Biodiversity

Biodiversity, short for **biological diversity**, refers to the sum total of all the variety and variability of life in a defined area. In contrast to the more specific term *species diversity*, the term *biodiversity* was coined to emphasize the many complex kinds of variations that exist within and among organisms at different levels of organization. It refers to the totality of genes, species and ecosystems of a region. United Nations Earth Summit defined biological diversity as:

'*Biological diversity means the variability among living organisms from all sources including, inter alia (among other things), terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems*.'

Convention on Biological Diversity, 1992

2.1 Levels of biodiversity

Biodiversity includes three hierarchical levels: Genetic, species and ecosystem diversity

Genetic diversity

Genetic diversity refers to the variation of genes within a species. The genetic diversity enables the population to adapt to its environment and respond to natural selection. The amount of genetic variation is the basis of speciation. It has a key role in the maintenance of diversity at the species and community levels. Genetic diversity within a species often increases with environmental variability.

Species diversity

Species diversity refers to the variety of species within a region. The simplest measure of species diversity is species richness, i.e. the number of species present in per unit area. Generally, the greater the species richness, the greater is the species diversity. Number of individuals among the species may also vary, resulting into differences in evenness, or equitability and consequently in diversity.

Species richness and evenness

Species richness is only one aspect of diversity. Not all species exist in equal numbers: some are rare, some are common but not numerous, and others are very abundant. Imagine two forests, both of which contain a total of 100 individuals belonging to 5 different species. In one

forest, there are 20 individuals of each species. In the other, one species has 60 individuals, while each of the other four species has 10 individuals. These two samples differ in a property called evenness. The first, in which the species are represented by the same number of individuals, is more even, and thus, has high overall species diversity. Thus, the species diversity of a community depends on both its richness as well as evenness: higher species numbers, with the individuals more evenly distributed among them, contribute to higher community diversity.

Ecosystem diversity

Ecosystems include all the species, plus all the abiotic factors characteristic of a region. For example, a desert ecosystem has soil, temperature, rainfall patterns, and solar radiation that affect not only what species occur there, but also the morphology, behaviour and the interactions among those species. Ecosystem diversity describes the number of niches, trophic levels and various ecological processes that sustain energy flow, food webs and the recycling of nutrients.

2.2 Gradients and Magnitude of biodiversity

Gradients of biodiversity

Biodiversity varies with changes in latitude or altitude. As we move from the poles to the equator, the biodiversity increases, and vice versa. The increase in species richness or biodiversity that occurs from the poles to the tropics often referred to as the latitudinal gradient in species diversity, is one of the most widely recognized patterns in ecology.

In general, species diversity decreases as we move away from the equator towards the poles. With very few exceptions, tropics (latitudinal range of 23.5° N to 23.5° S) harbour more species than temperate or polar areas. For example, Colombia located near the equator has nearly 1,400 species of birds while New York at 41° N has about 105 species and Greenland at 71° N only about 56 species. India, with much of its land area in the tropical latitudes, has more than 1,200 species of birds. The tropical Amazon rain forest in South America has the greatest biodiversity on the Earth – it is home to more than 40,000 species of plants.

Whittaker (1972) described three terms for measuring biodiversity over spatial scales: alpha, beta and gamma diversity. **Alpha diversity** refers to the diversity within a particular habitat or ecosystem (within-habitat diversity). It is expressed as the number of species per unit area. If we compare the species diversity between two habitats or ecosystems then it is called **beta diversity** (between-habitat diversity). **Gamma diversity** is the total species diversity in a landscape (regional diversity).

Just like latitudinal variation, altitudinal variation also causes changes in the biodiversity. A decrease in species diversity occurs from lower to higher altitudes on a mountain. A 1000 m increase in altitude results in a temperature drop of about 6.5°C. The drop in temperature and greater seasonal variability at higher altitudes are major factors that reduce biodiversity.

Magnitude of biodiversity

The total number of species on the Earth described so far is about 1.6 million. There are many more species that have not yet been described. Current estimates of the total number of species range from 2 million to 10 million. The known species are unevenly distributed across taxonomic group. More than 70 percent of all the species recorded are animals, while plants (including algae, fungi) comprise no more than 22 percent of the total. Among animals, insects are the most species-rich taxonomic group, making up more than 70 percent of the total. The table given below describes the approximate numbers of species on the Earth.

Table 2.1 Approximate numbers of named species on the Earth

Group	*Number of named species*
Mammals	4650
Birds	9700
Reptiles	7150
Fishes	26959
Amphibians	4780
Insects	1025000
Vascular plants	270000
Algae	40000
Protozoans	40000

Source: Gibbs, W. W. 2001. On the termination of species. Scientific American, 285: 40-49.

Biodiversity of India

India is a megadiversity nation. A *megadiverse nation* is one that harbors the majority of the Earth's species and is therefore considered extremely biodiverse. To qualify as a megadiverse country, a country must:

- Have at least 5000 of the world's plants as endemics.

  The principle criterion to be a megadiverse country is *endemism*, first at the species level and then at higher taxonomic levels such as genus and family.
- Have marine ecosystems within its borders.

Till now, 17 countries have been identified as the megadiverse countries of the world, with a particular focus on endemic biodiversity. The identified megadiverse countries are: United States of America, Mexico, Colombia, Ecuador, Peru, Venezuela, Brazil, Democratic Republic of Congo, South Africa, Madagascar, India, Malaysia, Indonesia, Philippines, Papua New Guinea, China and Australia.

India constitutes only 2.4% of the world's land area but having 11% of flora and 6.5% of the fauna of the world. India contains 172, or 2.9%, of IUCN-designated threatened species. India has 350 species of mammals, 1,200 species of birds, 453 species of reptiles (fifth in the world) and 45,000 plant species, of which most are angiosperms. It is estimated that 18% of Indian plants are endemic to the country. Four of 35 globally identified biodiversity hotspots: The Himalayas, the Western Ghats, the North-East, and the Nicobar Islands, are present in India.

2.3 Uses of biodiversity

At the ecosystem level, biodiversity provides the conditions to drive the processes that sustain the global economy – and our survival as a species. The benefits and services provided by ecosystems include:

Ecosystem services

Biodiversity is essential for the maintenance of ecosystem services and their sustainable utilization. These services include maintenance of gaseous composition of the atmosphere, climate control by forests and oceanic systems, natural pest control, pollination of plants by insects and birds, formation and protection of soil, conservation and purification of water and nutrient cycling etc.

Prevention and mitigation of natural disasters

Forests and grasslands protect landscapes against erosion, nutrient loss, and landslides through the binding action of roots. Ecosystems bordering regularly flooding rivers (floodplain forests and wetlands) help to absorb excess water and thus, reduce the damage caused by floods.

