Biodiversity Conservation in India

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Biodiversity Conservation

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INTRODUCTION

For much of the time man lived in a hunter-gather society and thus depended entirely on biodiversity for sustenance. But, with the increased dependence on agriculture and industrialization, the emphasis on biodiversity has decreased. Indeed, the biodiversity, in wild and domesticated forms, is the source for most of humanity, food, medicine, clothing and housing, much of the cultural diversity and most of the intellectual and spiritual inspiration. It is, without doubt, the very basis of life. Further that, a quarter of the earth's total biological diversity amounting to 1.7 million species, which might be useful to mankind in one way or other, would be in serious risk of existence over the next 2-3 decades. On realization that the erosion of biodiversity may threaten the very existence of life has awakened man to take steps to conserve it. In this paper, the overview of biodiversity status of India, its importance, threats to it and various approaches for biodiversity conservation, action plan and current status have been discussed.

1. WHAT IS BIODIVERSITY?

The concept of biodiversity (synonyms with biological diversity) has been known to man ever since he began to minutely observe the living being around him. The term biological diversity was used by Robert E. Jenkins and Thomas Lovejoy in 1980. The word biodiversity itself may have been coined by W. G. Rosen in 1985. The term biodiversity was used as the title for a symposium organized by national Research council in Washington in 1986. At about that time, as people became more aware of the extinction crisis, biodiversity emerged as a significant issue. It was given concrete expression in the World Resources Institute (WRI), World Bank (WB), International Union of Nature and Natural Resources (IUCN) and World Wide Fund for Nature (WWF) publications concerned with conservation of world's biological diversity. However, biodiversity did not became a familiar term to general public until the United Nations Conference on the Environmental and Development (UNCED) held at Rio de Janerio (Brazil) in 1992. The Conference laid immense stress on the biological diversity of our earth planet and the need to preserve it for posterity. It defined the biodiversity: **'*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.

The most straight forward definition of biodiversity is the variation of life at all levels of biological organization. It includes diversity of forms right from the molecular unit to the individual organism, and then on to the population, community, ecosystem, landscape and biosphere levels. *In the simplest sense,* ***biodiversity may be defined as the sum total of species richness, i.e. the number of species of plants, animals and microorganisms occurring in a given region, country, continent of the entire globe***. Broadly speaking, the term biodiversity includes genetic diversity, species diversity, ecosystem diversity and habit diversity.

Genetic diversity (Diversity of genes within a species). Genetic diversity refers to the variation of genes among the population and the individuals of the same species. There are about 1.7 million known species

of living forms on the earth. Each one stores an immense amount of genetic information. For example, the number of genes is ~35,000 in *Homo sapiens.*

Genetic variation within species constitutes distinct populations of the same species or genetic variation within population or varieties. Genetic variations represent the differences in the sequence of bases in nucleotides, which constitutes the genetic code. Genetic variations are due to gene mutations, and in an organism with sexual reproduction these can spread by crossing-over and recombination. Other kinds of genetic diversity can be seen at all levels of organization, including the amount of DNA per cell, chromosome structure and their number. Genetic diversity provides the raw materials for adaptation to changing environment and for the natural selection to act upon. If a species has more genetic variability, it can adapt better of to the changed environment. The amount of genetic variation is the basis of the evolution of new life forms (speciation). It has a key role in the maintenance of biodiversity at species levels.

Species diversity (Diversity among species). It refers to the variety of species within a region, i.e. the number of species per unit area at the site (species richness). An estimated 1.7 million species have been described to date. Species are the primary focus of evolutionary mechanisms and therefore the origin and evolution of species are principle agents in maintenance of global biodiversity.

Ecosystem diversity (Diversity at the level of community/ecosystem). In an ecosystem there may exist different landforms, each of which supports different but specific vegetations. Ecosystem diversity in contrast to genetic and specific diversity is difficult to assess quantitatively since the boundaries of the communities, which constitute the various sub-ecosystems are elusive. Ecosystem diversity could best understood 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.

Habitat diversity. It involves more than just the kind of communities and species- it depends on the spatial arrangement of habitats across a large and on the fluxes of energy, nutrients, disturbances and organisms across the area.

Ecological use three different terms for various practical measures of biodiversity:

- **Alpha diversity**. It refers to diversity within a particular area, community or ecosystem, and is measured by counting the number of texa within the ecosystem (usually species).
- **Beta diversity**. It refers to species diversity between ecosystems and is measured by comparing the number of texa that are unique to each of the ecosystems.
- **Gamma diversity**. It is a measure of overall diversity for different ecosystems within a region.

Species diversity in natural habitats is a high in warm areas and decreases with increasing latitude and altitude. On land, diversity is higher in areas of higher rainfall and lower in drier areas. Tropical moist forests undoubtedly, are the richer areas. These comprise only 7% of the world surface area, but contain over 90% of all species.

In India we are endowed with a rich diversity of biogeographically distinct regions due to varying physical conditions and species groupings.

2. BIODIVERSITY AT GLOBAL AND COUNTRY LEVEL

It is estimated that there exists 5-50 million species of living forms on the earth. However, only 1.7 million have been identified so far. These include 4,27,205 species of green plants, fungi, bacteria and viruses; 61,917 species of vertebrates and protochordata; and12,32,490 species of invertebrates including protista. Comparative accounts of recorded plant and animal species in India and the world are given in Table 1 and 2.

Table 1- Comparative account of recorded number of plant species in India and the world.

Texa	Species		Percentage of India to the world
	India	World	
Bacteria	850	8,050	10.56
Viruses	Unknown	4,000	-
Algae	6,500	40,000	16-25
Fungi	14,500	72,000	20.14
Lichens	2,021	35,000	14.97
Bryophyta	2,825	17,000	16.62
Pteridophyta	1,200	13,025*	9.21
Gymnosperms	48	980*	4.90
Angiosperms	18,000+	2,58,650*	6.96
Total	**45,944**	**4,27,205**	**10.75**

Source: ENVIS, BSI, 2006; IUCN Red List 2007*.

Table 2- Comparative account of recorded number of animal species in India and the world.

Texa	Species		Percentage of India to the world
	India	World	
Protista	2,577	31,290	8.24
Mollusca	5,070	81,000*	6.26
Arthropoda	68,389	9,90,000*	6.91
Other invertebrates	8,329	1,30,200*	6.40
Protochordata	119	2,106	5.65
Pisces	2,546	30,000*	8.49
Amphibia	209	6,199*	3.37
Reptilia	456	8,240*	5.53
Aves	1,232	9,956*	12.37
Mammalia	390	5,416*	7.20
Total	**89,317**	**12,94,407**	**6.90**

Source: MoEF 1999; IUCN Red List 2007*.

India with 2.45% of the world's area, has 8.10% of the world's total biodiversity with a species count of over 1,35,261. Some salient features of India's biodiversity are as follows:

- India has two major realms called Palearctic and the Indo-Malayan, and three biomes namely the tropical humid forests, the tropical dry/deciduous forests and the warm desert/semi deserts.
- India has 10 biogeographical regions including (i) the Trans-Himalayan, (ii) Himalayan, (iii) Desert, (iv) Semi-Arid, (v) Western Ghats, (vi) Deccan Peninsula, (vii) Gangetic plain, (viii) Coasts, (ix) Northeast, and (x) Islands (Rodgers and Panwar, 1988). Among these biogeographic

zones, Deccan Peninsula has the most extensive coverage of the Indian landmass (42%). The most biodiversity-rich zones, Western Ghats and Northeast, account only for 4 and 5.2 per cent of the geographical area. These zones have habitats, biotic communities and ecosystems.

- India has 15 Biosphere Reserves, 44 tiger Reserves, 102 national Parks, and 512 Wildlife Sanctuaries. The total protected area is about 0.20 million km^2 (about 4.9 % of the geographical area). Also, it has 5 world heritage sites and 25 Ramsar wetlands.

In addition, the country is one of the very important Vavilovian Centers of biodiversity and origin of over 167 species of crops, 320 species of wild crop relatives, and several species of domesticated animals. In flora, the country can boast of 45,944 species, which accounts for 10.75% of the known world plants. Of the 18,000 species of flowering plants (angiosperms) 36% are endemic and located in 26 endemic centers. Our country is very rich in faunal wealth too. The country has nearly 89,317 animal species, about 75 percent of which are insects, 4,952 vertebrates including protochordata and about 84,365 are invertebrates, including protista. In animals, the rate of endemism in reptiles is 33%, in amphibians 41%, in mammals 9%, and birds 4%.

