natural or historical objects of national significance and to conserve wildlife therein, in such a manner, and by such means as will leave them unimpaired for the enjoyment of future generations, with such modifications as local conditions may demand. Since a national park is created by central legislation, it has a permanent status. There are 103 National Parks in India.
- (ii) **Wildlife Sanctuary:** Place where rare, wild, indigenous mammals, birds, reptiles and any other form of wildlife in good numbers and representative of a region are considered to be in need of protection together with the natural environment, the area is declared as a Wildlife Sanctuary. It is created by the State Forest Department by Gazette notification. It can therefore be abolished in a similar manner. There are 543 wildlife sanctuaries.
- (iii) **Biosphere Reserve:** It is a natural protected area for preservation of natural ecological processes. In 1971, Biosphere network programme was started by UNESCO under the Man and Biosphere Programme (MAB) with the aim of ecosystem

conservation and rational use of natural resources. Biosphere reserve consists of core, buffer and transitional zone. The core area is ecologically most sensitive and strictly protected. The buffer zone is a rural area where recreational activities and sustainable utilization of natural resources are done. However, the transitional zone which is least ecologically sensitive hence, the site for anthropogenic activities, research and sustainable development. There are 18 biosphere reserves in India (Table 1).

Table 1: Biosphere Reserves in India

Nilgiri	Nokrek	Agasthymalai
Pachmarhi	Gulf of Mannar	Dibru-Saikhowa
Achanakmar-Amarkantak	Manas	kangchenjunga
Simlipal	Dihang-Dibang	Sesachalam Hills
Sunderbans	Panna	Cold Desert
Nanda devi	Kachchh	Great Nicobar

(iv) Ramsar sites: These are internationally acclaimed Wetlands that require immediate protection. There are 26 Ramsar wetlands in India (Table 2).

Table 2: Ramsar Wetlands in India

1.Ashtamudi Wetland	Kerala	13. Nalsarovar Bird Sanctuary	Gujarat
2. Bhoj Wetland	Madhya Pradesh	14. Point Calimere Wildlife and Bird Sanctuary	Tamil Nadu
3. Chandra Taal	Himachal Pradesh	15. Pong Dam Lake	Himachal Pradesh
4. Chilika Lake	Odisha	16. Renuka Lake	Himachal Pradesh
5. DeeporBeel	Assam	17. Rudrasagar Lake	Tripura
6.East Calcutta Wetlands	West Bengal	18. Ropar Wetland	Punjab
7. Harike Wetland	Punjab	19. Sambhar Lake	Rajasthan
8. Hokersa Wetland	Jammu and Kashmir	20. Sasthamkotta Lake	Kerala
9. Kanjli Wetland	Punjab	21. Surinsar-Mansar Lakes	Jammu and Kashmir
10. Keoladeo National Park	Rajasthan	22. Tsomoriri	Jammu and Kashmir
11. Kolleru Lake	Andhra Pradesh	23. Upper Ganga River (Brijghat to Narora Stretch)	Utter Pradesh
12. Loktak Lake	Manipur	24. Vembanad-Kol Wetland	Kerala
25. Wular Lake	Jammu and Kashmir	26. Bhitarkanika Mangroves	Odisha

(v) World Heritage Sites: According to the ‘Convention on World Cultural and Natural Heritage’ or ‘World Heritage Convention’ (1977), a number of protected areas, such as Kaziranga, Keolado National Park, Sunderbans, Manas, Nanda devi are declared as world heritage sites. These are places of ecological and historical importance.

(vi) **Community Reserve:** These are communally owned private, protected lands or lands held under non-profit organizations like land trusts that afford conservation to wildlife. Conservation reserves and community reserves act as buffer zones, connectors or migration corridors between two protected areas. The administration of such reserves is maintained through local people and the gram panchayat.

The concept was introduced first in the Wildlife (Protection) Amendment Act of 2002, for protection of wildlife in and around the reserve forests. Tiruvudaimarudur conservation reserve is the first conservation reserve in the country. Keshopur Chhamb community reserve in Gurdaspur district of Punjab, declared in 2007, is the first community reserve in India. The Siju-Rewak corridor in the Garo hills of Meghalaya connects the Siju wildlife sanctuary and the Rewak reserve forest. The Tirunelli-Kudrakote corridor in Kerala functions as an elephant corridor between reserves forests of both. In India, the private protected areas include the protected areas owned by an individual, corporation or organization that are of immense ecological significance.