Source of economically important products

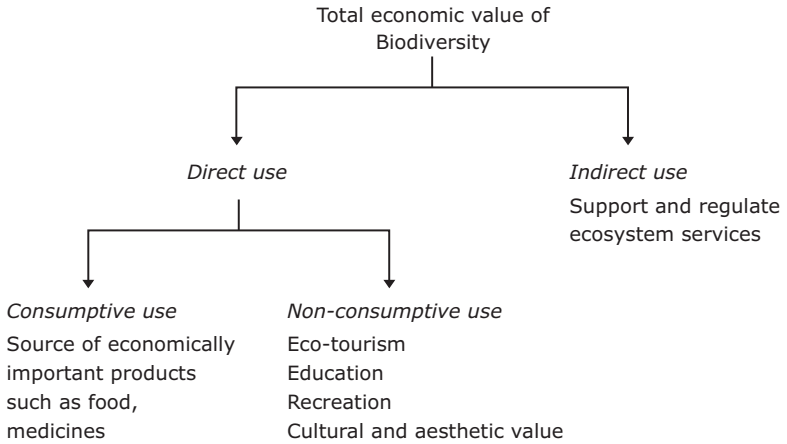
Food: About 150 crops feed most of the human population at present, but just 12 of them provide about 80% of food energy (with wheat, rice, maize and potato alone providing about 60%). Also, about 30 mammalian and bird species are used extensively, but just 15 of them account for over 90 percent of global livestock production. Biodiversity increases the range of food products suitable for human consumption. Wild biodiversity provides a wide variety of important foodstuffs, including fruits, meats, nuts, mushrooms, honey, spices and flavourings. These wild foods are especially important when agricultural supplies fail. Indeed, wild biodiversity guards against the failure of even the most advanced agricultural systems. For example, the productivity of many of the developed world's agricultural crops is maintained through the regular assimilation of new genes from wild relatives of these crops. These wild genes offer resistance to the pests and diseases that pose an ever-evolving threat to harvests.

Medicines: Biodiversity is also a rich source of substances with therapeutic properties like morphine (used as an analgesic), quinine (used for the treatment of malaria) and taxol (an anticancer drug). A significant proportion of drugs are derived, directly or indirectly, from biological sources. Moreover, only a small proportion of the total diversity of organisms has been thoroughly investigated for potential sources of new drugs.

Industrial materials: A wide range of industrial materials are derived directly from biological resources. These include building materials, fibers, dyes, resins, gums, adhesives, rubber and oil. There is enormous potential of obtaining economically important materials from a wider diversity of organisms.

Aesthetic and cultural benefits

Biodiversity has also great aesthetic value. Aesthetic aspects include ecotourism, bird–watching, wildlife, pet keeping, gardening etc. The beauty of nature is something many people are enthralled by. There is something within the natural environment which people really connect to, and gives them an immense sense of satisfaction when they experience nature. For some, there are cultural or spiritual meanings attached to the landscape, whereas for others it is simply the aesthetic quality of the natural environment which they enjoy so much.



Consequences of biodiversity loss

There is considerable evidence that contemporary biodiversity decline will lead to subsequent decline in the functioning and stability of ecosystem. Biodiversity experiments have tested whether biodiversity declines will influence ecosystem functioning or stability by manipulating some component of biodiversity, such as the number of species, and measuring various types of ecosystem functioning or stability. These studies have been conducted in lab, grassland, forest, marine and freshwater ecosystems. From these studies, it is clear that ecosystem functioning often depends on species richness, species composition and also on species evenness and genetic diversity. Furthermore, stability often depends on species richness and species composition. Thus, contemporary changes in biodiversity will likely lead to subsequent changes in ecosystem properties. Further investigation at larger spatiotemporal scales in managed ecosystems is needed to improve our understanding of the consequences of biodiversity declines.

2.4 Threats to biodiversity

The most obvious manifestation of biodiversity loss is the extinction of species. This is a natural phenomenon: species have been going extinct since life began. Indeed, it is estimated that many more species have gone extinct than exist at present. What's worrying is the rate at which species are currently dying out. Since the total number of species on the Earth can only be estimated, the exact rate of current species loss is difficult to gauge. Working from the conservative estimate that the Earth is home to 10 million species in all, it is estimated that between 0.2 and 0.6 percent of species are being lost every year. This rate is at least 10,000 times greater than the 'background' or natural rate of species extinction, as estimated using the fossil record. The main causes of biodiversity loss are considered under the following headings:

Habitat loss and fragmentation

Habitat means the place or type of site where an organism or population naturally occurs. When a natural habitat, such as a forest or wetland, is altered so dramatically that it no longer supports the species it originally sustained. Plant and animal populations are destroyed or displaced, leading to a loss of biodiversity. It is called *habitat loss* or *habitat destruction*. Habitat destruction is different from *habitat degradation*. According to IUCN, a decline in species-specific habitat quality that leads to reduced survival and/or reproductive success in a population is called habitat degradation. *Habitat fragmentation* is the 'breaking apart' of continuous habitat into distinct pieces. The loss of habitats is the primary reason for the loss of biodiversity. When people cut down trees, fill a wetland, plough grassland or burn a forest, the natural habitat of a species is changed or destroyed. These changes can kill or force out many plants, animals and microorganisms as well as disrupt complex interactions among the species. With the fragmentation of a large forest tract, species occupying deeper parts of forest are the first to disappear.

Introduction of invasive species

An invasive species (also called *introduced, exotic, non-native*) can be any kind of living organism that is not native to an ecosystem and which has a tendency to damage the ecosystem. Common characteristics of invasive species include rapid reproduction and growth, high dispersal ability, phenotypic plasticity (ability to adapt physiologically to new conditions) and ability to survive on various food types and in a wide range of environmental conditions. These

Native species
A species or lower taxon living within its natural range (past or present) including the area which it can reach and occupy using its natural dispersal systems.
Indigenous species is equivalent to native species.
Source: Convention on Biological Diversity (CBD).

Endemic species
Any species whose range is restricted to a limited geographical area.

species grow and reproduce quickly, and spread aggressively, with potential to cause harm. Invasive species are capable of causing extinctions of native plants and animals by competing with them for limited resources and altering habitats. Thus, leading to loss of biodiversity.

The sudden introduction of invasive species to a given ecosystem (especially on islands and in freshwater habitats) causes disastrous consequences for native species. Such introductions are usually the result of human activities. The accidental introduction of an Atlantic comb jellyfish species to the Black Sea is a well-known example. These invaders have out-competed native fauna, and now comprise some 95 percent of the Black Sea's total biomass. In the US, meanwhile, the introduction of exotic species has been implicated in close to 70 percent of the past century's freshwater fish extinctions.

Overexploitation

The term *overexploitation* refers to the human activities connected with excessive capturing and harvesting (hunting, fishing, farming) of organisms. According to IUCN, it is an exploitation of (removal of individuals or biomass from) a natural population at a rate greater than the population is able to match with its own recruitment, thus tending to drive the population towards extinction. Overexploitation of a particular species reduces the size of its population to an extent that it becomes vulnerable to extinction. The decline of the Earth's largest terrestrial animal, the African elephant, is a classic example of the impact of overhunting. Largely because of the trade in ivory, elephant populations have been declining in most of Africa.

Climate change and pollution

The link between climate change and biodiversity has long been established. Although throughout Earth's history the climate has always changed but rapid climate change due to man made activities affects species ability to adapt and so biodiversity loss increases. In addition to global warming, more frequent extreme weather and changing patterns of rainfall and drought have significant impacts on biodiversity. Some species may benefit from rapid climate change but most species will not find it as beneficial as they will not be able to adapt.

2.5 Extinction of species

Extinction is a natural process. Extinction (the complete disappearance of a species from Earth) is an important part of the evolution of life on Earth. The current diversity of species is a product of the processes of extinction and speciation operating throughout the previous 3.8 billion years of life. It is assumed that between 5 and 50 billion species have lived at some time during the history of the Earth. Therefore, 99.9% of all the life that has existed is now extinct. However, extinction has not occurred at a constant pace through the Earth's history and also not same for all species. There are three types of extinction processes:

Natural extinction

With the change in environmental condition, some species disappear and others, which are more adapted to the changed conditions, replace them.