3. IMPORTANCE OF BIODIVERSITY

The Benefits of Biodiversity to mankind are:

3.1 Ecological role of biodiversity

All species provide some kind of function to an ecosystem. They can capture and store energy, produce organic material, decompose organic material, help to recycle water and nutrients throughout the ecosystem, control erosion or pests, fix atmospheric gases, and help regulate climate. These physiologically processes are important for ecosystem function and human survival.

Diverse is the ecosystem better able to withstand environmental stress and consequently is more productive. The loss of a species is thus likely to decrease the ability of the system to maintain itself or to recover from damage or disturbance. Just like a species with high genetic diversity, an ecosystem with high biodiversity may have a greater chance of adapting to environmental change. In other words, the more species comprising an ecosystem, the more stable the ecosystem is likely to be.

3.2 Economic role of biodiversity

For all humans, biodiversity is first a resource for daily life. One important part of biodiversity is crop diversity, which is also called agrobiodiversity.

Most people see biodiversity as a reservoir of resources to be drawn upon for the manufacture of food, pharmaceutical, and cosmetic products.

Some of the important economic commodities that biodiversity supplies to humankind are:

- Modern agriculture: Biodiversoty is used as a source of material for breeding improved varieties, and as biopesticides, biofertilizers etc.
- Food: Crops, livestock, forestry and fish. Mangroves and coral reefs in coastal zone support fisheries.

- Medical drugs: Wild plant species have been used for medicinal purposes since before the beginning of recorded history. For example, quinine comes from the cinchona tree (used to treat malaria), digitalis from the foxglove plant (chronic heart trouble), and morphine from the poppy plant (pain relief). According to the National cancer Institute, over 70% of the promising anti-cancer drugs come from plants in the tropical rainforests. It is estimated that of the 2,50,000 known plants species, only 5,000 have been investigated for possible medical applications.
- Industry: Fibers are used for clothing, wood for shelter, energy and various other uses. Biodiversity may be a source of energy (such as biomass). Other industrial products are oils, fragrances, dyes paper, waxes, rubber, latexes, resins, poisons, and cork, which all can be derived from various plant species. Supplies from animal origin include wool, silk, fur, leather, lubricants and waxes. Animals may also be used as a mode of transport.

3.3 Aesthetic and cultural benefits

Biodiversity has great aesthetic value. Examples of aesthetic value include eco-tourism, bird watching, wildlife, gardening, etc. Eco-tourism is a source of economical wealth for many areas, such as many parks and forests, where wild nature and animals are a source of beauty and joy for many people. Biodiversity is also 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 symbols of national and heritage.

3.4 Scientific role of biodiversity

Biodiversity is important because each species can give scientists some clue as to how the life evolved and will continue to evolve on Earth. In addition, biodiversity helps scientists understand how life functions and the role of each species in sustaining ecosystems.

From above it is clear that the survival and well being of the present day human population, depends on several substances obtained from plants and animals. The nutritional needs of mankind are also met by wild and domesticated animal and plant species. Indeed, the biodiversity in wild and domesticated form is the source for most of humanity's food, medicine, clothing and housing, much of the cultural diversity, and most of the intellectual and spiritual inspiration. It is, without doubt, the very basis of man's being. It is believed that $1/4^{th}$ of the known biodiversity, which might be useful to mankind in one way or the other, is in serious risk of extinction. This calls for an integrated approach for conserving global biodiversity.

4. THE THREATENED BIODIVERSITY

The loss of biological diversity is a global crisis. There is hardly any region on the Earth that is not facing ecological catastrophes. Of the 1.7 million species known to inhibit the Earth (human are just one of them), one third to one fourth is likely to extinct within the next few decades. Biological extinction has been a natural phenomenon in geological history. But the rate of extinction was perhaps one species every 1000 years. But man's intervention has speeded up extinction rates all the more. Between 1600 and 1500, the rate of extinction went up to one species every 10 years. It is estimated that about 50 species are being driven to extinction every year, bulk of them in tropical forest, due to human interference.

4.1 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:

- **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.
- **Endangered** species that have a high likelihood of going extinct in the near future.
- **Vulnerable** species that may become endangered in the near future because populations of the species are decreasing in size throughout its range.
- **Rare** species that have small total numbers of individuals often due to limited geographical ranges or low population densities.
- **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 texa 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 pants 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 texa that are facing a higher risk of global extinction (i.e. those listed Critically Endangered, Endangered and Vulnerable.

4.2 Reasons for extinction of Biodiversity

1. **Destruction of habitat:** The natural habitat may be destroyed by man for his settlement, grazing grounds, agriculture, mining, industries, highway construction, drainage, dam building, etc. as a consequence of this, the species must adapt to the changes, move elsewhere or may succumb to predation, starvation or disease and eventually die. This is the most pervasive threat to birds, mammals and plants affecting 89% of all threatened birds, 83% of the threatened animals assessed. In our country, several rare butterfly species are facing extinction with the uncannily swift habitat destruction of the Western Ghats. Of the 370 butterfly species available in the Ghats, up to 70 are at the brink of extinction.
2. **Hunting:** From time immemorial, man has hunted for food. Commercially, wild animals are hunted for their products such as hide and skin, tusk, antlers, fur meat, pharmaceuticals, perfumes, cosmetics and decoration purposes. For example, in India, rhino is hunted for its horns, tigers for bones and skin, musk deer for musk (have medicinal value), elephant for ivory, gharial and crocodile for their skin, and jackal for thriving fur trade in Kashmir. One of the most publicized commercial hunts in that of whale. The whalebone or ‘baleen’ is used to make combs and other products.

Poaching of the Indian tiger has been risen because of the increasing demand from pharmaceutical industries, which consume the bones of 100 tigers per year. Such huge demand has been mat by poachers from India. Even the Project tiger Programme failed to check poaching and resultantly the tigers have been almost disappeared from Ranthambore and Keoladeo national parks. Smuggling of tiger bones and skins is a lucrative business. Hunting for sport is also a factor for loss of wild animals.

3. **Over exploitation:** This is one of the main cause of the loss of not only economic species but also biological ciriosities like the insectivorous and primitive species and other taxa needed for teaching or laboratory (like *Nepenthes, Gnetum, Psilotum,* etc.). commercial exploitation of wild plants has invariably causes their overuse and eventual destruction. This has been true in case of Indian wild mango trees, which were turned into plywood as of the whales that were hunted for tallow. Plants of medicinal value like *Podophyllum hexandrum, Coptis teeta, Aconitum, Disocorea deltoidea, Rauwolfia serpentine, Paphiopedilum druryi,* etc., and horticultural plants like orchids and rhododendrons come under the over-exploited category. Faunal losses have been mainly because of over-exploitation. For instance, excessive harvesting of marine organisms such as fish, mollusks, sea cows and sea turtles has resulted in extinction of these animals.
4. **Collection for zoo and research:** Animals and plants are collected throughout the world for zoo and biological laboratories for study and research in science and medicine. For example, primates such as monkey and chimpanzees are sacrificed for research as they have anatomical, genetic and physiological similarities to human being.
5. **Introduction of exotic species:** Native species are subjected to competition for food and space due to competition for food and space due to introduction of exotic species. For example, introduction of goats and rabbits in the Pacific and Indian regions has resulted in destruction of habitats of several plants, birds and reptiles.
6. **Control of pest and predators:** predator and pest control measures, generally kill predators that are a component of balanced ecosystem and may also indiscriminately poison non-target species.
7. **Pollution:** Pollution alters the natural habitat. Water pollution especially injurious to the biotic components of estuary and coastal ecosystem. Toxic wastes entering the water bodies disturb the food chaion, and so to the aquatic ecosystems. Insecticides, pesticides, sulphur dioxide, nitrogen oxides, acid rain, ozone depletion and global warming too, affect adversely the plant and animal species.