(vii) **Reserve Forest and Protected Forests** – The Indian Forest Act, 1927 is a major legal provision to protect and manage forest, transit of forest produce and timber and other forest produce. This act is all inclusive and provides mechanism for the management of reserve, protected and village forests along with conservation of forest resources and protection of forest and wildlife diversity. To insure the conservation of Indian forests, the Forest Conservation Act, was enacted in 1980. It strictly restricts and regulates the de-reservation of forests or use of forest land for non-forest uses without prior permission of the Government of India. To address this goal this Act has fixed prerequisites for this diversion of land use/land cover. The National Forest Policy (1988) has set a goal of a minimum of one third of the total geographical area of the country under forest cover. The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006, has been enacted to protect the rights of the forest dwellers whose life and livelihood would be affected by any new provisions in the forest conversation regulations.

In 2002, National Forest Commission was set up to critically review and make an assessment of India's policy and rules and their implications on forest resources and forest dwellers. It will also make recommendations for sustainability of forest cover and for ecological security of the country.

(viii) **Conservation and Management of Mangroves and Coral Reefs** – For intensive conservation and management of mangroves and coral reefs 38 mangrove and 4 coral reef sites have been identified by the central government.

(ix) **Species specific projects – Project Tiger and Project Elephant.**

Project Tiger - In India Project Tiger was launched in 1973 with an objective “to ensure maintenance of a viable population of tigers in India for scientific, economic, aesthetic, cultural and ecological values and to preserve for all times areas of biological importance as a national heritage for the benefit, education and enjoyment of the people”. The Project has been successfully implemented and under this project, 50 Tiger Reserves have been

set up in the country so far. The tiger population has depleted to 1,411 in 2007. This number increased to 1,706 tigers in 2011 and gave the country hope of being able to revive its big cat population. In the last national tiger census, 2014 the population was reported 1,706 tigers.

Project Elephant – This project is central government sponsored programme and was started in 1992. The objectives of the project are following – (i) to provide financial and technical help to major elephant bearing States of India for the protection of elephants, their habitats and elephant corridors; (ii) to support research on the ecology and management of elephants; (iii) to create conservation awareness among local people; (iv) to provide better veterinary care for captive elephants, and (v) it also seeks to address the issues of human-elephant conflict

V. EX-SITU CONSERVATION

Ex-situ conservation stands for the conservation of elements of biodiversity outside their natural habitats. This involves diverse techniques and facilities for long-term storage of genetic resource of wild or cultivated species or their parts. Maintenance and breeding of threatened fauna and flora are done either partially or wholly under controlled conditions in zoos, botanical gardens, nurseries and laboratories as a part of the off-site conservation programme. Ex-situ conservation is basically a process of protecting an endangered species by shifting a representative part of the population from a threatened habitat to a new safe habitat. The new habitat may be under laboratory conditions or a wild area within the care and vigilance of human being. Following methods are used in ex-situ conservation:

- 1) Gene banks, including seed banks, germ banks or DNA banking and field banks.
- 2) Captive breeding programme (semen collection, artificial insemination, embryo transfer, in-vitro fertilization).
- 3) Release and reintroduction.
- 4) Zoological garden, aquaria
- 5) Botanical garden, arboreta.

(i) Gene Banks: In a generalized way - a gene bank is temperature-controlled storage unit which is meant to preserve biodiversity in the form of seeds, sperms, ovule, tissue culture, pollen and even DNA. Gene bank represents a place or organization where germplasm is conserved in live condition. Therefore, these are also called germplasm banks. The germplasm is conserved as seeds, pollen or in vitro cultures, or in the case of a field gene bank, as plants growing in the field. The major merits of gene banks are following

– (a) large number of germplasm samples or entire variability can be conserved in a very small space; (b) handling of germplasm is easy; (c) germplasm is conserved under pathogen and insect free environment. It requires periodical evaluation to get new or fresh seeds for storage. The main repositories of biological resources in India are following:

