BIODIVERSITY; CONCEPTS & DEFINITION

Biodiversity is the variety of life on earth. It includes the variability of species in terrestrial, aerial and aquatic habitats, the diversity of ecosystems and the diversity of genes they harbor. It is an essential component of the nature and it ensures the survival of human species by providing food, fuel, shelter, medicines and other resources to mankind. Indirectly, biodiversity serves the humans by providing the basic life supporting systems such as clean air, water and fertile soil.

The convention on biodiversity (1992) has defined it more precisely as 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. Biodiversity indicates the health of ecosystem.

The aesthetic value of biodiversity is better realized and it could not be valued ideally with the current economic valuation models. Biodiversity is more reckoned for its unbelievable potential for supplying novel genes for a variety of applications in biotechnology and pharmacology.

Literally, "bio" means "life" & "diversity" means "variety", so 'Biodiversity' is 'the study of variety & richness of life in biosphere'. It is a term used to describe the variability of life on Earth. It can be used more specifically to refer to all of the species in one region or ecosystem because it refers to every living thing, including plants, bacteria, animals, and humans.

The term biodiversity gained popular attention by the world media during the earth Summit in Rio-de-Janeiro in year 1992.

According to the World Resource Institute, "Biodiversity is the variety of the world's organisms including their genetic diversity and the assemblage they form.

The word biodiversity was coined in the mid-1980s to capture the essence of research into the variety and richness of life on Earth. It is now widely used all over the globe by every environment related scientific or protesting community.

The word 'Biodiversity' does succinctly imply a fundamental idea: life on earth is extraordinarily diverse and complex. This idea is not as well captured in other words such as

"nature" or "wild life." Furthermore, "biodiversity" has entered the public vocabulary at a time when global concerns about the survival of life are at their zenith, and thus to many people the term carries a conviction to stem the loss of the planet's life-forms.

The term, biological diversity was coined by Norse & Mc Manus in 1980 and it's abridging form- Biodiversity was coined by W.G. Rosen in 1985. It is a compound word of the longer form 'Biological diversity' which was coined by Lovejoy in 1980 to denote the number of species present in a group.

International council for Birds Preservation, 1992 defined as Biodiversity is the total variety of life on earth. It includes all genes, species and ecosystems and the ecological process of which that are part.

Edward Wilson defines biodiversity as **all things living on the planet, and the rest as the physical world**. He bemoans the fact that so many of us seem to put so much stock in the physical world and so much effort in obtaining physical stuff to the detriment of the living world or biodiversity.

- In short we can define biological diversity or biodiversity as the variety and variability of flora and fauna in an ecosystem. We can say richness of species, genera and families at a place.
- Briefly it can be described as the richness of species, genera and family at a place.

1.	Genetic diversity	Variation of genes within species
2.	Species diversity	Diversity between species within a region
3.	Ecosystem diversity	Communities in various richness within a given ecosystem
4.	Landscape diversity	Spatial arrangement of habitats across a large area and on fluxes of energy, nutrients distribution, disturbance and organisms across the area

Definition

- Biological diversity is the central tenet of nature, one of its key defining features. Evolution has produced an amazing variety of plants, animals and micro-organisms, intricately interconnected, and worthy of respect and conservation in their own right.

Biodiversity is also the basis for the continuous evolution of species. This diversity is also the backbone of human societies and cultures, in terms of the ecological functions it provides and the myriad survival and livelihood it meets**.**

- According to Convention on Biological Diversity (CBD), biodiversity is "the variability among all living organisms from all sources, including, *inter alia*, terrestrial, marine and other aquatic ecosystems and ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems".
- **'Biodiversity',** or biological diversity, refers to the variety of plants, animals and microorganisms that exist, the genes they contain and the ecosystems they live in.
- The term biodiversity was coined in 1985. It is important in natural as well as artificial ecosystems. It deals with nature's variety is biosphere. It refers to variabilities among plants, animals and microorganism species.
- Biodiversity includes the number of different organisms and their relative frequencies in an ecosystem. It also reflects the organization of organisms at different levels.
- Biodiversity holds ecological and economic significance. It provides us with nourishment, housing, fuel, clothing and several other resources. It also extracts monetary benefits through tourism. Therefore, it is very important to have a good knowledge of biodiversity for a sustainable livelihood.

Biodiversity of any given area being a function of precipitation, temperature, soils, altitude etc, and its distribution across the globe is quite uneven. For instance, terrestrial biodiversity is as much as 25 times higher than marine biodiversity. Within the terrestrial habitats, tropics are found to support much richer biodiversity than alpine or polar regions. India is considered very rich in biodiversity. It is estimated that about 1/6 th plant species of entire world belong to India. An area with a high concentration of endemic species is called a "hotspot". **Out of the 35 hotspots of the world, 4 (Himalaya, Indo-Burma, Western Ghats and Sri Lanka, Sundaland) are in India.**

Conceptual History of Biodiversity

The diversity of life on Earth has been a central theme of the natural sciences but it also touches on many other areas. The Bible credits Adam with the job of naming the animals, a fundamental task for facing those quantifying biodiversity. The same approaches to classifying life are apparent in ancient and modern societies.

Western culture has repeatedly revised its understanding of the variety and nature of life. The Greek philosopher Aristotle recognised between 500 and 600 species, echoing modern folk classifications which typically recognise 300 to 600. Slavish copying of classical texts was abandoned during the sixteenth and seventeenth centuries, spurred by technological advances and the spread of ideas through printing. Classification increasingly focused on the species.

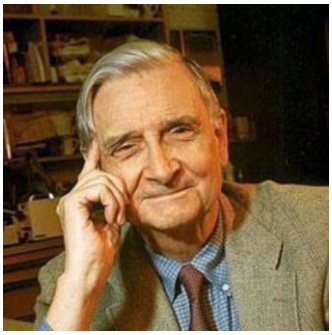
The nineteenth century saw the final abandonment of the folk biology principle that lumped species together by broad type (e.g. tree) in favour of biodiversity described by detailed structure and relatedness. Our attitudes to life continue to change: the twenty-first century is dominated by our understanding of evolution, which is a powerful theory. The richness of life has been central to human society and science but the term biodiversity is an upstart.

Origin of the term 'Biodiversity'

The origins of term 'Biodiversity' are credited to two papers published in 1980 (Lovejoy 1980; Norse and McManus 1980). Lovejoy, working for the World Wildlife Fund in Washington DC, contributed to The Global 2000 Report to the President of the United States, reviewing global environmental topics such as energy, human population and economics. Examining the extent of global forestry resources, Lovejoy reviewed two consequences of forest exploitation: changes to global climate and to **biological diversity**. Estimates of extinctions based on different forest loss rates were given. Lovejoy wrote of biological or biotic diversity defined as simply the total number of species.

Norse and McManus were ecologists on the White House Council on Environmental Quality during Jimmy Carter's presidency and in 1980 contributed a chapter to the Eleventh Annual Report of the Council on Environmental Quality entitled Ecology and Living Resources: **Biological Diversity**. The chapter examines global biodiversity which is defined as two related concepts, genetic and ecological diversity (the latter equated with numbers of species).

The snappy abbreviation biodiversity (fleetingly Bio Diversity) is credited to **Walter Rosen**, working for the American Natural Research Council/National Academy of Sciences, as a co-director for the 1986 Conference 'The National Forum on Biodiversity', held in Washington, DC. The publication of papers from the Forum, in a book entitled Biodiversity (Wilson 1988), was the spark igniting wider interest and usage. The contents of Biodiversity are revealing. The themes of the fifty-seven chapters in the book extend beyond pure science.



So, the term Biodiversity was proposed by Walter Rosen in 1986.

Walter G. Rosen. Source

Why diversity is Rich in the Tropics?

There are following reasons-

- Over geological times the tropics had a more stable climate than the temperate zones. Therefore, local species continued to live there itself, whereas in temperate they tend to disperse to other area.
- Tropical communities are older than temperate ones. Therefore, there has been more time for them to evolve.
- Warm temperatures and high humidity in most tropical area provide favourable conditions for many species that are unable to survive in temperate area.
- In tropics, there may be greater pressure from pests, parasites and diseases. This does not allow any single species to dominate and thus there is opportunity for many species to co-exist.
- Amongst plants rates of out crossing appear to be higher in tropics. Higher rates of out crossing may lead to higher levels of genetic variability.
- Tropics areas receive more solar energy over the year.
- Living in the lowland tropics we are blessed with abundant biodiversity. Tropical areas are known to have more species per unit area than temperate areas and biodiversity decreases with increasing altitudes.