   The impact of coastal pollution is also very important, it is seen that coral reefs are being threatened by pollution from industrialization along the coast, oil transport and offshore mining. Noise pollution is also the cause of wildlife extinction. According to a study Arctic whales are seen on the verge of extinction as a result of increasing noise of ships, particularly ice breakers and tankers.
8. **Deforestation:** One of the main causes for the loss of wildlife is population explosion and the resultant deforestation. Deforestation mainly results from population settlement, shifting cultivation, development projects, demand for fuel wood, demand of wood as a raw material for many industries such as paper and pulp, match, veneer and plywood, furniture etc.

   In the Country, the current rate of deforestation is 13,000 sq. km annually. If this rate of deforestation continues, one can imagine the ultimate fate of our forest and biological richness. It is presumed that in coming years, the global loss of biodiversity from deforestation alone would be 100 species every day.

9. **Other factors:** Other ecological factors that may also contribute to the extinction of wildlife are as follows:
    i. Distribution range – The smaller the range of distribution, the greater the threat of extinction.
    ii. Degree of specialization – The more specialized an organism is, the more vulnerable it is to extinction.
    iii. Position of the organism in the food chain – The higher the position of the organism is in food chain, the more susceptibility it becomes.
    iv. Reproductive rate – Large organisms tend to produce fewer offspring at widely spaced intervals.
    v. Outbreaks of diseases – it is also one of the major causes for the decline in wildlife species.
    vi. Loss of gene flow – The individuals of plant and animal life may decline to the significant levels as a result of loss of gene flow.
    vii. Substitution – During the process of evolution an existing species may be replaced by ecologically another one.

In developing counties like India, the development policies and projects have rarely been sensitive to the need for biodiversity conservation, and that of the local communities. The government's failure to remove poverty and curb middle-class consumerism has led conditions in which sensible natural resources management assumes low priority.

5. BIODIVERSITY CONSERVATION METHODS

We must make every effort to preserve, conserve and manage biodiversity. Protected areas, from large wilderness reserves to small sites for particular species and reserves for controlled uses, will all be part of this process. Protected areas are legally established sites managed for conservation of biodiversity. Worldwide about 8,163 protected areas cover over 750 million hectares of marine and terrestrial ecosystems, amounting to 1.5 percent of Earth's surface.

India is the second most populous country, and therefore any plan attempting at conservation must consider socio-economic development as the mounting human pressure threatens the biotic resources of the country. Furthermore, ours is predominantly an agriculture country, and hence, policy makers should realize that conservation and sustainable utilization of biodiversity is the key to all developmental planning projects.

5.1 ACTION PLAN

To conserve the biodiversity, the immediate task will be to devise and enforce time bound programme for saving plant and animal species as well as habitats of biological resources. Action plan for conservation, therefore, must be directed to:

- Inventorization of biological resources in different parts of the country including the island ecosystem;

- Conservation of biodiversity through a network of protected areas including National Parks, Wildlife Sanctuaries, Biosphere Reserves, Tiger Reserves, Marine Reserves, Gene Banks, Wetlands, Mangroves, Coral Refs, etc.;
- Rehabilitation of rural poor/tribes displaced due to creation of protected areas;
- Conservation of micro-organisms which help in reclamation of wastelands and revival of biological potential of land;
- Protection and sustainable use of genetic resources/germplasm through appropriate laws and practices;
- Regular access to biological resources of the country with the purpose of securing equitable share in benefits arising out of the use of biological resources and associated knowledge relating to it;
- Control of over-exploitation through TRAFFIC, CITES and other agencies, and also through treaties/protocols//environmental protection laws at National/International level;
- Protection of domesticated plant and animal species in order to conserve indigenous genetic diversity;
- Maintenance of corridors between different nature reserves for the possible migration of species in response to climate, or any other disturbing factor;
- Support for protecting traditional skills and knowledge for conservation;
- Multiplication and breeding of threatened species through modern techniques of tissue culture and biotechnology;
- Discouragement of monoculture introduction; and
- Restriction on introduction of exotic species without adequate investigations.

During the last twenty years, plans for biodiversity conservation have been developed by the WRI and the IUCN with support from World Bank and other institution. Basically, the conservation plan should have a holistic approach and encompasses whole spectrum of biota and activities ranging from ecosystems at the macro level to DNA libraries at the molecular level. There are two approaches of biodiversity conservation namely *in situ* (on site) conservation which tries to protect the specie where they are, i.e., in their natural habitat and *ex situ* (off site) conservation which attempts to protect and preserve a species in place away from its natural habitat.

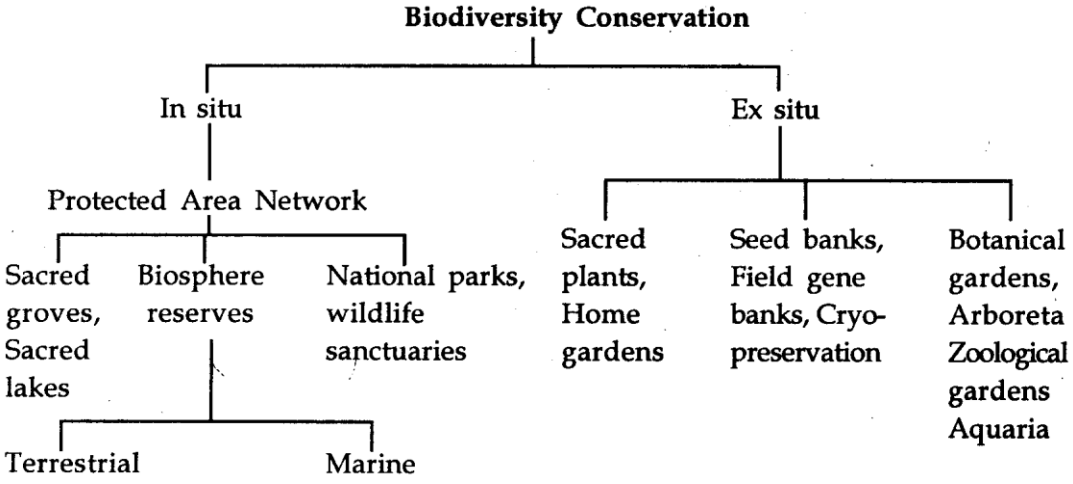

Fig. 1 The *in-situ* and *ex-situ* approaches of conserving biodiversity in India

5.2 *In situ* Conservation

In situ conservation means the conservation of ecosystem and natural habitat and maintenance and recovery of viable population of species in the natural surrounding where they have developed their distinctive characteristics.

In situ conservation methods pertain to conserving animals and plants in their natural habitats. It emphasizes the preservation and protection of total ecosystems at their original or natural environment. Human societies have always taken interest in preserving wildlife areas. The main objective is to recognize a particular biodiversity rich area and to preserve it so that the biodiversity can continue to flourish and evolve. This involves establishment of protected areas, national parks, sanctuaries, biosphere reserves, reserve forests etc. over past few decades there has been an increase in the number of such areas. Protection of the ecosystem by simply eliminating factors detrimental to the existence of species concerned has given good results in conservation of constituent species, known or unknown.

In situ conservation of biodiversity is advantageous in that it is a cheap and convenient method that requires people's our supportive role. It maintains all organisms at different trophic levels from producers to top consumers such as carnivores. In natural environment, organisms not only live and multiply but also evolve and continue to maintain their ability to resist various environmental tresses such as drought storm, snow, temperature fluctuations, excessive rains, flood, fires, pathogens etc. *In situ* conservation requires only elimination of factors detrimental to the existence of the species and allows the larger number of species to grow simultaneously and flourish in their natural environment in which they were growing since a long time. The only disadvantage of *in situ* conservation is that it requires larger areas and minimizes the space for inhibiting human population which is increasing tremendously. The following areas may be set aside for *in situ* conservation:

5.2.1 National Parks and Wildlife Sanctuaries

These are legally constituted protected areas for conserving both flora and fauna of a region. In India, the Wildlife Protection act of 1972 empowers the State Governments to declare an area as a Sanctuary or National Park. This is done for protecting, propagating and developing wildlife and its environment. Section 18 to 34 and 38 of the Act, deal with the declaration of sanctuaries, Section 35 and 38 with National Parks and Section 37 with closed areas. There are 102 national parks and 512 wildlife Sanctuaries, 47 Conservation Reserves and 4 Community Reserves in the country, covering an area of 1,61,221.57 km^2 (4.90% of total geographic area).