Mass extinction

There have been several periods in the Earth's geological history when a large number of species became extinct because of catastrophes. In Earth's history, two most important mass extinctions happened at the end of the Permian and the second at the end of the Cretaceous.

The end-Permian mass extinction is the biggest in history, with more than 80% of species going extinct. In the Cretaceous-Tertiary mass extinction, at least half of species went extinct. Asteroidal collisions, volcanic eruption, climatic cooling, sea level changes and changes in habitat area caused by plate-tectonic movements are the five potentially general theories of mass extinction. Large concentrations of the rare Earth element iridium at the Cretaceous – Tertiary boundary rocks in Italy, suggested that the Cretaceous – Tertiary mass extinction may have been caused by the collision of an asteroid.

Anthropogenic extinction

This man-made extinction represents a very severe depletion of biodiversity, particularly because it is occurring within a short period of time. Based on a rough estimate, the pace at which species vanish—accelerated during the past 100 years to roughly 1,000 times of what it was before humans showed up.

Susceptibility to extinction

Susceptibility to extinction is not same for all species. Some species are more susceptible to extinction than others. The susceptibility of species to extinction is related to various life history characteristics that influence the species' vulnerability to human activities as well as natural catastrophes.

A species with a geographically widespread distribution is referred to as ubiquitous, whereas a species found to occur naturally in a single geographic area and no place else is said to be endemic to that location. Endemic species are particularly susceptible to extinction because a loss of habitat in the one geographic region will result in a complete loss of habitat for the species. In general, the species with following characteristics are more susceptible to extinction.

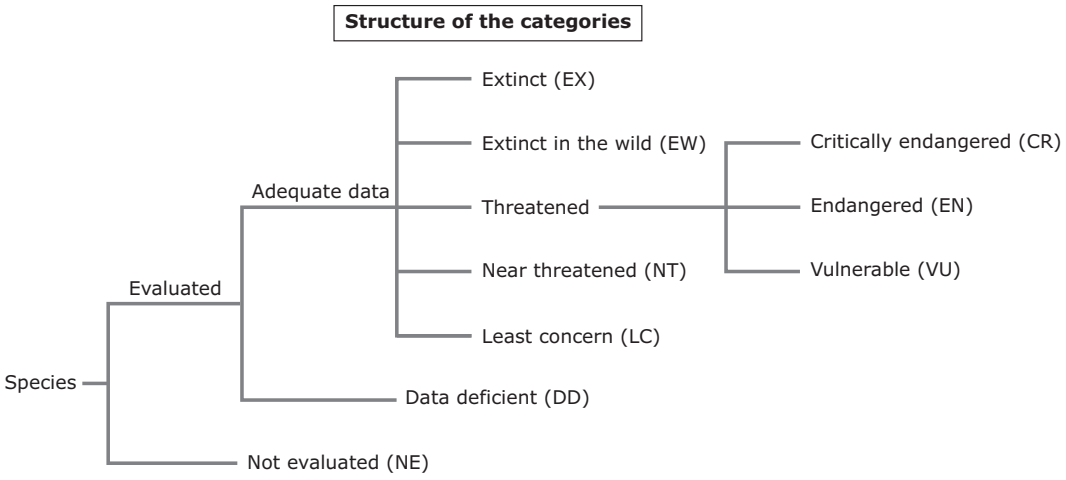
- Large body size,
- Small population size,
- Low reproductive rate,
- Feeding at high trophic levels in the food chain,
- Fixed migratory routes,
- Narrow range of distribution,
- High specialization,
- Poor dispersal rate.

The International Union for Conservation of Nature (**IUCN**) is an international organization working in the field of nature conservation and sustainable use of natural resources. IUCN was established in 1948. It was previously called the International Union for Protection of Nature (1948–1956) and the World Conservation Union (1990–2008). Its headquarters are in Gland, Switzerland. India became a State Member of IUCN in 1969, through the Ministry of Environment, Forest and Climate Change.

2.6 IUCN Red List categories and criteria

The International Union for the Conservation of Nature and natural resources (IUCN) is an organization working in the field of nature conservation and sustainable use of natural resources. The IUCN Red List categories and criteria are clearly defined system for classifying species which are at high risk of global extinction. It is based upon precise criteria to evaluate the risk of extinction of thousands of species and subspecies. Species are classified by the IUCN Red List into nine groups based on criteria such as rate of decline, population size, area of geographic distribution, and degree of population distribution and fragmentation.

Data deficient
A category on the IUCN Red List which indicates there is inadequate information to make a direct, or indirect, assessment of a taxon's risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking.
IUCN 2012



Extinct

A species is extinct when there is no reasonable doubt that the last individual has died. Example: Dodo and Passenger pigeon.

Extinct in the wild

Only survives in cultivation (plants) or in captivity (animals). Examples: Alagoas curassow.

Threatened species

For categorization of threatened species – *critically endangered*, *endangered* and *vulnerable* – there is a range of quantitative criteria; meeting any one of these criteria qualifies a species for listing at that level of threat. Each species should be evaluated against all the criteria. Even though some criteria will be inappropriate for certain species. The relevant factor is whether any one criterion is met or all are met. Because it will never be clear in advance which criteria are appropriate for a particular species, each species should be evaluated against all the criteria.

Of the 47,677 species in the International Union for Conservation of Nature (IUCN) Red List of Threatened Species of 2009, 17,291 are deemed to be at serious risk. The list reveals that 21 percent of all known mammals, 30 percent of all known amphibians, 12 percent of all known birds, 28 percent of reptiles, 37 percent of freshwater fishes, 70 percent of plants and 35 percent of invertebrates assessed so far, are under threat.

Critically endangered

A species is critically endangered when it is facing an extremely high risk of extinction in the wild in the immediate future. To be defined as critically endangered, a species must meet any of the following criteria.

- Population reduction: ≥80-90% population decline
- Geographic range
  Extent of occurrence: <100 km^2
  Area of occupancy: <10 km^2
- Population size: <250 mature individuals
- Extinction probability (in the wild): at least 50% within 10 years or 3 generations.

Example: Gharial, Great Indian bustard, Ganges shark, Pygmy hog.

Reduction of population size causes loss of genetic diversity due to loss of some alleles from the species. It also increases the chance of inbreeding and homozygosity. Increased homozygosity increases mortality of young, and inbreeding depression leads to reduced offspring fitness.

Table 2.2 Numbers of threatened species by major groups of organisms (1996–2017).

	Estimated Number of described species	Number of species evaluated by 2017 (IUCN Red List version 2017-1)	Number of threatened species* in 1996/98	Number of threatened species* in 2017 (IUCN Red List version 2017-1)
Vertebrates				
Mammals	5,560	5,560	1,096	1,194
Birds	11,121	11,121	1,107	1,460
Reptiles	10,450	5,473	253	1,090
Amphibians	7,635	6,533	124	2,067
Fishes	33,500	16,134	734	2,359
Subtotal	*68,266*	*44,821*	*3,314*	*8,170*
Invertebrates				
Insects	1,000,000	6,912	537	1,298
Molluscs	85,000	7,276	920	1,984
Crustaceans	47,000	3,177	407	732
Corals	2,175	864	1	237
Arachnids	102,248	249	11	170
Velvet Worms	165	11	6	9
Horseshoe Crabs	4	4	0	1
Others	68,658	625	9	122
Subtotal	*1,305,250*	*19,118*	*1,891*	*4,553*
Plants				
Mosses	16,236	102	–	76
Ferns and Allies	12,000	417	–	217
Gymnosperms	1,052	1,011	142	400
Flowering Plants	268,000	20,725	5,186	10,972
Green Algae	6,050	13	–	0
Red Algae	7,104	58	–	9
Subtotal	*310,442*	*22,326*	*5,328*	*11,674*
Fungi and Protists				
Lichens	17,000	8	–	7
Mushrooms	31,496	25	–	21
Brown algae	3,784	15	–	6
Subtotal	52,280	48	–	34
Total	**1,736,238**	**86,313**	**10,533**	**24,431**

* Threatened species are those listed as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU).