With the rapid changes we are seeing in India, there are concerns that man-made changes to our environment are leading to too many of our species being lost and our biodiversity becoming seriously depleted. One of the reasons biodiversity is important is because it helps to keep the environment in a natural balance.

An ecosystem which is species-rich is more resilient and adaptable to external stress than one in which the range of species is limited. In a system where species are limited, the loss or temporary reduction of any one could disrupt a complex food chain with serious effects on other species in that same system. Once biodiversity is sufficient, if one nutrient cycling path is affected another pathway can function and the ecosystem and the biological species it supports can survive.

Biodiversity Benefits

This section discusses some of the key benefits the natural environment provides. This list is not meant to be exhaustive, but cover the main benefits from the literature. For each benefit there is a brief description of how the natural environment provides the benefit. This is supported by a discussion of some of the key studies that provide evidence that people actually value these benefits, although figures are not always available.

1. **Economic Activity**: Economic activity refers to the direct economic benefits that biodiversity can provide. These include resources that can be taken from nature for consumption, the economic impact of maintaining and enjoying a high quality natural environment and the regenerative effects an improved environment can bring to an area. The natural environment is rich in wild plants and animals that are harvested for food, for fuel or for medicine. This is additional to farm produce which comes from specially managed lands.

   There have been a number of studies which estimate the contribution to the economy of a high quality natural environment. The argument here is twofold. Firstly, in restoring and maintaining a high quality natural environment, conservation agencies employ a large number of people, and spend money in the economy. Secondly, the provision of a high quality natural environment attracts visitors who spend money.
2. **Cultural/Spiritual/Aesthetic**: 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. Anecdotally, this argument is quite well-founded, but finding empirical evidence with monetary values is difficult.
3. **Recreation/Tourism:** Here, recreation and tourism refer to the benefits people enjoy from taking recreation in the natural environment. As mentioned before, there is scope here to include other benefits in any valuation study. For example, part of the enjoyment of recreation in the countryside is aesthetic and it is difficult to separate these out. However, it clear that many people do take day trips and holidays to areas because of the quality of the natural environment as well as to visit wildlife.

Awareness of biodiversity has recently led to a boom in ecotourism. Travel companies promote tours into off-the-beaten-path locations, such as forests and jungles, where tourists can go on river cruises, hike, and observe and enjoy nature without disturbing the ecosystem. Money from ecotourism goes back into the region and helps to preserve the diversity of plants and animals.

4. **Education/Information:** Unique natural spaces have an important function in enabling society to improve its knowledge of the natural world. Scientists can use these areas to gather data and conduct research which can materially benefit society. Natural spaces also provide an arena in which children can learn outside of the classroom, and there is evidence to suggest that this is a more effective form of learning. Another incredibly important function of natural spaces is environmental monitoring. Observing the natural environment allows scientists to understand underlying trends that indicate the health of the natural environment. The effects of climate change can be traced through geology and biodiversity, providing an invaluable resource to scientists predicting the effects of global warming. Such benefits are hard to quantify as some of the information may never be 'used' in a commercial way.
5. **Health:** A key component in an individual's health is their activity level. How much exercise they do, and how often, has a significant impact on the risk of a variety of illnesses. Despite this, many do not take regular exercise. There is evidence to suggest that the provision of green spaces makes it more likely people will undertake and sustain physical activity. This refers back to the enjoyment most people feel from being in a more natural environment. A lack of physical activity also impacts on psychological wellbeing, and so physical inactivity is a root cause for a host of physiological and psychological ailments which cost society billions of pounds every year. Another aspect is that living in a high quality environment obviously provides a better atmosphere, reducing health costs associated with pollution.
6. **Regulating and Supporting Ecosystem Services:** The natural environment provides many benefits to societies that are often overlooked. Recently these have started to be classified as ecosystem services, see Millennium Ecosystem Assessment (2005). In this section the focus is on regulating and supporting ecosystem services, by which is meant those natural processes that provide benefits such as climate control, pollution

attenuation, water purification, flood control, nutrient cycling and soil formation. These are all processes upon which society is heavily dependent and which it would be very expensive or impossible to replace. It is difficult to quantify exactly how much different landscapes or habitats on different scales provider of these services. It is equally difficult to put monetary values on these services, partly because of the interdependencies between all sites: the value of any one site depends on its relationship with wider ecosystems.

7. **Option/Existence:** Society benefits in many ways simply from having a natural environment regardless of whether it is used. This 'non-use' value can be divided to option and existence value. Option value refers to the possible benefits society could gain in the future from the natural resource. This relates largely to the possibility of new discoveries of plant and animal functions or species that could herald new drugs and treatments. This 'bioprospecting' can have value to pharmaceutical companies but depends upon there being healthy natural environments around the world to maintain biological resources around the world and allow their exploration.
8. **Soils:** Biodiversity includes not only the large plants and animals we see, but also microscopic bacteria, fungi, algae, and a host of tiny insects and invertebrates. These smaller organisms are the ones responsible for creating soil and maintaining the quality of soil. Worms are well known for conditioning soil by digging through and aerating it and providing nutrients from their castings or waste. Bacteria and fungi degrade organic material, which then further breaks down in the soil, where plants can use the nutrients.
9. **Water Quality:** The benefits of biodiversity include keeping water quality pure. In wetlands, plants will take up contaminants in water and process and purify the water. Shellfish such as mollusks take in nutrients from the water, thereby preventing a condition called eutrophication, which can cause a huge increase in organisms in the water that leads to oxygen depletion and mass die-offs. If any species is removed from the food webs of an ecosystem, the ecosystem can crash, and in the case of water quality, contaminants can remain and cause immense additional problems.
10. **Waste Removal:** The biodiversity of microbes, fungi, and other smaller organisms is important in decomposing waste matter. Organic material in nature, such as leaves, logs and twigs, and dead animals and insects, is all degraded and decomposed by the

biodiversity of organisms in the ecosystem. It is a delicate balance, in which certain insects or microbes perform a vital function in removing waste from the environment, making it cleaner and less ripe for the spread of disease.

11. **Pollination and Seed Dispersal:** Bees are not the only organisms responsible for pollinating plants and crops. In fact, birds, bats, and butterflies play a vital role in spreading pollen and in dispersing seeds. Butterflies and hummingbirds, for instance, feed on nectar and can transport pollen from flower to flower. Birds and fruit bats eat the fruit and nuts from plants, and then disperse the seeds inside through their fecal matter.
12. **Medicine**: Many modern medicines incorporate natural ingredients from plants that are found in jungles or forests, notably the Amazon rainforest. There is a huge number of plant species used in modern medicine, somewhere around 50,000 to 70,000. Should any of these plants become extinct, medicinal cures would suffer. Examples of plants used in modern medicine include quinine from the cinchona tree in South America, used to treat malaria, cortisone from Central American yams, which is a main ingredient in birth control pills, and no vaccine, which is derived from the coca plant and used as an anesthetic in dentistry.
13. **Poverty Alleviation**: Biological diversity provides the world's population, particularly the poor, with food, medicines, building materials, bioenergy and protection against natural disasters.
14. **Agriculture**: Many of the benefits of biodiversity accrue to agriculture itself. For example, the marine environment is a source for insecticides. Nereistoxin is an insecticidal poison isolated from the marine worm, *Lumbrineris brevicirra*. Others benefits include crop pollination, soil fertility services provided by microorganisms, and pest control services provided by insects and wildlife. Biodiversity loss has important implications for agriculture.
15. **Mitigation of Floods:** Floodplains are ecosystems that border rivers subject to flooding. Following excessive rains, flood waters flow over riverbanks and into these floodplain forests and wetlands. Some of the water is soaked up by the soil.
16. **Carbon Sequestration:** Carbon storage (sequestration) occurs in forests and soils primarily through the natural process of photosynthesis. The movement of carbon in and out of trees and soils is part of the Earth's global carbon cycle. Forests and coral reefs

contain massive carbon reservoirs, which significantly contribute to regulating the global climate.

17. **Buffering the Land against Ocean Storms**: Mangrove forest protect coastlines against Vegetated banks bind the soil, preventing erosion caused by wave and surface water flow.
18. **Preservation of Soil Fertility:** Soils, with their active microbial and animal populations, have the capacity to supply adequate nutrients to plants in suitable proportions. Natural forest soil had a higher content of total nutrients and biomass.