National parks (NP): A National Park is an area of land set aside to conserve the scenery (or environment) and natural objects and the wildlife therein. Under sec. 35 of the wildlife Protection Act (1972), whenever it appears to the State Government that an area, whether within a sanctuary or not, is by reason of its ecological, faunal, floral, geomorphological or zoological importance, needed to be constituted as a National park for the purpose of propagating or developing wildlife therein or its environment, it may, by notification, declare its intention to constitute such as a National Park.

All kinds of destruction, exploitation and removal of wildlife and damage to the habitat of any animal are strictly prohibited inside a National park. Grazing of domestic animals is also prohibited. However, the

Chief Wildlife Warden may, after prior approval of the state government, permit destruction, exploitation and removal of wildlife from the NP if necessary for the improvement and better management of wildlife therein.

Wildlife Sanctuaries (WLS): Similar to the National park, a wildlife sanctuary is dedicated to protect wildlife, but it considers the conservation of species only and also the boundary of it is not limited by state legislation. Under Section 26-A (b) of the Wildlife (Protection) Act of 1972, the state government may declare any area comprised within any reserve forest or any part of territorial waters which is considered to be of adequate ecological, faunal, floral, geomorphological, natural or zoological significance for the purpose of protecting, propagating or developing wildlife or its environment to be included in a sanctuary. As per provision of the Wildlife (Protection) Act of 1972 no person shall destroy, exploit or remove any wildlife from a sanctuary, or destroy or damage the habitat of any wild animal or deprive any wild animal from its habitat, except the permission granted by Chief Wildlife Warden, after prior approval of the state government. Also, no person allowed moving freely inside the sanctuary except with the permission of the authorities. The permanent residents of the area are bound to perform certain duties such as helping in controlling fire damage, to report about dead animals and render all kinds of help in resisting the offenders.

Conservation Reserves can be declared by the State Governments in any area owned by the Government, particularly the areas adjacent to National Parks and Sanctuaries and those areas which link one Protected Area with another. Such declaration should be made after having consultations with the local communities. Conservation Reserves are declared for the purpose of protecting landscapes, seascapes, flora and fauna and their habitat. The rights of people living inside a Conservation Reserve are not affected.

Community Reserves can be declared by the State Government in any private or community land, not comprised within a National Park, Sanctuary or a Conservation Reserve, where an individual or a community has volunteered to conserve wildlife and its habitat. Community Reserves are declared for the purpose of protecting fauna, flora and traditional or cultural conservation values and practices. As in the case of a Conservation Reserve, the rights of people living inside a Community Reserve are not affected.

Table 3 - State-wise details of the Protected Area Network of the country

S.No.	State/UT	No. of National Parks	No. of Wildlife Sanctuaries	No. of Conservation Reserves	No. of Community Reserves
1	Andhra Pradesh	6	21	0	0
2	Arunachal Pradesh	2	11	0	0
3	Assam	5	18	0	0
4	Bihar	1	12	0	0
5	Chhatisgarh	3	11	0	0
6	Goa	1	6	0	0
7	Gujarat	4	23	0	0
8	Haryana	2	8	2	0
9	Himachal Pradesh	5	32	0	0
10	Jammu &Kashmir	4	15	34	0
11	Jharkhand	1	11	0	0
12	Karnataka	2	22	2	1
13	Kerala	6	16	0	1
14	Madhya Pradesh	9	25	0	0

15	Maharashtra	6	35	1	0
16	Manipur	1	1	0	0
17	Meghalaya	2	3	0	0
18	Mizoram	2	8	0	0
19	Nagaland	1	3	0	0
20	Orissa	2	18	0	0
21	Punjab	0	12	1	2
22	Rajasthan	5	25	3	0
23	Sikkim	1	7	0	0
24	Tamil Nadu	5	21	1	0
25	Tripura	2	4	0	0
26	Uttar Pradesh	1	23	0	0
27	Uttaranchal	6	6	2	0
28	West Bengal	5	15	0	0
29	Andaman & Nicobar	9	96	0	0
30	Chandigarh	0	2	0	0
31	Dadar & Nagar Haweli	0	1	0	0
32	Lakshadweep	0	1	0	0
33	Daman & Diu	0	1	0	0
34	Delhi	0	1	0	0
35	Pondicherry	0	1	0	0
	TOTAL	**102**	**515**	**47**	**4**

Source: MoEF report of protected area network, 2009.

5.2.2 Biosphere reserve

Biosphere reserves have been described as undisturbed natural areas for scientific study as well as areas in which conditions of disturbance are under control. They have been set aside for ecological research and habitat preservation. Biosphere Reserves are areas of terrestrial and coastal ecosystems which are internationally recognized within the framework of UNESCO's Man and Biosphere (MAB) Programme launched in 1971. These reserves are required to meet a minimal set of criteria and adhere to a minimal set of conditions before being admitted to the World Network of Biosphere Reserves designated by UNESCO for inclusion in the World Network of Biosphere Reserves. The world's major ecosystem types and landscapes are represented in this Network, which is devoted to conserving biological diversity, promoting research and monitoring as well as seeking to provide models of sustainable development in the service of mankind. The objectives of the programme are:

- Conserve biotic diversity for ecological evidence.
- Safeguard genetic diversity for the process of evolution to act upon.
- Provide natural areas for basic and applied research in ecology and environmental biology.
- Provide opportunity for environmental education and training.
- Promote international co-operation.
- Promote appropriate sustainable management of the available biotic resources.
- Disseminate the experience so as to promote sustainable development elsewhere.

These reserves are rich in biological and cultural diversity and encompass unique features of exceptionally pristine nature. The goal is to facilitate conservation of representative landscapes and their immense biological diversity and cultural heritage, foster economic and human development which is culturally and ecologically sustainable and to provide support for research, monitoring, education and information exchange. The Scheme is a pioneering effort at pursuing the increasingly difficult yet urgent

task of conserving ecological diversity under mounting pressures. The main features of biosphere reserve are:

- They are representative areas of specific terrestrial and coastal environment of country, continent or the entire earth planet that must be conserved for posterity;
- They are representative example of the natural or minimally disturbed ecosystem;
- The extent and size of such areas is large enough to function as a unit of conservation; and
- Biosphere Reserves remain and function as an open system; changes in land use are not usually allowed.

As of May 2008, under UNESCO-MAB Programme, 531biosphere reserves have been established in 105 countries. This list includes four biosphere reserves from India, namely Sunderbans (West Bengal), Gulf of Mannar (Tamil Nadu), Nilgiri (Tamil Nadu, Kerala and Karnataka) and Nanda Devi (Uttaranchal) biosphere reserves in its Network of Biosphere reserves. Efforts are on for getting remaining Biosphere Reserves included in the World Network of Biosphere Reserve.

The country's first biosphere reserve came into being on 1st August 1986 in Nilgiri, covering 5520 km^2 in Tamil Nadu, Kerala and Karnataka. Including this one, in all 15 Biosphere Reserves covering an area of 74,275.60 km^2 (Table- 4), have been set up in the country till January 29, 2008 (MoEF Annual Report, 2007-08). In addition, a number of potential sites are under consideration to be designed as biosphere reserves. Out of them Runn of Kachchh in Gujarat and Cold desert Biosphere Reserve in Jammu & Kashmir and Himanchal Pradesh are at an advanced stage.

Table 4 - Biosphere Reserves of India

S. No.	Name of Biosphere Reserve	State	Biogeographic zone	Date of notification	Area (in km^2)
1.	*Nilgiri	Tamil Nadu, Kerala and Karnataka	Western Ghats	01.08.1986	5,520.00
2.	*Nanda Devi	Uttaranchal	West Himalayas	18.01.1988	6,497.03
3.	Nokrek	Meghalaya	East Himalayas	01.09.1988	820.00
4.	Manas	Assam	East Himalayas	14.03.1989	2,837.00
5.	*Sunderbans	West Bengal	Gangetic Delta	29.03.1989	9,630.00
6.	*Gulf of Mannar	Tamil Nadu	Coasts	18.02.1989	10,500.00
7.	Great Nicobar	Andaman & Nicobar Islands	Islands	06.01.1989	885.00
8.	Similipal	Orissa	Deccan Peninsula	21.06.1994	4,374.00
9.	Dibru-Saikhowa	Assam	East Himalayas	28.07.1997	765.00
10.	DehangDebang	Arunachal Pradesh	East Himalayas	02.09.1998	5,111.50
11.	Kanchanjungha	Sikkim	East Himalayas	07.02.2000	2,619.92
12.	Pachmarhi	Madhya Pradesh	Semi-arid	13.03.1999	4,926.28
13.	Agasthyamalai	Kerala	Western Ghats	12.11.2001#	3,500.36
14.	Achanakamar-Amarkantak	Madhya Pradesh and Chhattishgarh		30.03.2005	3,835.51
15.	Kachchh	Gujarat	Arid	29.01.2008	12,454.00
					74,275.60

Note: *Sites which have been recognized by UNESCO on World Network of Biosphere Reserves.
#Area expended on 30.03.2005

Source: MoEF Annual Report 2007-08.