Changes in number of threatened species from year to year should not be directly interpreted as trends in the status of biodiversity. The figures displayed above reflect increased assessment efforts by IUCN and its Partners over time, rather than genuine changes in numbers of threatened species. For a clearer view of genuine trends in the status of biodiversity please refer to the IUCN Red List Index.

Endangered

A species, whose numbers are so small that the species is at risk of extinction. To be defined as endangered, a species must meet any of the following criteria.

- Population reduction: 50-70% population decline
- Geographic range

  Extent of occurrence: <5,000 km^2

  Area of occupancy: <500 km^2
- Population size: <2,500 mature individuals
- Extinction probability (in the wild): at least 20% within 20 years or 5 generations.

Example: Red panda, Snow leopard, Bengal Tiger and One horned rhinoceros and Black buck.

Vulnerable

A species is vulnerable when it is not critically endangered or endangered, but is facing a high risk of becoming endangered in the near future.

- Population reduction: ≥30-50% population decline
- Geographic range

  Extent of occurrence: <20,000 km^2

  Area of occupancy: <2,000 km^2
- Population size: <10,000 mature individuals
- Extinction probability (in the wild): at least 10% within 100 years.

Near threatened

A category on the IUCN Red List of threatened species which indicates that a taxon has been evaluated against the Red List criteria does not qualify for critically endangered, endangered and vulnerable status now but it is close to qualify or likely to qualify for a threatened category in the near future.

Least concern

A category on the IUCN Red List which indicates that a taxon has been evaluated against the Red List criteria and does not qualify for critically endangered, endangered, vulnerable or near threatened. Widespread and abundant taxa are included in this category.

IUCN Red List of threatened species

The IUCN Red List of threatened species is the world's most comprehensive inventory of the global conservation status of plant and animal species. It uses a set of criteria to evaluate the extinction risk of thousands of species and subspecies. These criteria are relevant to all species and all regions of the world.

It is based on an objective system for assessing the risk of extinction of a species based on past, present and projected threats. Species assessments are conducted following a standardized process using the rigorous *IUCN Red List categories* and *criteria*, ensuring the highest standards of scientific documentation, information management, expert review, and justification. There are eight IUCN Red List categories based on criteria linked to population trend, size and structure and geographic range. Species listed as critically endangered, endangered or vulnerable are collectively described as threatened.

2.7 Conservation of biodiversity

Biodiversity is a source of significant economic, aesthetic, health and cultural benefits which form the foundation for sustainable development. However, there is general scientific consensus that the world is rapidly becoming less biologically diverse in terms of genes, species and ecosystems. The reason for this is clearly anthropogenic. The scale of human impact on biological diversity has been increasing exponentially primarily because of world-wide patterns of consumption, production, trade; agricultural, industrial and settlement development; and human population growth.

Neither the economic nor the ecosystem value of biodiversity is as yet well understood. In particular, there is insufficient knowledge of the interdependence of species within ecosystems and the impact of the extinction of one species on others. Hence, reducing the rate of biodiversity loss and conserving still existing biodiversity as the basis of sustainable development remains a major global challenge.

Conservation is the protection, preservation, management or restoration of wildlife and natural resources such as forests and water. Through the conservation of biodiversity, the survival of many species and habitats which are threatened due to human activities can be ensured.

'*Conservation of biodiversity is an active management of the biosphere to ensure the survival of the maximum diversity of species and the maintenance of genetic variability within species. It includes the maintenance of biosphere function e.g. nutrient cycling and ecosystem function. The term also includes the concept of sustainable resource use so that the environment may yield the greatest sustainable benefit to current generations while maintaining its potential to meet the needs and aspirations of future generations. Conservation of species and biological processes must be simultaneous with conservation of abiotic resources or it is unlikely to succeed*.'

Adapted from International Union for Conservation of Nature (IUCN) & United Nations Environment Programme (UNEP) 1992.

Ex-situ and in-situ conservation

In-situ conservation means maintenance of biodiversity in natural habitat whereas *ex-situ conservation* emphasises the conservation of biodiversity outside natural habitat.

Ex-situ ('off site') conservation is a set of conservation techniques involving the transfer of a target species away from its native habitat to a place of safety, such as a *zoological garden, botanical garden* or *seed bank*. Its primary objective is to support conservation by ensuring the survival of threatened species and the maintenance of associated genetic diversity. To do so, ex-situ institutions preserve the genetic or reproductive material of a target species, or take care of the living target species for the purpose of reintroduction.

Germplasm is living genetic resources such as seeds or tissues that are maintained for the purpose of animal and plant breeding, preservation, and other research uses.

In-situ ('on site') is conservation of habitats and ecosystems where organisms naturally occur i.e. the on-site conservation. The conservation of organisms in Biosphere Reserves (terrestrial and marine), National parks, Wildlife sanctuaries, Sacred groves, Biodiversity hotspots are all examples of *in-situ conservation*.

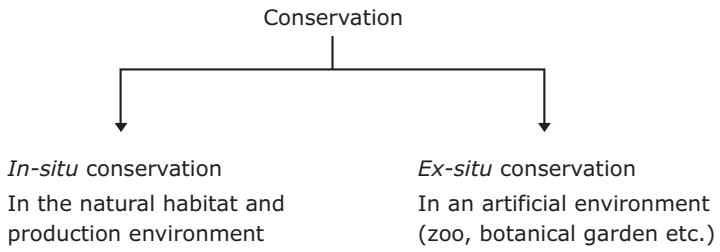


Figure 2.1 Overview of basic conservation schemes.

Gene banks are biorepositories where biological material is collected, stored, catalogued and made available for redistribution. Gene banks are also known as *germplasm banks*. It functions as *ex-situ* conservation, where a sample containing *genetic material* is preserved in an artificial environment, outside of its normal habitat. The germplasm is stored in the form of seeds, pollen or *in vitro* cultures. A *seed bank* preserves dried seeds by storing them at a very low temperature. In general, the seeds of plant species are stored in environments at low temperature and humidity. In these conditions, their viability can be preserved for several decades.

Biodiversity Hotspots

The concept of biodiversity hotspots originated with British ecologist and writer Norman Myers in 1988. A biodiversity hotspot is a relatively small area with an exceptional concentration of endemic species and a large number of endangered and threatened species. To qualify as a hotspot, a region must meet two strict criteria: it must contain at least 1,500 species of vascular plants (>0.5 percent of the world's total) as endemics, and it has to have lost at least 70 percent of its original habitat. Thus, hotspots are areas with the richest and most threatened reservoirs of plants and animals life on Earth. Norman Myers developed the hotspot concept to designate priority areas for in-situ conservation. A key criteria for determining a hotspot are:

1. Number of endemic species i.e. the species which are found nowhere else.
2. Degree of threat, which is measured in terms of habitat loss.