Another option value is the benefit society could receive in the future from the resilience of the natural environment to some sort of disturbance. As society is heavily dependent on the natural environment any disturbance would cause significant economic loss. However, the scale of this loss could be reduced if the natural environment were more resilient. Resilience is associated with more complex species diversity where a range of species fill ecological functions to ensure that natural processes continue in the face of disturbance. One major potential disturbance is climate change, adding to the importance of preserving a high quality natural environment today.

Profile of Indian Biodiversity

(Status and trends of biodiversity, 2018 Nagoya-Kuala Lumpur Protocol)

India is one of the recognized mega-diverse countries of the world, harbouring nearly 7-8% of the recorded species of the world, and representing 4 of the 35 globally identified biodiversity hotspots (Himalaya, Indo-Burma, Western Ghats and Sri Lanka, Sundaland). India is also a vast repository of traditional knowledge associated with biological resources. So far, over 91,200 species of animals and 45,500 species of plants have been documented in the ten biogeographic regions of the country.

Inventories of floral and faunal diversities are being progressively updated with several new discoveries through the conduct of continuous surveys and exploration. Along with species richness, India also possesses high rates of endemism. In terms of endemic vertebrate groups, India's global ranking is tenth in birds, with 69 species; fifth in reptiles with 156 species; and seventh in amphibians with 110 species. Endemic-rich Indian fauna is manifested most prominently in Amphibia (61.2%) and Reptilia (47%). India is also

recognized as one of the eight Vavilovian centres of origin and diversity of crop plants, having more than 300 wild ancestors and close relatives of cultivated plants, which are still evolving under natural conditions.

The varied edaphic, climatic and topographic conditions and years of geological stability have resulted in a wide range of ecosystems and habitats such as forests, grasslands, wetlands, deserts, and coastal and marine ecosystems. Arid and semi-arid regions cover 38.8% of India's total geographical area. The cold arid zone located in the Trans-Himalayan region covers 5.62% of the country's area. The region is the stronghold of three cat predators – the lion, leopard and tiger. Of the 140 species of known birds, the Great Indian Bustard is a globally threatened species. The floras of the Indian desert comprise 682 species, with over 6% of the total plant species being endemic. The cold desert is the home of rare endangered fauna, such as the Asiatic Ibex, Tibetan Argali, Wild Yak, Snow Leopard, etc., and the flora is rich in endemism and economically important species.

India has a variety of wetland ecosystems ranging from high altitude cold desert wetlands to hot and humid wetlands in coastal zones with diverse flora and fauna. About 4,445 km2 of the country is under mangroves. India is blessed with rich fish diversity that dwells in the inland waters. The major rivers of India and their tributaries traverse through varied geo-climatic zones, displaying high diversity in their biotic and abiotic characteristics throughout their 28,000 km linear drift. The current distribution of 783 species of freshwater fishes, belonging to 89 genera under 17 families, which includes 223 endemic fishes, is recorded in India. In total, the Indian fish population represents 11.72% of species, 23.96% of genera, 57% of families and 80% of the global fishes. The country is the third largest producer of fish in the world, with 2,411 fish species.

India has a vast coastline of 7,517 km, of which 5,423 km belong to Peninsular India and 2,094 km to the Andaman, Nicobar and Lakshadweep Islands, and an EEZ of 2.02 million km2 with a very wide range of habitats (e.g. estuaries, lagoons, mangroves, backwaters, salt marshes, rocky coasts, stretches and coral reefs, all of which are characterized by rich and unique biodiversity components).

Another crucial ecosystem for India is its forest, covering 23.39% of the geographical area of the country (of which 75% occurs in the northeastern states) and counting over 16 major

forest types and 251 sub-types. Against the global trend of deforestation, it is worth underlining the achievement made by India in stabilizing its area under forest cover over the years.

The mountain ecosystems of India are largely described under two global hotspots, viz., the Eastern Himalaya, and the Western Ghats and Sri Lanka. They contribute prominently in geographic extent, biophysical and socio-cultural diversity and uniqueness. The extent of species endemism in vascular plants alone ranges from 32% to 40% in the mountain ecosystems. Other groups, such as reptiles, amphibians and fish show more than 50% of species endemism in Western Ghats. Of the 979 bird species recorded from the Himalayan region, four Endemic Bird Areas have been delineated for priority conservation measures and, likewise, identification of Key Biodiversity Areas (KBAs) has been initiated in Western Ghats.

As per the IUCN Red List version-2010, 94 species of mammals, 78 species of birds, 66 species of amphibians, 30 species of reptiles, 122 species of fish, 113 species of invertebrates and 255 species of plants in India are listed as Critically Endangered, Endangered and Vulnerable. So far, 758 animal and plant species are listed as globally threatened in India by IUCN, which is about less than 1% (i.e. 0.55%) of species documented in India.

For India, conservation of biodiversity is crucial not only because it provides several goods and services necessary for human survival, but also because it is directly linked with providing livelihoods to and improving socio-economic conditions for millions of local people, thereby contributing to sustainable development and poverty alleviation. An example of a benefit derived from biodiversity in India is reflected by the forest sector, which is increasingly being looked upon as a major performer in poverty alleviation programmes. India's forests neutralize nearly 11% of India's greenhouse gas emissions. Nearly 200 million people are dependent on forests for livelihood in India. As per formal estimates, forestry and logging contributed to approximately 1.5% of the total gross domestic product (GDP) of the country in 2001-2002 – a figure that includes neither informal trade and use of forest products nor the non-tangible benefits derived from them (such as their role in terms of CO2 fixation). Joint Forest Management (JFM) is aimed at

regenerating and sustainably using forests through the involvement of local communities. At present, there are more than 100,000 JFM Committees involving 2.2 million people living in and around forests. To complement this initiative, a National Afforestation Programme is being implemented which aims to rehabilitate degraded forests and fringe areas through people's participation and adherence to the principles of JFM.

As a part of the National Action Plan on Climate Change (NAPCC), and with a budget of 10 billion USD over a ten-year period, India recently launched the Green India Mission (GIM) with the objective of doubling the area for afforestation/ecorestoration to 20 million ha, improve ecosystem services, biodiversity and carbon sequestration in 10 million ha, and increase forests-based livelihood incomes for 3 million forests-dependent households. Realizing the crucial role of forests in maintaining ecological balance and socio-economic development, the National Forest Policy (NFP) aims at maintaining a minimum of 33% of the country's geographical area under forest and tree cover.

India's vast coastline also supports a huge human population, which is dependent on the rich coastal and marine resources. It is estimated that nearly 250 million people live within the swath of 50 km from the coastline of India. Therefore, the ecological services of marine and coastal ecosystems of India play a vital role in India's economic growth.

The world's largest social security scheme under the Mahatma Gandhi National Rural Employment Guarantee Act (2005) (MGNREGA) has created nearly five million green jobs in activities such as afforestation, water harvesting, soil conservation and land development.

Main pressures on and drivers of change to biodiversity (direct and indirect)

The main threats to biodiversity include: habitat fragmentation, degradation and loss; over-exploitation of resources; shrinking genetic diversity; invasive alien species; declining forest resource base; climate change and desertification; impact of development projects; impact of pollution. In the backdrop of the varying socio-cultural milieu and often conflicting demands of various stakeholders, there is an urgent need for augmenting and accelerating the efforts for conservation and sustainable use of biodiversity, and for the fair and equitable sharing of benefits arising from the utilization of genetic resources.