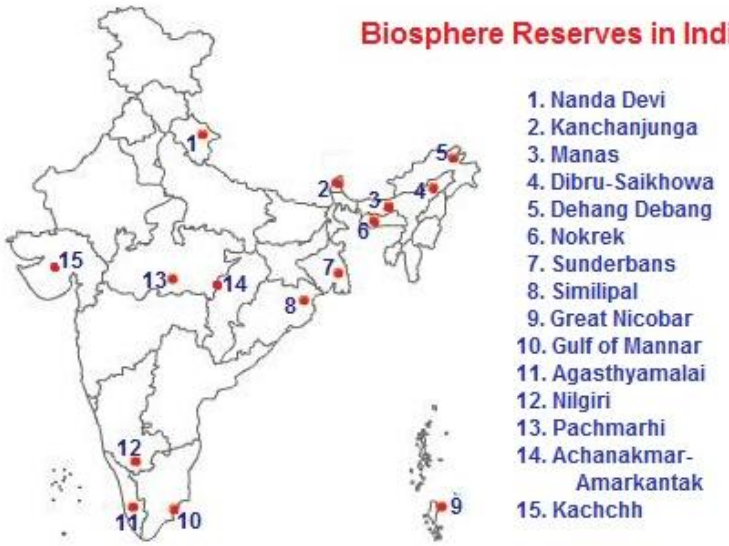

Fig. 2 Map showing the sites of 15 Biosphere Reserves setup in India

The fifteen Biosphere Reserves set up in the country so far not only aim to protect representative ecosystems, but also serve as laboratories for evolving alternative models of development. The Ministry of Environment and Forestry (MoEF) provided financial assistance to the respective State Governments for conservation and management of these Biosphere Reserves. Research and development projects were also supported. Biosphere Reserves of the country qualify the essential criteria i.e. they:

- represent an ecological protectorate,
- occur in a definite biogeographic region,
- contains abundant genetic diversity (India harbor nearly 49,219 plant and 81, 251 animal species),
- have complete structure and size sufficient to ensure efficient conservation,
- have ample opportunities for research in ecology/environment, population, genetics, evolutionary biology, plant-animal interaction, eco-de3velopment, etc., and
- receive adequate long-term legal protection.

Basically the Biosphere Reserve is consisting of two zones (Fig. 3):

(i) **Core zone** forming the *sanctum sanctorum*, and
(ii) **Buffer zone** that concentrically surrounds the core zone.

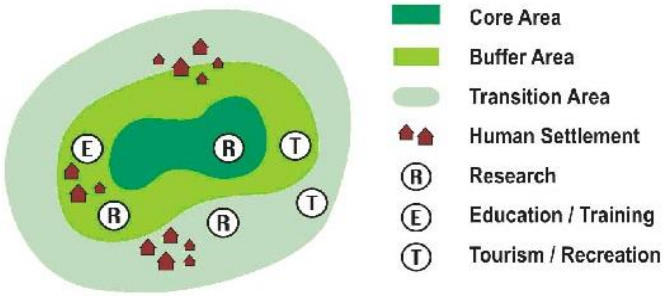

Fig. 3 Structure of a model biosphere reserve

The Biosphere Reserves are constituted on a 'core-buffer strategy'. The core area is kept free of biotic disturbances and forestry operations, where collection of minor forest produce, grazing, human disturbances are not allowed within. However, the buffer zone is managed as a 'multiple use area' with twin objectives of providing habitat supplement to the spillover population of wild animals from the core conservation unit, and to provide site specific eco-developmental inputs to surrounding villages for relieving the impact on the core. No relocation is visualized in the buffer area, and forestry operations, Non-Timber Forest Produce (NTFP) collection and other rights and concessions to the indigenous communities are permitted in a regulated manner to complement the initiatives in the core unit.

Difference between the protected area categories:

Name	Objectives	Features	Zone
National Parks	Conservation of species of a habitat with minimal or very low intensity of human activity.	No human resides in the Park, other than a public servant on duty and permitted persons by the Chief Wild Life Warden.	Core
Sanctuaries	Conservation of species and habitats by manipulative management.	No human resides in the Sanctuary, other than a public servant on duty and permitted persons by the Chief Wild Life Warden.	Core, Buffer and Restoration
Biosphere Reserves	Conservation of the natural resources and for the improvement of the relationship between man and the environment therein.	Both natural and human-influenced ecosystems; substantial human settlements (rural).	Core, Buffer, Restoration and Cultural

5.2.3 Wetlands, Mangroves and Coral Reefs

Wetlands: Several wetlands, mangroves and coral reefs have been identified for conservation and management of specific biodiversity. National Wetland Committee was constituted in 1989. The committee in the same year identified 16 wetlands, which need conservation measures. Recognizing the fundamental ecological function of wetlands and their economic cultural, scientific and recreational value, an international convention (Ramsar Convention) was held of Ramsar, Iron on February 2, 1971 and came into force on December 21, 1975. As of January, 157 nations signed the treaty. The Ramsar convention identified 1708 sites covering around 15,30,000 km^2. This includes 25 wetlands in the country which needs protection. Recently in September 2012, Nalsarovar in Gujrat added into this list as 26th Ramsar site.

Mangroves and Coral Reefs: The National Environmental Policy, 2006 recognizes that mangroves and coral reefs are important coastal environmental resources. They provide habits for marine species, protection from extreme weather events, and a resource base sustainable tourism.

The mangrove cover in the country occupies an area of 4,500 km^2 (0.15% of the geographical area) along the coastal states/UTs (MoEF, 2007-08) an about five percent of the World's mangrove vegetation. To protect and conserve this most fragile ecosystem, Mangrove Conservation Programme was launched in

1987. It has so far identified 38 mangrove areas for intensive conservation and management. West Bengal has maximum of mangrove cover in the country followed by Gujarat and Andman & Nicobar Island. MoEF has established a National Mangrove Genetic Resources Centre in Orissa.

The Indian coral reef area is estimated to be 2,375 km^2. India has four coral reef areas in the Gulf of Mannar, Gulf of Kutchh, Lakshadeep Island and Andaman & Nicobar Island. Their conservation and management is being implemented since 1987. There is a National Coral Reef Research Centre at Port Blair.

Table 5 - The list of Ramsar Sites in India (as of September 24, 2012)

Name	State	Date of Notification	Area (km^2)
Ashtamudi Wetland	Kerala	19/08/02	614
Bhitarkanika Mangroves	Orissa	19/08/02	650
Bhoj Wetland	Madhya Pradesh	19/08/02	32
Chandra Taal	Himachal Pradesh	08/11/05	.49
Chilika Lake	Orissa	01/10/81	1165
Deepor Beel	Assam	19/08/02	40
East Calcutta Wetlands	West Bengal	19/08/02	125
Harike Wetland	Punjab	23/03/90	41
Hokersar Wetland	Jammu and Kashmir	08/11/05	13.75
Kanjli Wetland	Punjab	22/01/02	1.83
Keoladeo National Park	Rajasthan	01/10/81	28.73
Kolleru Lake	Andhra Pradesh	19/08/02	901
Loktak Lake	Manipur	23/03/90	266
Nalsarovar Bird Sanctuary	Gujarat	24/09/12	123
Point Calimere Wildlife and Bird Sanctuary	Tamil Nadu	19/08/02	385
Pong Dam Lake	Himachal Pradesh	19/08/02	156.62
Renuka Wetland	Himachal Pradesh	08/11/05	.2
Ropar	Punjab	22/01/02	13.65
Rudrasagar Lake	Tripura	08/11/05	2.4
Sambhar Lake	Rajasthan	23/03/90	240
Sasthamkotta Lake	Kerala	19/08/02	3.73
Surinsar-Mansar Lakes	Jammu and Kashmir	08/11/05	3.5
Thrissur Kole Wetlands	Kerala	08/11/05	546.25
Tsomoriri	Jammu and Kashmir	19/08/02	120
Upper Ganga River (Brijghat to Narora Stretch)	Uttar Pradesh	08/11/05	265.9
Vembanad-Kol Wetland	Kerala	19/08/02	1512.5
Wular Lake	Jammu and Kashmir	23/03/90	189