Table 3: Indian Repositories

Name of the Institutions	Category of Biological Resources
Botanical Survey of India, Kolkata	Flora (Angiosperms, Gymnosperms, Pteridophytes, Bryophytes, Lichens, Macrofungi, Macroalgae)
National Bureau of Plant Genetic Resources (NBPGR), New Delhi	Plant Genetic Resource, National Gene Bank of 1762 crop species established by 2016, tissue culture and cryo-preservation of 1961 crops, 484 pollen and 495 DNA preserved by 2016.
National Botanical Research Institute, Lucknow	Flora (Angiosperms, Gymnosperms, Pteridophytes, Bryophytes, Lichens, Macrofungi, Macroalgae)
Indian Council of forestry Research and Education, Deharadun (Forest Research Institute, Dehradun; Institute of Forest Genetics and Tree Breeding, Coimbatore; and Tropical Forest Research Institute, Jabalpur	Flora (Angiosperms, Gymnosperms, Pteridophytes, Bryophytes, Lichens, Macrofungi, Macroalgae) For TFRI only – Fauna (termites, butterflies, moths)
Zoological Survey of India, Kolkata	Fauna
National Bureau of Animal Genetic Resources (NBAGR), Karnal, Haryana	The National Animal Gene Bank at the Bureau has been established with the objective of conserving the indigenous livestock diversity. Presently, a total of 1,29,174 deep frozen semen doses belonging to 311 breeding males of 44 breeds representing cattle, buffalo, sheep, goat, camel and yak have been collected and preserved.
National Bureau of Fish Genetic Resources, Lucknow	Fish genetic resources
National Institute of Oceanography, Goa	Marine flora and fauna
Wildlife Institute of India, Dehradun	Faunal resources in protected areas
National Bureau of Agriculturally Important Micro-organisms, Mau Nathan Bhanjan, UP	Agriculturally important microorganisms
Institute of Microbial Technology, Chandigarh	Microorganisms
National Institute of virology, Pune	Viruses
Indian Agricultural Research Institute, New Delhi	Microbes/ Fungi
National Bureau of Agriculturally Important Insects , Bangalore	Insects

The major gene banks associated with different crop species are listed in the following table:

Table 4: Gene Banks of Crops in India

Crop Species	Location of Gene Bank	Name of Research Institute
Wheat	Karnal	Directorate of Wheat Research (DWR)
Rice	Cuttack	Central Rice Research Institute(CRR)
Potato	Shimla	Central Potato Research Institute (CPRI)
Cotton	Nagpur	Central Institute for Cotton Research (CICR)
Pulses	Kanpur	Indian Institute for Pulses Research (IIPR)
Oil seed crops	Hyderabad	Directorate of Oil Seed Research (DOR)
Sorghum	Hyderabad	National Research Centre of Sorghum
Soybean	Indore	National Research Centre of Soybean
Groundnut	Junagarh	National Research Centre of Groundnut
Maize	New Delhi	Indian Agricultural Research Institute
Citrus	Nagpur	National Research Centre of Citrus
Sugarcane	Coimbatore	Sugarcane Breeding Institute
Forage Crop	Jhansi	Indian grassland and Fodder Research Institute (GFRI)
Tobacco	Rajahmundry	Central Tobacco Research Institute (CTRI)
Tuber Crop	Trivandrum	Central Tuber Crop Research Institute (CPCRI)
Horticultural Crops	Bangalore	Indian Institute for Horticultural Research (IIHR)
Grapes	Pune	National Research Centre For Grape.

(ii) **Captive breeding programme:** Captive breeding is a process of breeding of rare or endangered animals in man-controlled environment. Breeding is usually done in wildlife reserves, zoos, hatcheries, aquariums or any other conservation facility. Captive breeding programmes involve the following processes of artificial breeding:

- **Semen collection:** semen is artificially collected by the using artificial females or by electro ejaculation using mild electric shock.
- **Artificial insemination:** is the introduction of semen in the vagina of female intended for captive breeding artificially. Currently it is well practiced in India in the livestock breeding.
- **Embryo transfer:** Embryos from fertile females are transferred to surrogate mothers for gestation.
- **In-vitro fertilization:** sperms and eggs from the donors are used for fertilization in the test tube. The resulting embryo is planted in a surrogate mother. Often cryopreserved sperms and ova are used.

The procedure of captive breeding is expensive, complicated and highly scientific.

(iii) **Release and reintroduction:** Captive bred animals are released in new habitat, when their original habitat is completely degraded and resources are exhausted. Reintroduction programme is undertaken when captive bred animals are released in their original habitat, where they once existed.