Currently, 35 biodiversity hotspots have been identified, most of which occur in tropical forests. They represent just 2.3% of Earth's land surface, but between them they contain around 50% of the world's endemic plant species and 42% of all terrestrial vertebrates. Four of 35 globally identified biodiversity hotspots: The Himalayas, the Western Ghats, the North-East, and the Nicobar Islands, are present in India.

Flagship and Umbrella species

A *flagship* species is a species chosen to represent an environmental cause, such as an ecosystem in need of conservation. These species are chosen for their vulnerability, attractiveness or distinctiveness in order to generate support and acknowledgment from the public at large. Thus, the concept of a flagship species holds that by giving publicity to a few key species, the support given to those species will successfully leverage conservation of entire ecosystems. *Umbrella species* are species selected for making conservation related decisions, typically because protecting these species indirectly protects many other species that make up the ecological community of its habitat.

IUCN Protected Area Management Categories

The criteria used to define protected areas vary widely, depending on the objective and on the mechanisms behind the establishment of the protected area. They are usually locations of significant environmental, cultural or natural value that in most cases have some forms of management authority in place for their protection.

The IUCN has developed *six* Protected Area Management Categories that define protected areas according to their management objectives, which are internationally recognised by various national governments and the United Nations. The categories provide international standards for defining protected areas and encourage conservation planning according to their management aims.

IUCN Protected Area Management Categories

Category Ia Strict nature reserve

Category Ia are strictly protected areas set aside to protect biodiversity and also possibly geological/geomorphical features, where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values. Such protected areas can serve as indispensable reference areas for scientific research and monitoring.

Category Ib Wilderness area

Category Ib protected areas are usually large unmodified or slightly modified areas, retaining their natural character and influence without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition.

Category Ib protected areas will generally be larger and less strictly protected from human visitation than category Ia.

Category II National park

Category II protected areas are large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible, spiritual, scientific, educational, recreational and visitor opportunities.

Category Ib and II protected areas are often similar in size and in their aim to protect functioning ecosystems. But whereas II usually includes use by visitors, including supporting infrastructure, in Ib visitor use is more limited.

Category III Natural monument or feature

Category III protected areas are set aside to protect a specific natural monument, which can be a landform, sea mount, submarine cavern, geological feature such as a cave or even a living feature such as an ancient grove. They are generally quite small protected areas and often have high visitor value.

Management in category III is focused around a single natural feature, whereas in category II it is focused on maintaining a whole ecosystem.

Category IV Habitat/Species management area

Category IV protected areas aim to protect particular species or habitats and management reflects this priority. Many Category IV protected areas will need regular, active interventions to address the requirements of particular species or to maintain habitats, but this is not a requirement of the category.

Category IV protected areas protect fragments of ecosystems or habitats, which often require continual management intervention to maintain. These protected areas are also often established to protect particular species or habitats.

Category V Protected landscape/seascape

A protected area where the interaction of people and nature over time has produced an area of distinct character with significant, ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values.

Category V protected areas are generally cultural landscapes or seascapes that have been altered by humans over hundreds or even thousands of years and that rely on continuing intervention to maintain their qualities including biodiversity.

Category VI Protected area with sustainable use of natural resources

Category VI protected areas conserve ecosystems and habitats together with associated cultural values and traditional natural resource management systems. They are generally large, with most of the area in a natural condition, where a proportion is under sustainable natural resource management and where low-level non-industrial use of natural resources compatible with nature conservation is seen as one of the main aims of the area.

Category VI protected areas contain natural areas where biodiversity conservation is linked with sustainable use of natural resources.

2.8 Protected Areas of India

Protected areas are those in which human occupation or at least the exploitation of resources is limited. The definition that has been widely accepted across regional and global frameworks has been provided by the IUCN in its categorization guidelines for protected areas. The definition is as follows:

'*A clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values*.'

There are several kinds of protected areas, which vary by level of protection depending on the enabling laws of each country or the regulations of the international organizations involved. The term '*protected area*' also includes *marine* protected areas, the boundaries of which will include some area of ocean, and *transboundary protected areas* that overlap multiple countries which remove the borders inside the area for conservation and economic purposes.

India has the following kinds of protected areas:

- National parks
- Wildlife sanctuaries
- Conservation reserves
- Community reserves
- Marine protected areas

The **World Wide Fund for Nature** (WWF) is an international non-governmental organization founded in 1961. It was formerly named the World Wildlife Fund. It is the world's largest conservation organization, working in more than 100 countries, supporting around 1,300 conservation and environmental projects.

National parks

National parks are protected areas, usually declared and owned by the central government. India's first national park was established in 1936 as Hailey National Park (now known as Jim Corbett National Park) in Uttarakhand. At present, there are 103 national parks in India covering an area of 40,500 km^2, which is 1.23% of the geographical area of the country (*National Wildlife Database*, April 2015).

Wildlife sanctuary

Any area other than area comprised with any reserve forest or the territorial waters can be notified by the State Government to constitute as a sanctuary if such area is of adequate ecological, faunal, floral, geomorphological, natural or zoological significance, for the purpose of protecting, propagating or developing wildlife or its environment. Some restricted human activities are allowed inside the Sanctuary area. There are 543 existing wildlife sanctuaries in India covering an area of 118,918 km^2, which is 3.62% of the geographical area of the country (*National Wildlife Database*, June, 2017).

Conservation reserves and Community reserves

Conservation reserves and community reserves in India are terms denoting protected areas of India which typically act as buffer zones or connectors and migration corridors between established national parks, wildlife sanctuaries and reserved and protected forests of India. Such areas are designated as **conservation reserves** if they are uninhabited and completely owned by the Government of India but used for subsistence (livelihood) by communities and **community reserves** if part of the lands is privately owned. These protected area categories were first introduced in the Wildlife (Protection) Amendment Act of 2002.

Marine protected areas

Marine protected areas (MPA) are protected areas of seas, oceans or estuaries. It is essentially a space in the ocean where human activities are more strictly regulated than the surrounding waters for a conservation purpose. These places are given special protections for natural or historic marine resources by local, state, territorial, native, regional or national authorities.

Man and the Biosphere Programme
Launched in 1971, UNESCO's Man and the Biosphere Programme (MAB) is an Inter-governmental Scientific Programme that aims to establish a scientific basis for the improvement of relationships between people and their environments. It predicts the consequences of today's actions on tomorrow's world and thereby increases people's ability to efficiently manage natural resources for the well-being of both human populations and the environment.

Biosphere reserves

Biosphere reserves are a special category of protected areas of land and/or coastal environments, where people are an integral components of the system. These are representative examples of natural biomes and contain unique biological communities. The concept of biosphere reserves was launched in 1971 as a part of UNESCO's **Man and Biosphere** (MAB) programme. The first biosphere reserve of the world was established in 1979, since then the network of biosphere reserves has increased to 669 in 120 countries across the world (**MAB**, 2008). Biosphere reserves are nominated by national government and remain under the sovereign jurisdiction of the states where they are located. Presently, there are 18 biosphere reserves in India. 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.

Objectives of biosphere reserve

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

A ***conservation function*** – to contribute to the conservation of landscapes, ecosystems and species variation.

A ***development function*** – to foster economic and human development which is socio-culturally and ecologically sustainable.

A ***logistic function*** – to provide support for research, monitoring, education and information exchange related to local, national and global issues of conservation and development (UNESCO, 2005).