Source: http://en.wikipedia.org/wiki/List_of_Ramsar_Sites_in_India

Table 6 – Mangrove areas in India

	West Coast	
1	Gulf of Khambat	Gujarat
2	Gulf of Kutchh	Gujarat
3	Malvan	Maharashtra
4	Vasasi-Manori	Maharashtra
5	Vaitarna	Maharashtra
6	Shrivardhan	Maharashtra
7	Vikroli	Maharashtra
8	Mumbra-Diva	Maharashtra
9	Kundalika-Ravdana	Maharashtra
10	Veldur	Maharashtra
11	Devgarh-Vijay Dur	Maharashtra
12	Achra-Ratnagiri	Maharashtra
13	Karwar	Karnataka
14	Dakshin Kannada /Honnavar	Karnataka
15	Coondapur	Karnataka
16	Vembanad	Kerala

	East Coast	
17	Sunderbans	West Bengal
18	Bhitarkanika	Orissa
19	Mahanadi	Orissa
20	Subernarekha	Orissa
21	Devi	Orissa
22	Dhamra	Orissa
23	Bhitarkanika	Orissa
24	Chilka	Orissa
25	Coringa	Andhra Pradesh
26	East Godavari	Andhra Pradesh
27	Krishna	Andhra Pradesh
28	Pichavaram	Tamil Nadu
29	Muthupet	Tamil Nadu
30	Ramnad	Tamil Nadu
31	Pulicat	Tamil Nadu
32	Kazhuveli	Tamil Nadu
33	North Andamans	Andaman & Nicobar Islands
34	Nicobar	Andaman & Nicobar Islands

Source: http://en.wikipedia.org/wiki/Mangroves_in_India

5.2.4 Endangered Wildlife Special Projects

These special projects have been designated for species specific management of endangered species and their habitats.

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 benefit and enjoyment of the people". The Project has been successfully implemented and under this project, 44 Tiger Reserves have been set up in the country till June 2011, covering an area of over 52,653 km^2 of tiger habitat distributed in 21 states and few more have been proposed..

However, due to intense poaching, there is decline in tiger reserves as well as in wild. For strengthening tiger conservation measures and ensuring anti-poaching activities, National Tiger Conservation Authority and Crime Control Bureau were constituted w.e.f. 04.09.2006 and 06.06.2007, respectively. According to an estimate the number of tigers which was about 4026 in 1989 went down to about 1233 in 2000. Surprisingly no tiger in Sariska is seen since 2004. A survey of numbers of tigers in 2011 revealed that there are about 1706 tigers in India.

The Project Tiger is undisputedly the custodian of major gene pool of the country and a repository of some of the most valuable ecosystems and habitats for wildlife.

Project Elephant: This was launched in 1992 with the aim at ensuring long term survival of identified viable populations of elephant population. There have been drawn lines to restore the lost and degraded habitats of elephant including creation of corridors for their migration, mitigation of man-elephant conflict and establishment of data base on the migration and population dynamics of elephants. It also aims at improving quality of life of people living around elephant habitats through sustainable development. The project is being implemented in 13 states and 30 Elephant reserves have been established.

Gir Lion Project: The Gir forest in Saurashtra peninsula of Gujarat is unique as the only surviving habitat of the Asian lion *Panthera leon persica*. At present in whole of the Asia, this lion is found only in Gir forest of Gujarat. Clearing of forest for agriculture, excessive cattle grazing and other factors led to decline in the lion population.

A five year plan scheme was thus prepared in 1972 by the Govt. of Gujarat for this project. The total area of Gir sanctuary is now 1412,12 km^2. The central core of about 140.40 km^2 was constituted as a National

Park in 1975. In 1978 an additional area of 118.13 km^2 was declared as National Park increasing the area to 258.71 km^2. Ultimately the entire sanctuary was declared as National Park. As a result of this there has been increase in the lion population. In 1968, there were 177 lions in the Gir. This number increases to 180 in 1974.

Crocodile Breeding Project: The project arose from proposal for development of a crocodile farming industry in India and was initiated on 1.4.1974. there are three species of crocodiles in India (i) saltwater or estuarine crocodile (*Crocodylus prosus*) (ii) freshwater, swamp crocodile ir mugger (*C. palustris*), and (iii) gharial (*Gavialis gangeticus*).

Crocodile population decline worldwide in poster period. Crocodile hunting is legally banned in India. Work on project was begun on 1.4.1975 in Orissa. Gharial eggs were hatched for the first time in captivity anywhere in the world at Tikerpada, Distt. Dhenkanal, Orissa in June 1975. A small batch was also hatched at Kurkrail, near Lucknow same year. Crocodile husbandry work was undertaken with a view to sanctuary development. A total of 16 crocodile rearing centers have been developed in the country in eight states (1975-78). Eleven sanctuaries have been declared under the project, two of which among the largest

Gharial rehabilitation began in 1977 with the release of 26 animals in Mahanadi River, Orissa. By 1980, 107 animals had been released in the river where wild population had declined to five.

Rhinos Conservation: The centrally sponsored scheme "Conservation of Rhinos in Assam" was introduced in 1987 and is continued for effective and intensive management of rhino habitats.

Snow-Leopard Project: This is being taken to create 12 snow-leopard reserves throughout the Himalayas.

5.2.5 Preservation plots

Preservation plots are also important for conservation of biological diversity. Preservation plots are areas where chief types of forests are identified for preservation and conservation of biological diversity contained in them. This process was started in India in 1905. At present there are over 309 preservation plots all over the country, 287 in natural forest and 22 in plantation forest.

5.2.6 World Heritage Sites

India ratified the World Heritage Convention in 1977, and since then five natural sites have been taken over as areas of outstanding universal value. These sites are listed in Table below:

Table 7 – World Heritage sites in India

S. No.	Heritage sites	State
1.	Kaziranga national Park	Assam
2.	Keoladeo National Park	Rajasthan
3.	Manas National Park	Assam
4.	Nanda Devi National Park	Uttaranchal
5.	Sunderbans National park	West Bengal

5.2.7 Sacred Forest and Sacred Lakes

There has been a tradition strategy for the preservation of biodiversity in the form of sacred forest in India and many other Asian countries. Sacred forests are the forest in India and many other Asian countries. Sacred forests are the forest patches of varying dimensions protected by the tribal communities on account of their religious sanctity accorded to them. These represent islands of pristine forest i.e. most undisturbed forests with no human impact, and have been free from all disturbances despite they are frequently surrounded by highly degraded lands. Many states in our country, such as Maharashtra, Karnataka, Meghalaya and Kerala, have sacred forests which are serving as a refugia for many endemic, rare and endangered texa. Similarly, some fresh water lakes are also serving the purpose of protection of aquatic flora water lakes are also serving the purpose of protection of aquatic flora and fauna. For example Khecheopalri lake in Sikkim has been declared sacred by the people to save aquatic life from being degraded.

5.3 *Ex situ* Conservation

Ex situ conservation means the conservation of biological diversity components outside their natural habitat. It involves cultivation of rare plants/rearing of threatened animals outside of their natural habitats and also holding of plants and animal species in botanical and zoological gardens, and in arboretums or store them in the form of seeds in seed bank (gene banks) or some other suitable forms by means of tissue cultures techniques. There are a number of tissue cultures techniques. There are a number of plant and animal species, which have become more or less extinct in the wild, but they are being conserved in gardens or zoos, e.g. cheetah (*Acinonyx jubatus).*

Reintroduction of an animal or plant in the habitat from where it has become extinct is another form if ex situ conservation. The great Indian rhinoceros (*Rhinoceros unicornis*) has been reintroduced in the Dudhwa National Park, in an area where it has became extinct. The Gangetic gharial (*Gavialis gangeticus*) is being reintroduced in the rivers of Madhya Pradesh, Uttar Pradesh, and Rajasthan where it has became extinct.