(iv) **Zoological Gardens:** The National Wildlife Action Plan has stressed on the importance of the role of zoos in ex-situ conservation. The main objective of the National

Zoo Policy (1998) are – (a) all zoos are to be managed for ex-situ breeding of endangered species and motivate visitors to live in harmony with nature; (b) new zoos are to be set up for strengthening the national conservation efforts, (c) zoos shall ensure quality food and health care facilities and (d) zoos are intended for maintaining the genetic viability of the captive populations.

(v) Botanical Gardens and Arboreta:

Botanical gardens maintain collections of both herbaceous (bulbs, biennials, perennials) and woody (trees and shrubs) plants for research, study, and education. Arboreta traditionally focus on collection of large trees and shrubs. Many botanical gardens are associated with herbaria, while others with universities and research institutions. The contribution of botanical gardens to the conservation of species extends beyond the preservation of species threatened in wild. Botanical gardens supply plants for research and horticulture, thereby reducing pressure on wild population. Also, they are important education resources. The major botanical gardens of India are following:

- Acharya Jagadish Chandra Bose Indian Botanic Garden, Shibpur, Kolkata
- Agri Horticultural Society of India, Alipore, Kolkata
- Assam State Zoo-cum-Botanical Garden, Guwahati
- Botanical Garden, Near Sarangpur, Chandigarh
- Empress Garden, Pune
- Garden of Medicinal Plants, North Bengal University, West Bengal
- Government Botanical Gardens, Ootacamund, Nilgiris district, Tamil Nadu
- Botanic Gardens - Tamil Nadu Agricultural University, Coimbatore
- IFGTB Botanical Garden - The Institute of Forest Genetics and Tree Breeding (IFGTB), Coimbatore, Tamil Nadu
- Jawaharlal Nehru Tropical Botanical Garden and Research Institute (TBGRI), Trivandrum, Kerala (Biggest in India and conserves the largest number of plant species in Asia).
- Malampuzha Garden, Palakkad, Kerala
- Jhansi Botanical Garden, Jhansi, Uttar Pradesh
- Odisha State Botanical Garden Nandankanan, Bhubaneswar, Odisha
- Aligarh Fort (maintained by the Department of Botany, AMU), Aligarh, Uttar Pradesh.
- Lalbagh, Bangalore, Karnataka
- The Mysore Zoo, in Mysore, Karnataka is also a botanical garden
- Regional Museum of Natural History Mysore, Mysore, Karnataka
- University of Mysore Botanic Garden, Mysore, Karnataka
- Curzon Park, Mysore, Karnataka
- Pilikula Arboretum (Pilikula Botanical Garden) at Pilikula Nisargadhama near Mangalore, Karnataka
- Botanical Garden of the Department of Applied Botany at Mangalore University, Karnataka

- Lloyd's Botanical Garden, Darjeeling, West Bengal
- Saharanpur Botanical Garden, Saharanpur, Uttar Pradesh
- Semmozhi Poonga, Chennai, Tamil Nadu
- R. B. Botanical Garden and Amusement Park, Gujarat Technological University, Ahmedabad, Gujarat
- Vellayani Agricultural College, Trivandrum, Kerala
- The Garça Branca Ayurvedic Botanical Garden, Loutolim, Goa.
- Narendra Narayan Park at Cooch Behar, West Bengal.
- Botanical Garden of India Republic, Noida, Uttar Pradesh.

V. CONCLUSION

Biodiversity represents the ensemble and interactions of the genetic, species and ecological diversity. The benefits derived directly and indirectly from biodiversity are numerous. In Indian traditional knowledge and practice the conservation and sustainable use of biological resources is part and parcel of ethical way of living. Taking into consideration the significance and diversity of biological resources a lot of efforts in the form of legislative, *in-situ* conservation and *ex-situ* conservation measures have been taken in India. Forest Conservation Acts, Forest Policy of India, Biological Diversity Act, and the Wildlife (Protection) Act are major legislative measures of conservation of biodiversity. The national parks and wildlife Sanctuaries, biosphere reserves, Ramsar wetlands, mangrove and coral reefs, Conservation Reserves and Community Reserves in the country extend over an area about 5 per cent of total geographic area. These protected areas provide *in-situ* conservation of biodiversity. In *ex-situ* measures gene banks, captive breeding and establishment of botanical gardens are gaining momentum. Proper implementation of legislative measures, efficient management of *in-situ* and *ex-situ* biodiversity conservation measures is required for the sustainable development of India.

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