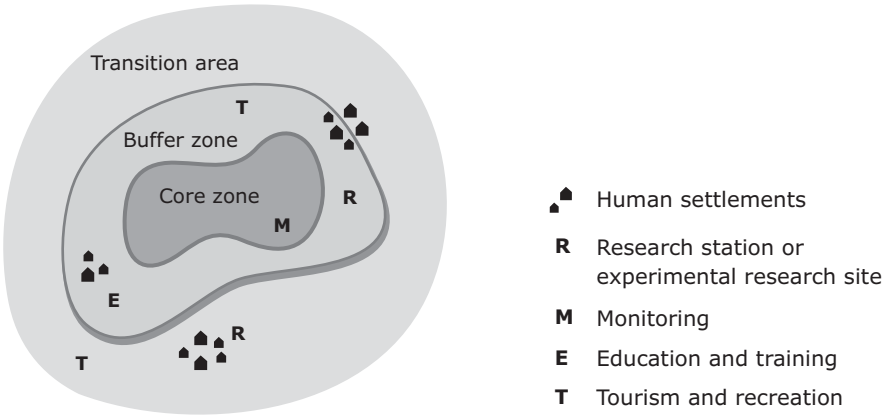
Structure of biosphere reserve

Biosphere reserves have three interrelated zones that aim to fulfil three complementary and mutually reinforcing functions— *core, buffer* and *transition zones*.

Core zone: The *natural* or *core zone* represents an undisturbed or least disturbed area of representative ecosystem.

Buffer zone: The buffer zone surrounds the core zone, and is managed for research, education and training activities. It is an area peripheral to a core zone, where restrictions are placed upon resource use or special development measures are undertaken to enhance the conservation values of the area. Traditional activities including timber production, hunting, fishing and grazing are permitted.

Transition zone: The transition zone, the outermost part of the biosphere reserve, is an area of active cooperation between reserve management and the local people, wherein activities like settlements, cropping, forestry and recreation and other economic uses continue in harmony with conservation goals.



Biosphere reserve zonation

S.No.	Name of the Biosphere Reserve and total geographical area (Km^2)	Date of designation	Location in the State/Union Territory
1.	Nilgiri (5520)	1.8.1986	Part of Waynad, Nagarhole, Bandipur and Madumalai, Nilambur, Silent Valley and Siruvani hills in Tamil Nadu, Kerala and Karnataka.
2.	Nanda Devi (5860.69)	18.1.1988	Part of Chamoli, Pithoragarh and Almora districts in Uttarakhand.
3.	Nokrek (820)	1.9.1988	Part of East, West and South Garo Hill districts in Meghalaya.
4.	Manas (2837)	14.3.1989	Part of Kokrajhar, Bongaigaon, Barpeta, Nalbari, Kamprup and Darang districts in Assam.
5.	Sunderban (9630)	29.3.1989	Part of delta of Ganges and Brahamaputra river system in West Bengal.
6.	Gulf of Mannar (10500)	18.2.1989	India part of Gulf of Mannar extending from Rameswaram island in the North to Kanyakumari in the South of Tamil Nadu.
7.	Great Nicobar (885)	6.1.1989	Southern most island of Andaman and Nicobar Islands.
8.	Similipal (4374)	21.6.1994	Part of Mayurbhanj district in Orissa.
9.	Dibru-Saikhova (765)	28.7.1997	Part of Dibrugarh and Tinsukia districts in Assam.
10.	Dehang-Dibang (5111.5)	2.9.1998	Part of Upper Siang, West Siang and Dibang Valley districts in Arunachal Pradesh.
11.	Pachmarhi (4981.72)	3.3.1999	Part of Betul, Hoshangabad and Chhindwara districts in Madhya Pradhesh.
12.	Khangchendzonga (2619.92)	7.2.2000	Part of North and West districts in Sikkim.
13.	Agasthyamalai (3500.36)	12.11.2001	Part of Thirunelveli and Kanyakumari districts in Tamil Nadu and Thiruvanthapuram, Kollam and Pathanamthitta districts in Kerala.
14.	Achanakmar-Amarkantak (3,835.51)	30.3.2005	Part of Anuppur and Dindori districts of Madhya Pradesh and Bilaspur district of Chattisgarh.
15.	Kachchh (12,454)	29.1.2008	Part of Kachchh, Rajkot, Surendranagar and Patan districts in Gujarat.
16.	Cold Desert (7,770)	28.8.2009	Pin Valley National Park and surroundings; Chandratal & Sarchu; and Kibber Wildlife sanctuary in Himachal Pradesh.
17.	Seshachalam (4755.997)	20.9.2010	Seshachalam hill ranges in Eastern Ghats encompassing part of Chittoor and Kadapa districts in Andhra Pradesh.
18.	Panna (2998.98)	25.8.2011	Part of Panna and Chhattarpur districts in Madhya Pradesh.

Source: http://www.moef.nic.in/sites/default/files/annual_report/AR-2013-14.

Sacred groves

Sacred groves comprise of patches of forests of varying sizes that are protected by local communities because of their religious beliefs and traditional rituals that run through several generations. The degree of sanctity of the sacred forests varies from one grove to another. People believe that any kind of disturbance will offend the local deity (devata), causing diseases, natural calamities or failure of crops. For example, the Garo and the Khasi tribes of North-Eastern India completely prohibit any human interference in the sacred groves.

2.9 Biodiversity conservation: International and National efforts

Biodiversity is a wealth to which no value can be put. In the final analysis, the very survival of the human race is dependent on conservation of biodiversity. It is evident that this invaluable resource is being destroyed at an alarming rate due to several reasons. Measures are being taken up at national and international levels to address this issue. The Earth Summit produced a plan of action on a number of issues (**Agenda 21**) including conservation of biodiversity during the 21st century.

International conservation strategies

Conserving biodiversity is not an issue confined to any one country or community. It is a crucial global concern. Several international treaties and agreements are in place in the attempt to strengthen international participation and commitment towards conserving biodiversity. Some of these are:

Convention on Biological diversity

The Convention on Biological Diversity (CBD), known informally as the Biodiversity Convention, is a multilateral treaty. The notion of an international convention on biological diversity was conceived at a United Nations Environment Programme (UNEP) by Ad Hoc Working Group of Experts on Biological Diversity in November 1988. The Convention was opened for signature at the Earth Summit in Rio de Janeiro on 5 June 1992 and entered into force on 29 December 1993. It has three main objectives:

- The conservation of biological diversity.
- The sustainable use of the components of biological diversity.
- The fair and equitable sharing of the benefits arising out of the utilization of genetic resources.

National Board for Wildlife
National Board for Wildlife (NBWL) is a statutory Board constituted on 22nd September 2003 under the Wild Life (Protection) Act, 1972. The NBWL is chaired by the Hon'ble Prime Minister. Primary function of the Board is to promote the conservation and development of wildlife and forests. It is a very important body because it serves as apex body to review all wildlife-related matters and approve projects in and around national parks and sanctuaries.

CITES

CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora), also known as the **Washington Convention**, is an international agreement to protect endangered plants and animals. It was drafted as a result of a resolution adopted in 1963 at a meeting of members of the International Union for Conservation of Nature (IUCN). The convention was opened for signature in 1973 and CITES entered into force on 1 July 1975. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten the survival of the species in the wild, and it accords varying degrees of protection to more than 35,000 species of animals and plants. India become party to CITES in 1976.

World Heritage Convention (WHC)

The convention concerning the protection of the world cultural and natural heritage commonly known as the 'World Heritage Convention', is an international treaty, adopted in 1972. The convention recognizes the way in which people interact with nature, and the fundamental need to preserve the balance between the two. The convention sets out the duties of states parties in identifying potential sites and their role in protecting and preserving them. By signing the convention, each country pledges to conserve not only the World Heritage sites situated on its territory, but also to protect its national heritage.