However, because of the prohibitive cost captive breeding should only be restored to when populations are in imminent danger of extinction in the wild. Therefore, priorities in selecting species for captive breeding efforts in zoos need to be carefully established. Some of the steps involved in *ex situ* conservation of animals species include:

- establishing minimum target population goals to provide for maintenance of captive genetic diversity at least for the next 100 years,
- compiling animal husbandry programmes for circulation to all breeding facilities, and
- implement an overall plan that contributes to the objectives of maintaining viable captive populations across the globe.

Reintroduction of the threatened plant species is done in the same way, in the areas from where they have become extinct: rare, endangered and even plants, which are extinct in their natural habitats are cultivated in gardens.

Apart from zoological gardens and captive breeding programmes, the new scientific advances in the case of genetic mapping and manipulation, artificial insemination, embryo transfer, cloning and germplasm

preservation and gene bank can contribute to survival of the rare animals. Some of these *ex situ* conservation methods are as follow:

5.3.1 Zoological Parks

There are roughly 5,00,000 mammals, birds, reptiles and amphibians in captivity in zoos throughout the world. Zoos contribute in many ways to the conservation of biodiversity:

- They propagate and reintroduce endangered species;
- They serve as centers for research to improve management of captive and wild populations; and
- They raise public awareness for biotic improvement.
- They enlighten the public that animals are equally important and are essential for the life support system.

The contributions that zoos have already made to the conservation of biodiversity are dramatic. Zoo populations are now the only representatives of several species including the California conder (*Gymnogypus californianus*) and possibly the Black-footed ferret (*Mustela nigripes*) and at least 18 species have been reintroduced into the wild after captive propagation.

In India first Zoo was set up in Madras in the year 1855, which was soon followed by Trivendrum (1857), Bombay (1863), Calcutta (1875), Jaipur (1876), and Udaipur (1878). After independence a number of zoos were set up. The important ones are Municipal Hill Garden Zoo (Ahmedabad) Delhi Zoologocal Park (Delhi), Himalayan Zoological Park (Darjeeling), Nehru Zoological Park (Hyderabad), Assam State Zoo (Guwahati), Van Vihar (Bhopal), Nandankanan (Bhubneswar), Sakkarbang zoo (Junagarh).

Table 8 – Important Zoos in India

Name	Location
Assam State Zoo-cum-Botanical Garden	Guwahati, Assam
Allen Forest Zoo	Kanpur, Uttar Pradesh
Alipore Zoological Gardens	Kolkata, West Bengal
Nandankanan Zoo	Bhubaneswar, Orissa
Arignar Anna Zoological Park (Vandalur Zoo)	Chennai, Tamil Nadu
Birsa Deer Park (Kalamati Birsa Mrig Vihar)	Ranchi
ChattBir Zoo	Zirakpur, Punjab
Chennai Snake Park Trust	Chennai, Tamil Nadu
Indira Gandhi Zoological Park	Visakhapatnam, Andhra Pradesh
Jawaharlal Nehru Biological Park	Bokaro Steel City
Jaipur Zoo	Jaipur, Rajasthan
Gulab Bagh and Zoo	Udaipur, Rajasthan
Jijamata Udyaan	Mumbai, Maharashtra
Kankaria Zoo,	Ahmedabad, Gujarat
Lucknow Zoo,	Lucknow, Uttar Pradesh
Madras Crocodile Bank Trust	Chennai, Tamil Nadu
Marble Palace zoo	Kolkata, West Bengal
Kanpur Zoo,	Kanpur, Uttar Pradesh
Mysore Zoo,	Mysore, Karnataka
National Zoological Park	Delhi
Nehru Zoological Park	Hyderabad, Andhra Pradesh
Padmaja Naidu Himalayan Zoological Park	Darjeeling, West Bengal
Parassinikkadavu Snake Park	
Ranchi Zoo (Bhagwan Birsa Munda Biological Park), (est. 1987)	Ranchi, Jharkhand
Sakkarbaug Zoological Garden	Junagadh, Gujarat
Sayaji Baug Zoo	Vadodara, Gujarat
Sarthana Zoo	Surat, Gujarat
Sanjay Gandhi Jaivik Udyan	Patna, Bihar
Sipahijola Wildlife Sanctuary	Tripura
Sri Venkateswara Zoological Park	Tirupati, Andhra Pradesh
Rajiv Gandhi Zoological Park	Pune, Maharashtra
Thiruvananthapuram Zoo	Trivandrum, Kerala
Thrissur Zoo	Thrissur, Kerala
Tilyar Zoo	Rohtak
Pt. G.B. Pant High Altitude Zoo	Nainital, Uttarakhand

Source: Central Zoo Authority (CZA). www.*cza.nic.in.* . Retrieved 3 July 2011

In the country, central Zoo authority (CZA) has been created through an amendment of the Wildlife (Protection) Act in 1979. Main functions of the CZA are:

- Specify minimum standards for housing, upkeeping and care of the animals in the zoos,
- Recognition of zoos on the basis of evaluation of their functioning,
- Identify endangered species of wild animals for the purpose of captive breeding and assigning responsibilities in this regards to zoos,
- Co-ordinate the acquisition, exchange and loading of animals for breeding, and
- Provide technical and other assistance to zoos for management and development on scientific lines.

Rescue Centres

Ministry of Environment and Forests has assigned the responsibility to Central Zoo Authority for creation of rescue centres, for rehabilitation of circus animals, consequent upon ban on performance of wild animals in Circuses. Five rescue centers were identified for creation at Chennai, Visakhapatnam, Tirupati, Bannerghatta (Bangalore) and Nahargarh (Jaipur). All the five rescue centers have already been established and are functional. A total of 179 lions, 33 tigers, 18 bears, 8 panthers, and 11 monkeys have been rescued from circuses and are now being housed in these centres. The Central Zoo Authority has released Rs. 186.10 lakhs towards establishment of rescue centres and feeding and health care for these animals.

5.3.2 Aquaria

The role of aquaria in the captive propagation of threatened freshwater species is significant. Accordingly, the captive Breeding Specialist Group of the World Conservation Union (IUCN) is mounting a major effort to develop captive breeding programmes for endangered fish species, starting from the lake Victoria, the desert fishes of North America, and Appalachian stream fishes. The programme shall also include the restoration of natural habitats, provides protection against loss of wild restoration of natural habitats, provides protection against loss of wild species and help educate the public on threats to fishes.

Table 9 - Important aquaria in India

Name	Location
Star aquarium	Karunagappally Kollam Kerala
Kollam Aquarium	Kollam Kerala
Travancore Royal Aquarium	Shangumukham Beach Trivandrum Kerala
Bangalore Aquarium	Bangalore
Calcutta Aquarium	Calcutta
Kankaria Aquarium	Ahmedabad
Lal Bagh aquarium	Bangalore
Marine Life Aquarium	Chennai
Marine Biological Research Station	Ratnagiri
Matsyadarsini Aquarium	Visakhapatnam
Sanjay Gandhi jaivik udhan	Patna
Taraporewala Aquarium	Mumbai
CIFA Aquarium	Bhubaneswar, Orissa
Nandankanan Zoo Aquarium	Bhubaneswar, Orissa

Source: http://en.wikipedia.org/wiki/List_of_aquaria_in_India

5.3.3 Botanical Gardens

There are more than 2000 botanical gardens in over 150 countries; together they maintain 6 million accessions in their living collections and 142 million herbaria specimens. The Royal Botanical Gardens of England (Kew Gardens) alone contain an estimated 25,000 species of plants (10 percent of the world's flora); and IUCN considers some 2,700 of these species rare, threatened, or endangered. For specific texa, the coverage afforded by the botanical gardens is even higher. About 300 to 400 of the world's botanical gardens harbor major conservation collections and 250 of these maintain seed banks. By these means, it is possible to save viable population of up to 20,000 plants species from extinction.

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 IUCN Botanical Garden Conservation Secretariat is now developing a computer data base of species occurrences in botanic gardens to help gardens collect species that are absent or underrepresented in captivity. The efforts of botanic gardens in germplasm conservation are being co-ordinating with the IUCN Botanical Garden Conservation Strategy. In association with the International Board for Plant Genetic Resources (IBPGR), IUCN is also putting together guidelines for collecting germplasm of wild species.