Actions taken to achieve the 2020 Aichi Biodiversity Targets

The protected area network in India has been used as a tool to manage natural resources for biodiversity conservation and for the well-being of resource-dependent populations. So far, India has established a network of 679 Protected Areas (PAs), extending over 1,62,365.49 km2 (4.9% of the total geographic area) and comprising 102 National Parks, 517 Wildlife Sanctuaries, four Community Reserves and 56 Conservation Reserves. These wildlife protected areas also include 39 Tiger Reserves and 28 Elephant Reserves, along with 6 World Heritage Sites within UNESCO's framework. Scientific monitoring and traditional observations confirm that depleted natural resources are being restored and/or pristine ecological conditions have been sustained in well-managed PAs. So far, 115 wetlands have been identified under the National Wetland Conservation Program and 25 wetlands are already classified as Ramsar sites. Particular attention is also drawn to forest protection, with numbers of programs, projects and vast regulation aimed at reforestation (the National Forest Policy aims to maintain a minimum of 33% of the country's geographical area under forest and tree cover), conservation and sustainable development, eco-development of degraded forests, development of community conservation reserves outside PAs, economic valuation of ecosystem services and climate change, and finally inculcating awareness and imparting training to a range of stakeholders, including school students, ex-servicemen, farmers, Panchayati Raj Institutions (PRIs), extension workers, community groups, etc. In parallel, recovery programs have been initiated for critically endangered species, and reintroduction of threatened species into their natural habitats has been carried out for crucial species, such as pitcher plants, rhinoceros and mangroves. As a result of improved conservation effectiveness, some positive trends have already been reported for several species. Tiger and elephant populations have been increasing in recent years, and the Indian rhino's endangerment level has been modified from endangered to vulnerable. In terms of ex situ conservation, several national gene banks were created for plants, animals, insects, fish and agriculturally-important micro-organisms (which notably hold 366,933 unique accessions of plant genetic resources and 2,517 microorganisms). Moreover, India, being a CITES Party, actively prohibits the international trade of endangered wild species and several measures are in place to control threats from invasive alien species (e.g. certificates for exports, permits for imports, etc.).

Towards achieving Aichi Biodiversity Targets 11 and 14, 106 coastal and marine sites have been identified and prioritized as Important Coastal and Marine Areas (ICMBA). Along India's west coast, 62 ICMBAs have been identified, and an additional 44 ICMBAs identified along the east coast. These sites have also been proposed as Conservation or Communities Reserves with the participation of local communities. Efforts are currently underway to secure and strengthen community participation in the management of the marine protected area network in India.

India has six natural World Heritage Sites having 'Outstanding Universal Values' (e.g. Kaziranga National Park, Manas National Park, Keoladeo National Park, Nandadevi National Park (including Valley of Flowers), Sundarbans National Park and Western Ghats serial site). More natural sites of India are tentatively listed for assessment and evaluation in regard to consideration of their inscription as World Heritage Sites. Further, India has identified 12Trans boundary Protected Areas through bilateral and/or multilateral cooperation that has been initiated with neighboring nations.

India's contribution to crop biodiversity has been impressive with repositories of over 50,000 varieties of rice, 5,000 of sorghum, 1,000 varieties of mango, etc. The National Genebank, primarily responsible for ex situ conservation of unique germplasm on a long-term basis, holds nearly 400,000 unique accessions of plant genetic resources. India's National Gene Bank is considered among the most dynamic and prominent systems in the world.

Support mechanisms for national implementation (legislation, funding, capacity-building, coordination, mainstreaming, etc.)

The conservation and sustainable use of biodiversity, based on local knowledge systems and practices, are engrained in Indian ethos and enshrined in the Constitution of India (Article 48A and Article 51(g)). Key laws, strategies and policies related to biodiversity include the Biodiversity Act (2002), National Wildlife Action Plan (2002-2016), National Environmental Policy (2006), NBAP (2008) and NAP for Climate Change (2008).

In addition, India has recently strengthened implementation mechanisms in policy, legislative and administrative measures for biodiversity conservation and management. In this context, major positive initiatives include: (i) Biological Diversity Act and Rules; (ii)

Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights Act, 2006); (iii) Wildlife Crime Control Bureau; (iv) Green India Mission; (v) Mahatma Gandhi National Rural Employment Guarantee Act; (vii) setting up the National Fisheries Development Board (2006). Biodiversity has been mainstreamed in the agricultural sector (e.g. National Policy for Farmers (2007); Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act; International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), Ministry of Agriculture), in forestry policies (e.g. Forest Rights Act), in planning and development (e.g. EIA Notification 2006), in tourism (e.g. National Wildlife Action Plan (NWAP)), and in the fishery sector (e.g. National River Conservation Programme, National Lake Conservation Plan, National Wetland Conservation Programme).

Preparation of an easily navigable database of codified traditional knowledge on Indian systems of medicine (Ayurveda, Sidha and Unani), in the form of a Traditional Knowledge Digital Library (TKDL), has been a pioneering initiative of India so as to prevent misappropriation of India's traditional knowledge at international patent offices. Non-disclosure agreements on TKDL have been entered into with the patent offices of the USA, EU and some EU countries. Following this, citation of TKDL references as prior art has led to setting aside of decisions to grant patents, or cancellation of intent to grant patents, or withdrawing of patent applications in over 50 cases in European patent offices in recent years.

India has made remarkable progress regarding capacity-building in several areas such as: (i) forest-based enterprises; (ii) development of Self Help Groups for synergy of Joint Forest Management with other schemes of the Government; and (iii) CEPA. The involvement of diverse stakeholders is enhanced through partnerships with NGOs, community groups, government, entrepreneurs and industry while regional and international cooperation for conservation and management of biodiversity is promoted through various extant and evolving bilateral agreements and MEAs.

India hosted COP-11 in Hyderabad from 1-19 October 2012. As the first Champion under the Hyderabad Call for Biodiversity Champions launched during CoP-11, India has earmarked a sum of USD $50 million during India's Presidency of COP to strengthen

institutional mechanisms, enhance the technical and human capabilities for biodiversity conservation in India, and to promote similar capacity-building in other developing countries.

Mechanisms for monitoring and reviewing implementation

Various monitoring programs have been put in place in several ecosystems as well as for particular species (e.g. monitoring of the Illegal Killing of Elephants (MIKE); participatory natural resource monitoring in selected villages in Uttara Kannada district; monitoring of climate change and forests; monitoring of genetic variation using techniques such as DNA fingerprinting under LaCONES; pollution monitoring and control; monitoring for Success in World Natural Heritage Sites under the UNESCO-IUCN project 'Enhancing Our Heritage: the management effectiveness evaluation of Keoladev National Park, Rajasthan and Kaziranga National Park'; and water quality monitoring stations which have been further upscaled to over 158 in 10 rivers). Finally, a crucial task is completed by the monitoring committee of the National Wildlife Action Plan (NWAP) which periodically assesses the status of the establishment and management of Indian PAs. India has advanced a forests mapping programme. The Forest Survey of India undertakes a biennial assessment of forest and tree cover.

Biogeographic Zones of India

The tendency to classify ecological regions, and plant and animal groupings, according to their geographical distribution and their essential similarities and differences, is not new. Traditional human communities did this on the basis of their own understanding, though their knowledge was necessarily somewhat restricted in its geographical spread (Banwari 1992; Gurukkal 1989). Unfortunately, this aspect of traditional community knowledge is not well appreciated or studied. In modern times, biogeographical classification started in the latter half of the 19th century, with Blandford (1870, 1901) and Elwes (1873) using the distribution of animals to classify bioregions, and Clarke (1898) followed by Hooker (1907), using plant distribution to the same end. What distinguished most of these early attempts and indeed all except some recent efforts was that they were either phytogeographic, *i.e.,* based solely on plant distribution, or zoogeographic, *i.e.,* based only on animal distribution. An attempt to synthesize the two approaches, or come up with a fresh classification based on the combination of plant and animal distribution, is very recent, and has been prompted by the need to use such zonation in fixing

conservation priorities. These three kinds of approaches have been used or analyzed by several authors recently, including Mani (1974), Puri *et al.*, (1983), Meher-Homji and Mishra (1973), Menon (1990) and Rodgers & Panwar (1988).

One of the major recent approaches to classification of India's ecosystems has been based on biogeography (Rodgers and Panwar 1988). The major objective of this exercise was to develop a biogeographical classification based on known information, which will enable conservation planning both at the national and state levels. This classification uses four levels of planning:

1. The biogeographic zone, a large distinctive unit of similar ecology, biome representation, community a. and species;
2. The biotic province, a secondary unit within a zone, giving weight to particular communities separated by dispersal barriers or gradual change in environmental factors;
3. The sub-division or region, a tertiary set of units within a province, indicating different land forms; and finally;
4. The biome, which is an ecological unit and not a biogeographic unit. A biome can be found in several biogeographic zones or provinces.

A slightly modified version of the biogeographic classification pr by Rodgers & Panwar (1988) and Rao (1994) has been followed here. There are 12 broad geographic zones in India.