World Heritage sites are places on Earth that are of Outstanding Universal Value (OUV) to humanity and therefore, have been inscribed on the World Heritage List to be protected for future generations. Places as diverse and unique as the Great Barrier Reef in Australia, Galapagos Islands in Ecuador and the Grand Canyon in the USA are examples of places inscribed on the World Heritage List. The World Heritage Convention 1, which has been ratified by 191 countries, was adopted by United Nations Educational, Scientific and Cultural Organization's (UNESCO) General Conference in 1972, and came into force in 1975, for the identification, protection, conservation, presentation and transmission to future generations of the world cultural and natural heritage. The secretariat to the World Heritage Convention is the UNESCO World Heritage Centre, whilst three organisations: International Council on Monuments and Sites (ICOMOS), International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM) and the International Union for Conservation of Nature (IUCN) act as its Advisory Bodies. The Advisory Body on natural heritage is IUCN.

Convention on the Conservation of Migratory Species of Wild Animals

The CMS, or the *Bonn Convention* aims to conserve terrestrial, marine and avian migratory species throughout their range. Parties to the CMS work together to conserve migratory species and their habitats by providing strict protection for the most endangered migratory species, by concluding regional multilateral agreements for the conservation and management of specific species or categories of species, and by undertaking co-operative research and conservation activities.

International Treaty on Plant Genetic Resources for Food and Agriculture

The objectives of the treaty are the conservation and sustainable use of plant genetic resources for food and agriculture and the fair and equitable sharing of the benefits arising out of their use, in harmony with the Convention on Biological Diversity, for sustainable agriculture and food security. The treaty covers all plant genetic resources for food and agriculture, while its Multilateral System of Access and Benefit-sharing covers a specific list of 64 crops and forages. The Treaty also includes provisions on Farmers' Rights.

Convention on Wetlands (Ramsar Convention)

The Ramsar Convention provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. The convention covers all aspects of wetland conservation and wise use, recognizing wetlands as ecosystems that are extremely important for biodiversity conservation in general and for the well-being of human communities.

International Plant Protection Convention (IPPC)

The IPPC aims to protect world plant resources, including cultivated and wild plants by preventing the introduction and spread of plant pests and promoting the appropriate measures for their control. The convention provides the mechanisms to develop the *International Standards for Phytosanitary Measures* (ISPMs), and to help countries to implement the ISPMs and the other obligations under the IPPC, by facilitating the national capacity development, national reporting and dispute settlement.

National conservation strategies

India has actively participated and contributed to various international initiatives. India signed the United Nations Convention on Biological Diversity, 1992 in Rio. Biodiversity was considered as a common concern of humankind. Due to ecological, genetic, economic, scientific, educational, cultural, recreational and aesthetic values of biological diversity, a large number of initiatives have been taken up at national level.

Biological Diversity Act

The *Biological Diversity Act*, 2002 is an Act of the Parliament of India for conservation of biological diversity in India. This was an attempt to realize the objectives enshrined in the United Nations Convention on Biological Diversity (CBD) 1992 which recognizes the sovereign rights of states to use their own biological resources. The Act aims at the conservation of biological resources and associated knowledge as well as facilitating access to them in a sustainable manner. To implement the provisions under the Act, a National Biodiversity Authority (NBA) has been constituted. The **National Biodiversity Authority** is a statutory autonomous body, headquartered in Chennai, under the Ministry of Environment and Forests, Government of India established in 2003 to implement the provisions under the Act.

National Green Tribunal
The National Green Tribunal has been established in year 2010 under the National Green Tribunal Act 2010 (an Act of the Parliament of India) for effective and expeditious disposal of cases relating to environmental protection and conservation of forests and other natural resources including enforcement of any legal right relating to environment and giving relief and compensation for damages to persons and property and for matters connected therewith or incidental thereto. It is a specialized body equipped with the necessary expertise to handle environmental disputes involving multi-disciplinary issues.

Wildlife (Protection) Act

The Government of India enacted Wildlife (Protection) Act 1972 with the objective of effectively protecting the wildlife of this country and to control poaching, smuggling and illegal trade in wildlife and its derivatives. The Act was amended seven times (1982, 1986, 1991, 1993, 2002, 2006 and 2013) and punishment and penalty for offences under the Act have been made more stringent. The Ministry has proposed further amendments in the law by introducing more rigid measures to strengthen the Act. The objective is to provide protection to the listed endangered flora and fauna and ecologically important protected areas.

The Government of India constituted a statutory body, the **Wildlife Crime Control Bureau** (WCCB) on 6 June 2007, by amending the Wildlife (Protection) Act, 1972. It is a statutory multi-disciplinary body established by the Government of India under the Ministry of Environment and Forests, to combat organized wildlife crime in the country. The Bureau has its headquarter in New Delhi.

Project Tiger and Project Elephant

Several special projects have also been launched by Government of India to save certain animal species which have been identified as needing concerted protection effort. These projects are designed to protect the species in situ, by protecting and conserving their natural habitat.

Project Tiger

Project Tiger is a wildlife conservation project initiated in India in 1972 to protect the tigers. It was launched on April 1, 1973 and has become one of the most successful wildlife conservation ventures. The main idea behind the project is to provide safe habitats for tigers where they could flourish as a species and hopefully reverse the startling decline in their population. Initially, the project started with 9 tiger reserves, covering an area of 16,339 km^2, with a population of 268 tigers. At present there are 49 tiger reserves, with a population of 2226 tigers. The selection of reserves was guided by representation of ecotypical wilderness areas across the biogeographic range of tiger distribution in the country.

Project Elephant

Elephant (*Elephas maximus*) is the largest terrestrial mammal of India. About 60% of the Asian elephant population is in India. Project Elephant was launched in 1992 by the Government of India, Ministry of Environment and Forests and Climate Change to provide financial and technical support to major elephant bearing states in the country for protection of elephants, their habitats and corridors. Project Elephant was launched by the Government of India with following objectives:

1. To protect elephants, their habitat and corridors.
2. To address issues of man-animal conflict.
3. Welfare of captive elephants.

National Wildlife Action Plan

A road map to conserve wildlife of the country, in the form of an Action Plan, the first National Wildlife Action Plan (**NWAP-1**) was drafted and adopted in 1983. It was implemented from 1983 through 2001. On its completion and based on the new concerns and challenges viz. increased commercial use of natural resources, growth in human and livestock population, changes in the consumption patterns, rising interest in biodiversity conservation etc., the Plan was revised and a new Action Plan (**NWAP-2**) was put in place for the period 2002-2016. On the suggestion of National Board for Wildlife and based on evaluations of **NWAP-2**, a third National Wildlife Action Plan (**NWAP-3**) has been drafted and adopted for the period 2017-2031. The Plan is based on the premise that essential ecological processes that are governed, supported or strongly moderated by ecosystems, are essential for food production, health and other aspects of human survival and sustainable development. And maintenance of these ecosystems which can be termed as 'Life Support Systems' is vital for all societies regardless of their stage of development.