Table 10 – Important Botanical Gardens in India

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
IFGTB Botanical Garden – The Institute of Forest Genetics and Tree Breeding (IFGTB),	Coimbatore, Tamil Nadu
Jammu and Kashmir Medicinal Plants Introduction Centre,	Sonamarag, Kashmir
Jawaharlal Nehru Tropical Botanic Garden and Research Institute (TBGRI), (Biggest in India and conserves the largest no:of plant species in Asia).	Trivandrum, Kerala
Jhansi Botanical Garden,	Jhansi, Uttar Pradesh
Lalbagh,	Bangalore, 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,	Ahmedabad, Gujarat
Vellayani Agricultural College,	Trivandrum, Kerala
The Garça Branca Ayurvedic Botanical Garden,	Loutolim, Goa.

Source: http://en.wikipedia.org/wiki/Botanical_Gardns_in_India

5.3.4 Gene Banks

A gene bank is a facility/institution where valuable plant materials likely to become irretrievably lost in the wild or in cultivation can be preserved in viable condition. Gene banks conserve stocks of both seeds

and vegetative plant parts. The seeds of many species can be stored in dry, low temperature, vacuum containers. Storage at extremely low temperature, below -196 ºC may extend the life of some of these species to more than a centaury (cryopreservation). The stored germplasm not only safeguards the species threatened but I also utilized actively by the plant scientists and breeders to develop novel verities as desired. The technique is efficient, reproducible, and feasible for short, medium and long-term storage.

In a generalized way - a gene bank is temperature-controlled storage unit – essentially a giant ice box – which is meant to preserve biodiversity in the form of seeds, sperms, ovule, tissue culture, pollen and even DNA. The important repositories in India are:

Table 11 – Indian Repositories

SL. NO.	NAME OF THE INSTITUTIONS	CATEGORY OF BIOLOGICAL RESOURCES	Web Link
1.	Botanical Survey of India, Kolkata	Flora (Angiosperms, Gymnosperms, Pteridophytes, Bryophytes, Lichens, Macrofungi, Macroalgae)	http://164.100.52.111/
2.	National Bureau of Plant Genetic Resources, New Delhi	Plant Genetic Resource	http://www.nbpgr.ernet.in/
3.	National Botanical Research Institute, Lucknow	Flora (Angiosperms, Gymnosperms, Pteridophytes, Bryophytes, Lichens, Macrofungi, Macroalgae)	http://www.nbri.res.in/#
4.	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)	http://www.icfre.org/ http://ifgtb.icfre.gov.in/ http://tfri.icfre.gov.in/
5.	Zoological Survey of India, Kolkata	Fauna	http://zsi.gov.in/
6.	National Bureau of Animal Genetic Resources, Karnal, Haryana	Genetic resources of domestic animals	http://www.nbagr.res.in/
7.	National Bureau of Fish Genetic Resources, Lucknow	Fish genetic resources	http://www.nbfgr.res.in/
8.	National Institute of Oceanography, Goa	Marine flora and fauna	http://www.nio.org/
9.	Wildlife Institute of India, Dehradun	Faunal resources in protected Areas	www.wii.gov.in
10.	National Bureau of Agriculturally Important Micro-organisms, Mau Nathan Bhanjan, UP	Agriculturally important micro-organisms	http://www.nbaim.org.in/
11.	Institute of Microbial Technology, Chandigarh	Microorganisms	http://www.imtech.res.in/
12.	National Institute of virology, Pune	Viruses	http://www.niv.co.in/
13.	Indian Agricultural Research Institute, New Delhi	Microbes/Fungi	http://www.iari.res.in/
14.	National Bureau of Agriculturally important insects , Bangalore	Insects	http://www.nbaii.res.in/

5.3.5 Pollen/Semen Conservation

Preservation of pollen and spores is of significant value for conservation of biodiversity of important flowering and spore bearing plants. The procedure for institution of pollen and spore banks is almost similar to that of gene banks. Cryogenic technique is useful in preserving pollen from flowering or cone bearing plants, and spores from non-flowering plants, such as ferns and mosses. Pollens preservation is thus advantageous over seeds preservation, as it gives opportunity to preserve the full range of variation within the population in a very simple manner

Pollen grains can be stored under appropriate condition allowing subsequent use for crossing with living plants materials. Stored semen can also used for artificial insemination in animals. A pollen bank can be an extremely powerful tool in plant breeding since it frees breeders from the tyranny of time. Also, it is useful in selfsterilised plant species.

5.3.6 Tissue Culture Technique

Tissue culture technique becomes necessary under the following conditions:

- If a specific genetic type (clone) is to be conserved and maintained;
- If the seeds progeny are highly variable;
- If plants have recalcitrant seeds; or
- If the seeds are altogether lacking, such as those of sugarcane, banana, arvi etc.

Shoot tips are preferred materials for conservation as they are more stable, easier to regenerate into whole plants, and produce virus free clonal plants. Shoot tips are also convenient materials for international exchange of germplasm.

Tissue culture technique for preserving germplasm has another advantage in that a large number of genotypes can be stored in a relatively small area in culture vessels and generally at a fraction of cost of growing and maintaining large living collections in the field. More importantly, tissue culture provides a means of multiplying “endangered species” with possibility of reintroducing them into their original habitats where they are becoming rare.

Through tissue culture technique it is now also possible to preserve animal cells, spermatozoa, ovarian and embryonic tissues as well as whole animals embryos under extremely low temperature in liquid nitrogen at -196 ºC (cryopreservation). These cultures can be used for livestock breeding programmes.

5.3.7 Recombinant DNA Technology

The recombinant DNA technology allows us to clone any DNA in *Escherichia coli,* and soon it will hopefully be possible to extend such cloning to yeast and other organisms. Cloned DNA, therefore, appears to be an attractive candidate for genetic conservation. In addition to cloned genes, the entire genomic DNA of plant population can be preserved. Recombinant DNA technology has still another novel advantage in that it can make use of genes of plant material that has lost viability. From DNA libraries of such material, a relevant gene or gene combination can be retrieved and put to use.

6. Efforts of an Individual to Conserve Snakes and Crocodiles

With the ban on snakeskin's trade, Irulas, expert snake catchers in Tamil Nadu, lost their livelihood. At that time Romulus Whitaker, entered their lives and helped them to set up Irula Cooperative Society for extracting snake venom and selling it to the institutes and organizations that make lifesaving anti-venom, a win-win formula stopping killing of the snakes and deriving profit. Romulus Whitaker came to India at the age of & bestowed with hi natural affinity for snakes and infect for all wildlife. During his school days at Kodaikanal he used to wander Palani Hills to pick up kill to deal with wildlife. Later he learnt snake catching from Irulas and crocodile catching from Papua New Guinea. In 1972, he along with hi friends set up Madras Snake Park which is today on the must see lit of tourist to Chennai. Park has 31 species if Indian snakes, all three species of Indian crocodiles, four species of exotic crocodiles, three species of Indian turtles and five species of lizards. Many species of reptiles, including endangered species of Indian python is subjected to captive breeding. He has also established a Crocodile bank – the gene bank for crocodile. Snake park is of great educational, scientific and conservation value. Whitaker's life and work throws light on that a single individual can make a significant contribution to the conservation of biodiversity through passion and dedication.

CONCLUSIONS

It is imperative that the phenomenon of biodiversity is very vast, complex and interdependent and there is no single over-arching effect of diversity on either productivity or stability. The realized effects will depend heavily on environmental context and the time scale over which the effects are studied. However, it has become obvious that biodiversity is indeed important for both managed and natural ecosystems, though the relative contributions of diversity and composition remain unclear. It is therefore necessary for legislators to understand the basic science in order to maintain diversity at its current levels. If current human growth and resource management patterns do not change, it is likely that we will lose many important species, and the ecosystems of the world may never recover. In present paper the various conservation strategies by government, voluntary organizations, public participation as well as the individual efforts have been discussed, that how they commutatively plays a major role for the conservation of the biodiversity.

Human is only one more of natural creatures and should not be alien to the other life-forms. We have no moral right to destroy nature and other beings that dwell on earth. We should treat all animals and plants with compassion. Every individual can make a small and yet significant effort in the race to save our planet and conserve biodiversity.

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