SN	Geographic Zone of India
1.	Trans- Himalaya
2.	West-Himalaya
3.	East Himalaya
4.	North-east Himalaya
5.	The Indian Desert
6.	Semi-Arid
7.	Gangetic Plain
8.	Western Ghats
9.	Deccan Peninsular
10.	Indian Coasts
11.	Andaman & Nicobar Islands
12.	Lakshadweep Islands

Rodgers *et al.,* (2002) recognize ten biogeographic zones divided into twenty-six biotic provinces in India:

SN	Zone Name	Zone Area (Sq km)	Percentage of India's Land Area (%)
1.	Trans- Himalaya	184823	5.62
2.	Himalaya	210662	6.41
3.	Desert	215757	6.56
4.	Semi-Arid	545850	16.60
5.	Western Ghats	132606	4.03
6.	Deccan Peninsula	1380380	41.99
7.	Gangetic Plain	354782	10.79
8.	Coasts	82813	2.52
9.	Northeast	171341	5.21
10	Islands	8249	0.25
	Grand Total	**3287263**	**100**
Source: Rodgers et al. 2002			

1. **Trans-Himalaya:** The Trans-Himalaya forming the " cold desert of India" is the most distinct zone covering the entire Laddakh and Kargil district of Laddakh Union Territory, and the Spiti valley, Lingti plains (Lahaul valley), and Pooh tehsil (district Kinnaur) in Himachal Pradesh. Small areas in the rain shadows of Nanda Devi range (Uttaranchal) and Kangchendzonga range (Sikkim) are also part of this zone (Mehta and Julka 2001). The area is a distinct biogeographic unit with harsh climatic conditions and is usually referred to as cold desert (Rodgers and Panwar 1998). The area is characterized by great extrems of heat &cold coupled with extreme dryness. **Due to the great fluctuation in temperature, the mountains get cracked and crumbed.** The region is the most elevated zone on the earth and varies from 2800 m in the Indus to over 7000 m in the Himalayan and Karakoram ranges (Mehta and Julka 2001). The flora is mainly of scrub types classified as alpine scrubs.

   Species: *Podophyllum hexandrum, Saussurea subulata, Ephedra gerardiana, Cicer microphyllum etc.*
2. **Western Himalaya:** The Himalaya zone consists of an area of 21,0662 sq km, approximately 6.41% of the country's total land surface. The west Himalaya cover Sutlej River to the Gandak River in Nepal. The western Himalaya biogeographic zone consists of two separate phytogeographical regions that are (A). The Western Himalaya or the Kumao Himalaya covering mainly the Garwal & Kumao and (B). North-west Himalaya comprising

the state of Himachal Pradesh & North-west part of Jammu & Kashmir state. It includes northwest Himalaya (Kashmir to the Sutlej River in Himachal Pradesh). The Himalaya is characterized by drought resistant/cold loving plants in a landscape dominated by vast and gregarious conifer forests of Chir, Pine, Deodar & Fir etc.

Floral Species: *Anogeisus latifolia, Terminalia alata, Dandrocalamus strictus, Diospyros malabarica, Grvia optica, Toona ciliate,* and *Pinus spp*.

3. **The Eastern Himalaya:** this geographic zone encludes Sikkim, Darjeeling district of West Bangal and Arunachal Pradesh. The climate and resultant vegetation types are so different that it is worthwhile to treat western & eastern Himalayas is distinct biogeographic zone.

   Floral Species: *Dipterocarpus retusus, Syzygium cumini, Gmelina arborea, rhododendron spp., Salix spp.*

4. **North-east India:** The north-east Indian biogeographic zone is most significant as it represents the transition zone between the Indian, Indo-Malayan and Indo-Chinese biogeographic regions, as well as a meeting-place of Himalayan Mountains with that of Peninsular India. It comprises eight states Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. The region acts as a biogeographic gateway for plant migration. In India, apart from the Western Ghats, Northeast India is one of the 34 biodiversity 'hotspots' in the world (Myers *et. al.*, 2002).

   Floral Species: *Hibiscus spp., Ficus recemosa, Lica asiatica, Careya arborea, Desmodium spp., Bamboo spp., D. giganteus, D, hamiltonii, Bambusa tulda, Gloriosa superb, Costus spp., Acarus calamus, Swertia chirayita, Rowoulfia serpentine etc.*

5. **The Indian Desert:** The Indian desert lies on the northwestern boundary of India and merges with the desert area of Pakistan. Prior to the separation of the country it was known as under common name “The Great Indian Desert”. It covers mainly the western and northwestern region of Rajasthan and part of Kachchh region of Gujarat in the southwest. It has an elevation of about 350-450 m above sea level at the Aravalli range in the east, about 100 m in the south and west and about 20 m in the Rann of Kachchh (Baqri and Kankane 2001). The Indian desert is characterized by high atmospheric temperature and low & erratic rainfall, high wind velocity, low humidity, high evaporation, the non existence of perennial water source and scanty vegetations.

Floral Species: *Indigofera spp, Prosopis cineraria, Cenchrus biflorus, Tamarix indica, Anogeisus latifolia, Boswellia association, Euphorbia spp, Commiphora spp, Bombax ceiba, etc.*

6. **Semi-Arid:** This region is a zone of transition between the true desert in the west to the extensive communities of the Deccan Peninsular India, to the south and east. Mainly the area surrounding the desert zone of western Gujrat and Rajsthan are considered under this. This zone has biological links with western Asia & North Africa. The climate is very hot in summer & markedly cold in winter. This zone includes the Punjab plains, Delhi, Haryana, fringes of Jammu and Kashmir, Himachal Pradesh, and western edges of Uttar Pradesh, eastern Rajasthan, eastern Gujarat and northwest Madhya Pradesh. The Semi-arid zone represents a characteristic savannah woodland and dry deciduous and tropical thorn forest zone in Western India. The Aravalli system constitutes the heart of this zone, which primarily supports two types of vegetation: Tropical Dry Deciduous Forest and Tropical Thorn Forest.

   Floral Species: *Acacia nilotica, Anogeisus latifolia, Grewia, Zyzyphus Xylopyra, Dendrocalamus strictus, Acacia leucocephala etc.*

7. **Western Ghats:** The Western Ghats biogeographic zone forms the "Malabar Provinces". According to several phytogeographers it is a narrow stretch running from the Tapti river in the north to Kanyakumari in south, along the west coast of India. It covers peninsular India through the states of Gujarat, Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala (Lakshminarayana *et. al.*, 2001).The Western Ghats zone is one of the 34 biodiversity 'hotspots' in the world (Myers *et. al.*, 2002) and is one of the major tropical evergreen forested regions in India, exhibiting enormous plant diversity. About 4000 species of flowering plants occur in the region, which harbors nearly 27% of the total flora in India (Nayar 1996). Among these, 1500 species are endemic (Mackinnon and Mackinnon 1986). The Western Ghats region is a major genetic estate with a rich biodiversity of ancient lineage. The climate and altitudinal gradient has resulted in a variety of forest types from evergreen to semi evergreen to moist deciduous and dry deciduous formations.

   Floral Species: *Semcarpus anacadium, Albizia labbeck, sterculia urens, Bombax ceiba, tectona grandis, Terminalia spp., Euphorbia spp., Canarium strictum* etc.

The Sholas: The Sholas are characteristically seen along the folds of rolling down at a height of 1600 m and above, where moisture content is very high. They are isolated compact evergreen patches composed of stunted trees & bushes called Sholas found in **Nilgiri.**

8. **Deccan Peninsula:** The Deccan Peninsula biogeographic zone includes a major portion of the states of Maharashtra, Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Karnataka, Tamil Nadu, Andhra Pradesh, Orissa and Bihar. The D. peninsula biogeographic zone in India is the most extensive but relatively a homogenous zone covering about 43% of total Indian landmass. Climatically it ranges from semi-arid to moist deciduous/ semi-evergreen type of climate. The central highlands comprise the Vindhya and Satpura hill ranges, Chhota Nagpur Plateau, Eastern Ghats, Tamil Nadu Plains and Karnataka Plateau (Cherian 2001). The Vindhya and Satpura hill range are known for a rich diversity of flora. The zone reveals a considerable variation in climate. The summer is long & very serves. The rainfall pattern is also highly variable.

   Floral Species: *Lagerstromia parviflora, Emblica officenalis, Schelicheira oleosa, anogeisus latifolia, Cassia auriculiformis, Caria asculata* etc.

9. **Gangetic Plains:** This zone includes the Gangetic divide, the Upper Gangetic plain, the Middle Gangetic plain and the Lower Gangetic plain (Hooker 1907). This zone is mostly under agriculture and supports dense human population stretching from eastern Rajasthan through Uttar Pradesh to Bihar and West Bengal. The Gangetic plain includes the area adjacent to Terai-Bhabar tracts in Uttar Pradesh, Bihar and West Bengal. The entire region is a flat alluvial region.