Forest Conservation Act

The Forest Conservation Act is a Central Act of Parliament and was passed in 1980 for the conservation of forests and for matters connected therewith. The Act extends to the whole of India except the State of Jammu & Kashmir and is in force from 25th October 1980. Forest (Conservation) Act, 1980 is a unique piece of legislation, and a regulatory mechanism that reflects the collective will of the nation to protect its rich biodiversity and natural heritage and that permits only unavoidable use of forest land for various developmental purposes. Under this act, prior approval of Central Government is required before any reserved forest is declared as dereserved, or forest land is diverted to non-forest purposes. If diversion is permitted by the government, compensatory afforestation is required in an equivalent area

if the land is available. If an equivalent land is not available, afforestation has to be done in degraded forest such that it is twice the extent of the area being de-forested. Later in 1988, forest conservation act was amended to incorporate strict penalization for violators.

Chipko movement

The *Chipko movement* (or chipko andolan) was primarily a forest conservation movement in India that began in 1973. The name of the movement comes from the word 'embrace', as the villagers hugged the trees, and prevented the contractors' from felling them. The original 'Chipko movement' was started around 260 years back in the early part of the 18th century in Rajasthan by the Bishnoi community. A large group villagers led by a lady called Amrita Devi laid down their lives in an effort to protect the trees from being felled on the orders of the King of Jodhpur. The Chipko movement of 1973 was one of the most famous among these. The first Chipko action took place spontaneously in April 1973 in the village of Mandal in the upper Alakananda valley and over the next five years spread to many districts of the Himalayas in Uttar Pradesh. It was sparked off by the government's decision to allot a plot of forest area in the Alakananda valley to a sports goods company. With encouragement from a local NGO, DGSS (Dasoli Gram Swarajya Sangh), the women of the area, under the leadership of an activist, Chandi Prasad Bhatt, went into the forest and formed a circle around the trees preventing the men from cutting them down.

2.10 Biogeographic classification of India

Biogeography is the study of geographical distributions of organisms, their habitats and the environmental factors that produce them. Biogeographic classification of India was done by Rodgers and Panwar (1988). Within India the classification recognizes 10 zones, divided into 26 provinces. The classification was done using various factors such as altitude, moisture, topography, rainfall, etc. ***Biogeographic zones*** are large distinctive units of similar ecology, biome representation, community and species e.g. The Himalaya, The Western Ghats, whereas the ***biotic province*** is the secondary units within a zone, giving weight to particular communities separated by dispersal barriers or gradual change in environmental factors e.g. North West and West Himalaya either side of the Sutlej River. Biogeographic zones of India are:

1. ***Trans-Himalaya***

   Biotic Province : Ladakh mountains (1a) and Ladakh plateau (1b).

   Biome : Tundra valley, lakes and marshes.

   Wildlife : Chiru, Black-necked Crane, Himalayan pit viper.

2. ***Himalaya***

   Biotic Province : Northwestern Himalaya (2a), Western Himalaya (2b), Central Himalaya (2c), and Eastern Himalaya (2d).

   Biome : All alpine, temperate conifer, temperate broadleaf, subtropical.

   Wildlife : Ibex, Red panda

3. ***Indian Desert***

   Biotic Province : Thar (3a) and Kutch (3b).

   Biome : Saltflats, scrublands, desert grasslands.

   Wildlife : Wild ass, Blackbuck, Flamingo, Desert monitor.

4. ***Semi-arid***

Biotic Province : Punjab (4a) and Gujarat-Rajwara (4b).

Biome : Scrublands, Bhabar forests, wetlands, dry deciduous, hill and thorn forests.

Wildlife : Tiger, Asiatic lion, Great Indian Bustard, Gharial.

5. ***Western Ghats***

Biotic Province : Malabar plain (5a) and Western Ghats mountains (5b).

Biome : Evergreen, moist deciduous, wetlands, Montane forests, grasslands.

Wildlife : Lion-tailed macaque, Malabar civet, Hornbill, Draco.

6. ***Deccan Peninsula***

Biotic Province : Central Highlands (6a), Chhotanagpur (6b), Eastern Plateau (6c), Central Plateau (6d) and Southern Plateau (6e).

Biome : Dry deciduous, thorn forests, wetlands, subtropical, moist deciduous.

Wildlife : Swamp deer, Chital, Elephant.

7. ***Gangetic Plains***

Biotic Province : Upper Gangetic plains (7a) and Lower Gangetic plains (7b).

Biome : Alluvial plain, wetlands, rivers.

Wildlife : Rhino, Gangetic dolphin, Nilgai.

8. ***Coasts***

Biotic Province : West Coast (8a), East Coast (8b) and Lakshadweep (8c).

Biome : Mangrove, brackish lakes and lagoons, mudflats, sandy or rocky littoral.

Wildlife : Dugong, Dolphin, Tiger, Sand skink.

9. ***North-East India***

Biotic Province : Brahmaputra valley (9a) and North-East hills (9b).

Biome : All grasslands, woodlands, evergreen moist deciduous, rivers, subtropical temperate.

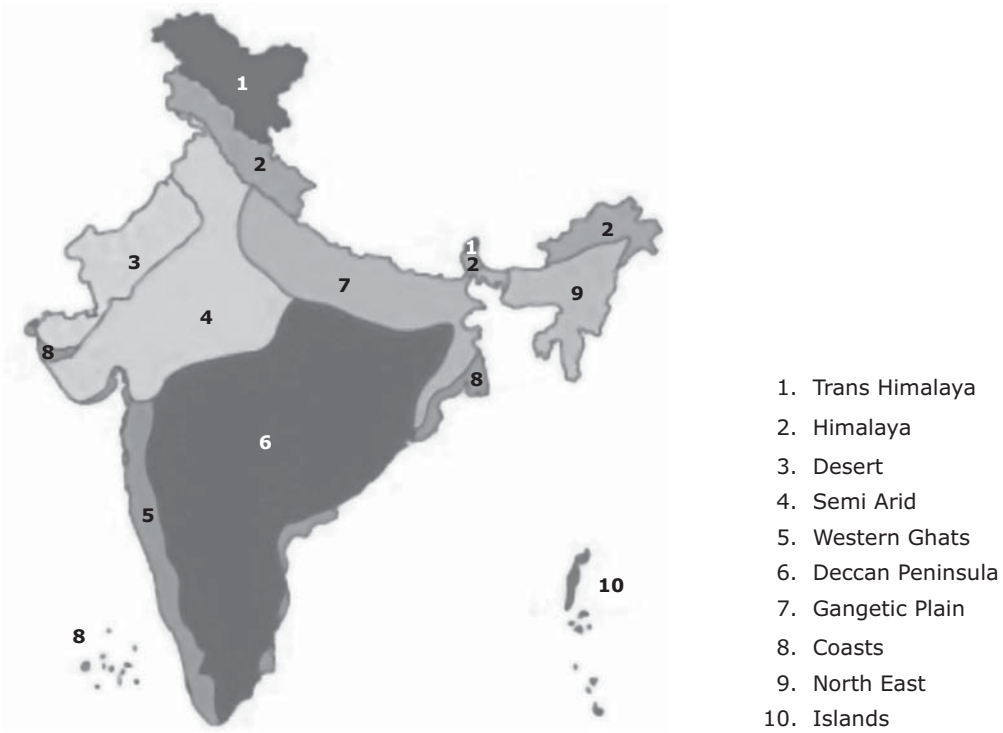
Wildlife : Pygmy hog, Golden langur, Yellow-backed Sunbird.

10. ***Islands***

Biotic Province : Andaman (10a) and Nicobar (10b).

Biome : Evergreen, moist deciduous, subtropical temperate wetlands, coastal habitat.

Wildlife : Dolphin, Narcondam Hornbill, turtles.



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