   Floral Species: *Adina cardifolia, Sachhrum munja, Boswellia saraata, Anogeisus pendula, Vetiveria, Cymbopogon spp., Dichanthium, Andropogon spp.,* of grassland are found in this geographical area.

10. **Indian Coasts:** The coast line of India stretches from Gujarat to Cape Comorin (Kanyakumari) in the west and from Sundarbans to Cape Comorin in the east. Approximate 4500 km long stretch of coastline in the mainland has a very diverse set of biotic communities. The coastal ecosystem of India includes the submerged vegetation and mangrove forest, and tidal or swamp forests.
11. **Andaman & Nicobar Islands:** The Andaman & Nicobar Islands are an elongated north-south oriented group of 348 islands in the way of Bengal stretching for 590 km from 6° to

13° N latitude and 92° to 93° E longitude. The Andaman Islands are about 190 km from Cape Negrais in Burma, the nearest point on the mainland. Five islands close together constitute the Great Andaman (300 km long), and the Little Andaman lies to the south. The Nicobar groups of Islands are separated from the Andaman as well as internally from each other by 800 m deep channels. This geographical zone has number of Dipterocarpaceae members, but shows a high diversity of tree ferns and palms, characteristics of Indonesian forests. The climate is hot and humid with the day temperature varying between 30-35^0 C, The rainfall is high; there is no marked winter season.

12. **Lakshadweep Islands:** The Lakshadweep Islands are an archipelago of 27 small islands stretching from 8° to 12° N latitude and 71° to 74° E longitude in the Arabian Sea. They are 320 km away from the Kerala coast. Rivers and streams are absent here only seepage water occurs below the land surface and is replenished by rain water.

Floral Species: *Salmalia malabarica, Carica papaya, Mengifere indica, Areca catechu, Piper betle.*

Global Biodiversity Hotspots with Special Emphasis on Indian Hotspots

Introduction

- Biodiversity hotspots are regions with high species richness and a high degree of endemism.
- The British biologist Norman Myers coined the term "biodiversity hotspot" in 1988 as a biogeographic region characterized both by exceptional levels of plant endemism and by serious levels of habitat loss.
- In 1990 Myers added a further eight hotspots, including four Mediterranean-type ecosystems.
- **Conservation International** (CI) adopted Myers' hotspots as its institutional blueprint in 1989, and in 1996, the organization made the decision to undertake a reassessment of the hotspots concept.
- **According to CI, to qualify as a hotspot a region must meet two strict criteria:**
    A. It must contain at least 1500 species of vascular plants (> 0.5% of world's total) as endemics- which is to say, it must have a high percentage of plant life found nowhere else on the planet. A hotspot, in other words, is irreplaceable.
    B. It has have lost at least 70% of its original habitat. (It must have 30 5 or less of its original natural vegetation). In other words, it must be threatened.
- Three years later an extensive global review was undertaken, which introduced quantitative thresholds for the designation of biodiversity hotspots.
- According to CI, 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% of the world's total) as endemics, and it has to have lost at least 70% of its original habitat.
- In 1999, CI identified 25 biodiversity hotspots in the book "Hotspots: Earth's biologically Richest and Most Endangered Terrestrial Ecoregions".
- In 2005 CI published an updated titled "Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions".
- Currently (2011), it was identified as the 35 Global biodiversity hotspot
- The **35 biodiversity hotspots** cover 2.3% of the Earth's land surface, yet more than 50% of the world's plant species and 42% of all terrestrial vertebrate species are endemic to these areas.

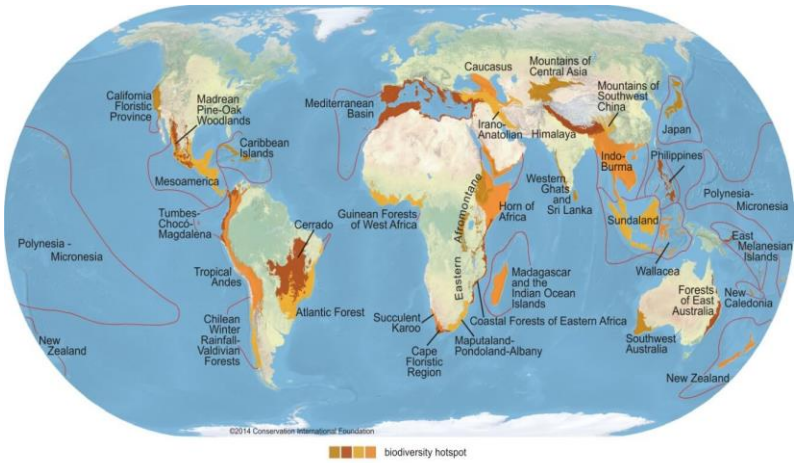
Collectively, these areas held as endemics about 44% of the world's plants and 35% of terrestrial vertebrates in an area that formerly covered only 11.8% of the planet's land surface. The habitat extent of this land area had been reduced by 87.8% of its original extent, such that this wealth of biodiversity was restricted to only 1.4% of Earth's land surface.

Global Biodiversity Hotspots: World

I. **AFRICA:** A total of 8 Hotspots in African continent hold a diversity of plant and animal life, many of which are found nowhere else on Earth.
II. **ASIA-PACIFIC:** Composed of large land areas as well as islands dotting the Pacific seas, these 14 Hotspots represent important biodiversity.
III. **EUROPE AND CENTRAL ASIA:** From the Mediterranean Basin to the Mountains of Central Asia, these four Hotspots are unique in their diversity.
IV. **NORTH AND CENTRAL AMERICA:** North and Central America play host to thousands of acres of important habitat.
V. **SOUTH AMERICA:** From Brazil's Cerrado to the Tropical Andes, South America has some of the richest and most diverse life on Earth.

Life on Earth faces a crisis of historical and planetary proportions. Unsustainable consumption in many northern countries and crushing poverty in the tropics are destroying wild nature. Biodiversity is besieged. Extinction is the gravest aspect of the biodiversity crisis: it is irreversible. While extinction is a natural process, human impacts have elevated the rate of extinction by at least a thousand, possibly several thousand, times the natural rate. Mass extinctions of this magnitude have only occurred five times in the history of our planet; the last brought the end of the dinosaur age. In a world where conservation budgets are insufficient given the number of species threatened with extinction, identifying conservation priorities is crucial.

The biodiversity hotspots hold especially high numbers of endemic species, yet their combined area of remaining habitat covers only 2.3% of the Earth's land surface. Each hotspot faces extreme threats and has already lost at least 70% of its original natural vegetation. Over 50% of the world's plant species and 42% of all terrestrial vertebrate species are endemic to the 35 biodiversity hotspots.



Conservation International (conservation.org) defines 35 biodiversity hotspots — extraordinary places that harbor vast numbers of plant and animal species found nowhere else. All are heavily threatened by habitat loss and degradation, making their conservation crucial to protecting nature for the benefit of all life on Earth.

World's 35 Biodiversity Hotspots

I	**Africa**	**III**	**Europe and Central Asia**
1.	Cape Floristic Region	23.	Caucasus
2.	Coastal Forests Eastern Africa	24.	Irano-Anatolian
3.	Eastern Afromontane	25.	Mediterranean basin
4.	Guinean Forests of West Africa	26.	Mountains of Central Asia
5.	Horn of Africa	**IV**	**North and Central America**
6.	Madagascar and the Indian ocean Islands	27.	California Floristic Province
7.	Maputaland-Pondoland-Albany	28	Caribbean Islands
8.	Succulent Karoo	29.	Madrean Pine-Oak Woodlands
II	**Asia-Pacific**	30.	Mesoamerica
9.	East Melanesian Islands	**V**	**South America**
10.	Himalaya	31.	Atlantic Forest
11.	Indo-Burma	32.	Cerrado
12.	Japan	33.	Chilean Winter Rainfall-Valdivian Forests
13.	Mountains of Southwest China	34.	Tumbes-Chocó-Magdalena
14	New Caledonia	35.	Tropical Andes
15	New Zealand		
16	Philippines		
17	Polynesia-Micronesia		
18	Southwest Australia		
19	Forests of Eastern Australia (new)		
20	Sundaland		
21	Wallacea		
22.	Western Ghats and Sri Lanka		

The map shows 35 biodiversity hotspots which cover 2.3% of the Earth's land surface, yet more than 50% of the world's plant species and 42% of all terrestrial vertebrate species are endemic to these areas (Conservation International). These are the areas which are suffering biodiversity loss and where attention is needed.

GLOBAL BIODIVERSITY HOTSPOTS: ASIA-PACIFIC

1. East Melanesian Islands

Once largely intact, the 1,600 East Melanesian Islands are now a hotspot due, sadly, to accelerating levels of habitat loss.

2. Himalaya

The Himalaya Hotspot is home to the world's highest mountains, including Mt. Everest.

3. Indo-Burma

Encompassing more than 2 million km² of tropical Asia, Indo-Burma is still revealing its biological treasures.

4. Japan

The islands that make up the Japanese Archipelago stretch from the humid subtropics in the south to the boreal zone in the north, resulting in a wide variety of climates and ecosystems.

5. Mountains of Southwest China

With dramatic variations in climate and topography, the Mountains of Southwest China support a wide array of habitats including the most endemic-rich temperate flora in the world.

6. New Caledonia

An island the size of New Jersey in the South Pacific Ocean, New Caledonia is the home of no less than five endemic plant families.

7. New Zealand

A mountainous archipelago once dominated by temperate rainforests, New Zealand harbors extraordinary levels of endemic species.

8. Philippines

More than 7,100 islands fall within the borders of the Philippines hotspot, identified as one of the world's biologically richest countries.

9. Polynesia-Micronesia

Comprising 4,500 islands stretched across the southern Pacific Ocean, the Polynesia-Micronesia hotspot is the epicenter of the current global extinction crisis.

10. Southwest Australia

The forest, woodlands, shrublands, and heath of Southwest Australia are characterized by high endemism among plants and reptiles.

11. Forests of Eastern Australia

Forests of East Australia Hotspot consists of a discontinuous coastal stretch along the Australian states of Queensland and New South Wales, extending inland and further west, although it includes the New England Tablelands and the Great Dividing Range. This region contains more than 1500 endemic vascular plants.

12. Sundaland

The spectacular flora and fauna of the Sundaland Hotspot are succumbing to the explosive growth of industrial forestry in these islands.

13. Wallacea

The flora and fauna of Wallacea are so varied that every island in this hotspot needs secure protected areas to preserve the region's biodiversity.

14. Western Ghats and Sri Lanka

Faced with tremendous population pressure, the forests of the Western Ghats and Sri Lanka have been dramatically impacted by the demands for timber and agricultural land.

BIODIVERSITY HOTSPOTS IN INDIA

1. **Himalaya:** Includes the entire Indian Himalayan region (and that falling in Pakistan, Tibet, Nepal, Bhutan, China and Myanmar)
2. **Indo-Burma:** Includes entire North-eastern India, except Assam and Andaman group of Islands (and Myanmar, Thailand, Vietnam, Laos, Cambodia and southern China)
3. **Sundalands:** Includes Nicobar group of Islands (and Indonesia, Malaysia, Singapore, Brunei, Philippines)
4. **Western Ghats and Sri Lanka:** Includes entire Western Ghats (and Sri Lanka)

1. HIMALAYA

The Himalaya Hotspot is home to the world's highest mountains, including Mt. Everest. The mountains rise abruptly, resulting in a diversity of ecosystems that range from alluvial grasslands and subtropical broadleaf forests to alpine meadows above the tree line. Vascular plants have even been recorded at more than 6,000 m. The hotspot is home to important populations of

numerous large birds and mammals, including vultures, tigers, elephants, rhinos and wild water buffalo.

OVERVIEW

Stretching in an arc over 3,000 kilometers of northern Pakistan, Nepal, Bhutan and the northwestern and northeastern states of India, the Himalaya hotspot includes all of the world's mountain peaks higher than 8,000 meters. This includes the world's highest mountain, Sagarmatha (Mt. Everest) as well as several of the world's deepest river gorges.

This immense mountain range, which covers nearly 750,000 km², has been divided into two regions: the Eastern Himalaya, which covers parts of Nepal, Bhutan, the northeast Indian states of West Bengal, Sikkim, Assam, and Arunachal Pradesh, southeast Tibet (Autonomous Region of China), and northern Myanmar; and the Western Himalaya, covering the Kumaon-Garhwal, northwest Kashmir, and northern Pakistan. While these divisions are largely artificial, the deep defile carved by the antecedent Kali Gandaki River between the Annapurna and Dhaulagiri mountains has been an effective dispersal barrier to many species.

The abrupt rise of the Himalayan Mountains from less than 500 m to more than 8,000 m results in a diversity of ecosystems that range, in only a couple of hundred kilometers, from alluvial grasslands (among the tallest in the world) and subtropical broadleaf forests along the foothills to temperate broadleaf forests in the mid hills, mixed conifer and conifer forests in the higher hills, and alpine meadows above the tree line.

Biogeographically, the Himalayan Mountain Range straddles a transition zone between the Palearctic and Indo-Malayan realms. Species from both realms are represented in the hotspot. In addition, geological, climatic and altitudinal variations in the hotspot, as well as topographic complexity, contribute to the biological diversity of the mountains along their east-west and northsouth axes.

PLANTS

Of the estimated 10,000 species of plants in the Himalaya hotspot, about 3,160 are endemic, as are 71 genera. Furthermore, five plant families are endemic to the region, the Tetracentraceae, Hamamelidaceae, Circaesteraceae, Butomaceae and Stachyuraceae. The largest family of flowering plants in the hotspot is the Orchidacea, with 750 species, and a large number of

orchids, many representing rather young endemic species, have recently been reported from the hotspot, indicating that further exploration will probably reveal a much higher degree of plant endemism.

The Eastern Himalaya is also a center of diversity for several widely distributed plant taxa, such as Rhododendron, Primula, and Pedicularis. In the Himalaya Hotspot, a zone of permanent rock and ice begins at about 5,500–6,000 m; in spite of these harsh conditions, there are records of vascular plants occurring at some of the highest elevations on Earth. Cushion plants have been recorded at more than 6,100 m, while a high-altitude scree plant in the mustard family, **Ermania himalayensis**, was found at 6,300 m on the slopes of Mt. Kamet in the northwestern Himalayas.

THREATS

Human Impacts

Despite their apparent remoteness and inaccessibility, the Himalayas have not been spared human-induced biodiversity loss. People have lived in the mountains of the Himalayas for thousands of years. In recent decades, greater access to the global market has increased the demand for natural resources in the area encouraged both immigration from outside (such as Arunachal Pradesh) and movement within the region (such as in Nepal). As a result, populations are growing in the most productive ecosystems, which are also some of the richest in biodiversity.

Today, remaining habitat in the Himalaya is patchy. The steadily increasing population in the hotspot has led to extensive clearing of forests and grasslands for cultivation, and widespread logging. Both legal and illegal logging often occurs on extremely steep slopes, resulting in severe erosion. Although cultivation has a general upper limit of about 2,100 m on slopes exposed to monsoons, people farm crops such as barley, potato and buckwheat at high elevations in the inner valleys and trans-montane regions, and in some areas such as Jumla, Kashmir, Lahoul, and Ladakh, there are major agriculturally based population centers well above this elevation. The land is also often cleared in the summer months for livestock; the use of fire to clear land poses an additional threat to forest land, as fires sometimes spread out of control. The conversion of forests and grasslands for agriculture and settlements has led to large-scale deforestation and habitat fragmentation in Nepal, and in the Indian States of Sikkim, Darjeeling, and Assam.

Large areas of remaining habitat in the hotspot are highly degraded. Overgrazing by domestic livestock, including cattle and domesticated yak, is widespread in the lowlands and alpine ecosystems. The flora of fragile alpine meadows has been overexploited for traditional medicine (because medicinal plant collectors invariably uproot the entire plant, regrowth is retarded). Fuelwood collection and non-timber forest product extraction, both for domestic consumption and export, has inflicted severe damage to some forest ecosystems. Unplanned and poorly managed tourism has led to environmental deterioration. Political unrest, often in the form of insurgencies, also threatens the integrity of some protected areas.

In addition to habitat loss and degradation – which has led to perhaps no more than 25% of the original vegetation in this hotspot still intact – poaching is a serious problem in the Himalayan Mountains, with tigers and rhinoceros hunted for their body parts for traditional Chinese medicine, while snow leopards (**Uncia uncia**, EN) and red pandas (**Ailurus fulgens**, EN) are sought for their beautiful pelts. Other threats to biodiversity and forest integrity include mining, the construction of roads and large dams, and pollution due to the use of agrochemicals.

1. INDO-BURMA

Encompassing more than 2 million km² of tropical Asia, Indo-Burma is still revealing its biological treasures. Six large mammal species have been discovered in the last 12 years: the large-antlered muntjac, the Annamite muntjac, the grey-shanked douc, the Annamite striped rabbit, the leaf deer, and the saola. This hotspot also holds remarkable endemism in freshwater turtle species, most of which are threatened with extinction, due to over-harvesting and extensive habitat loss. Bird life in Indo- Burma is also incredibly diverse, holding almost 1,300 different bird species, including the threatened white-eared night-heron, the grey-crowned crocias, and the orange-necked partridge.

OVERVIEW

The Indo-Burma hotspot encompasses 2,373,000 km² of tropical Asia east of the Ganges-Brahmaputra lowlands. Formerly including the Himalaya chain and the associated foothills in Nepal, Bhutan and India, the Indo-Burma hotspot has now been more narrowly redefined as the Indo-Chinese subregion. The hotspot contains the Lower Mekong catchment. It begins in eastern Bangladesh and then extends across north-eastern India, south of the Brahmaputra River, to

encompass nearly all of Myanmar, part of southern and western Yunnan Province in China, all of the Lao People's Democratic Republic, Cambodia and Vietnam, the vast majority of Thailand and a small part of Peninsular Malaysia. In addition, the hotspot covers the coastal lowlands of southern China (in southern Guangxi and Guangdong), as well as several offshore islands, such as Hainan Island (of China) in the South China Sea and the Andaman Islands (of India) in the Andaman Sea. The hotspot contains the Lower Mekong catchment.

The transition to the Sundaland Hotspot in the south occurs on the Thai-Malay Peninsula, the boundary between the two hotspots is represented by the Kangar-Pattani Line, which cuts across the Thailand-Malaysia border, though some analyses indicate that the phytogeographical and zoogeographical transition between the Sundaland and Indo-Burma biotas may lie just to the north of the Isthmus of Kra, associated with a gradual change from wet seasonal evergreen dipterocarp rainforest to mixed moist deciduous forest.
Much of Indo-Burma is characterized by distinct seasonal weather patterns. During the northern winter months, dry, cool winds blow from the stable continental Asian high-pressure system, resulting in a dry period under clear skies across much of the south, center, and west of the hotspot (the dry, northeast monsoon). As the continental system weakens in spring, the wind direction reverses and air masses forming the southwest monsoon pick up moisture from the seas to the southwest and bring abundant rains as they rise over the hills and mountains.

A wide diversity of ecosystems is represented in this hotspot, including mixed wet evergreen, dry evergreen, deciduous, and montane forests. There are also patches of shrublands and woodlands on karst limestone outcrops and, in some coastal areas, scattered heath forests. In addition, a wide variety of distinctive localized vegetation formations occur in Indo-Burma, including lowland floodplain swamps, mangroves, and seasonally inundated grasslands.

The patterns of biological diversity in Indo-Burma have resulted from the interaction of topography, past climate changes, soil characteristics, and the hotspot's patterns of seasonal rainfall. The hotspot contains many localized centers of endemism, particularly montane isolates, but also areas of lowland wet evergreen forest that were isolated at some stage, and river basins.

PLANTS

Knowledge of plant species within the Indo-Burma hotspot is uneven and is hampered by sociopolitical divisions and taxonomic complications. A conservative estimate of total plant diversity in the hotspot reveals about 13,500 vascular plant species, of which about 7,000 (52%) are endemic. Among the flora of the Indo-Burma Hotspot are a wide array of orchid and ginger species (there are more than 1,000 orchid species in Thailand alone) and many tropical hardwood trees, including commercially valuable dipterocarp species and teak (***Tectona grandis***).

THREATS

Human Impacts

Indo-Burma is one of the most threatened biodiversity hotspots, due to the rate of resource exploitation and habitat loss. Only about 5% of natural habitats remain in relatively pristine condition, with another 10 to 25% of the land in damaged, but ecologically functional, condition. Indo-Burma was one of the first places where humans developed agriculture, and has a long history of using fire to clear land for agriculture and other needs. The need for agricultural products has only increased in recent years, with the expansion of both human populations and markets. This has contributed to widespread forest destruction; tree plantations (teak, rubber, oil palm) have replaced large areas of lowland forest, while coffee, tea, vegetable crops and sugarcane plantations threaten montane and hill forests. Other threats to forests include logging, mining for gems and ore, firewood collection, and charcoal production.

Aquatic ecosystems are also under intense development pressure in many areas. Freshwater floodplain swamps and wetlands are destroyed by draining for wet rice cultivation, particularly in Thailand, Myanmar and Vietnam. Rivers have been dammed in order to store water to generate electricity for countries' economic growth, or for export to neighboring countries to generate foreign exchange earnings. Damming a river section not only transforms that section into a large pond, but also reduces the temperature and oxygen content, and increases river-bed erosion and water turbidity downriver. Reservoir operation procedures result in occasional or regular flooding of sandbars, sandbanks, stretches of channel mosaic, and other habitats that would normally be exposed during the dry season, with severe impacts on nesting bird and turtle species. Mangroves have been converted to shrimp aquacultural ponds, while intertidal mudflats

have been extensively afforested with mangrove or intensely fished by lines of stack nets, which severely impacts their value as feeding habitat for migratory water birds and other species.

Moreover, sand dune ecosystems are severely threatened by afforestation, for instance, with the Australian exotic ***Casuarina equisetifolia***. Finally, overfishing and the increasing use of destructive fishing techniques is a significant problem in both coastal and offshore marine ecosystems.

The combination of rapid population growth and economic development has also caused overexploitation of natural resources to reach critical levels in the hotspot. As in the other hotspots of Southeast Asia, the wildlife trade, particularly for the food and traditional medicine markets in China, is an enormous problem for biodiversity conservation. The increasingly high value of products derived from some species has put them at risk even within strictly protected areas. The Chinese demand for turtles, snakes, tigers, and other species has depleted populations to the brink of extinction in just a few years. The volume of trade in turtles is astounding, with over ten million individuals exported to China from Southeast Asia each year. Adults, juveniles, and eggs of all species are harvested.

The threat to plants through international and domestic trade could be just as great, but there is far less accurate information; timber species, orchids, and other high value plants are particularly at risk. Commercial logging has been particularly intense in lowland evergreen forests, to the point where few intact tracts remain and stocks of some species have been exhausted commercially.

3. SUNDALAND

The spectacular flora and fauna of the Sundaland Hotspot are succumbing to the explosive growth of industrial forestry in these islands and to the international animal trade that claims tigers,

monkeys, and turtle species for food and medicine in other countries. Populations of the orangutan, found only in this hotspot, are in dramatic decline. Some of the last refuges of two Southeast Asia rhino species are also found on the islands of Java and Sumatra. Like many tropical areas, the forests are being cleared for commercial uses. Rubber, oil palm, and pulp production are three of the most detrimental forces facing biodiversity in the Sundaland Hotspot.

OVERVIEW

The Sundaland hotspot covers the western half of the Indo-Malayan archipelago, an arc of some 17,000 equatorial islands, and is dominated by two of the largest islands in the world: Borneo (725,000 km²) and Sumatra (427,300 km²). More than a million years ago, the islands of Sundaland were connected to mainland Asia. As sea levels changed during the Pleistocene, this connection periodically disappeared, eventually leading to the current isolation of the islands. The topography of the hotspot ranges from the hilly and mountainous regions of Sumatra and Borneo, where Mt. Kinabalu rises to 4,101 m, to the fertile volcanic soils of Java and Bali, the former dominated by 23 active volcanoes. Granite and limestone mountains rising to 2,189 m are the backbone of the Malay Peninsula. Politically, Sundaland covers a small portion of southern Thailand (provinces of Pattani, Yala, and Narathiwat); nearly all of Malaysia (nearly all of Peninsular Malaysia and the East Malaysian states of Sarawak and Sabah in northern Borneo); Singapore at the tip of the Malay Peninsula; all of Brunei Darussalam; and all of the western half of the megadiversity country of Indonesia, including Kalimantan (the Indonesian portion of Borneo, Sumatra, Java, and Bali). The Nicobar Islands, which are under Indian jurisdiction, are also included.

Sundaland is bordered by three hotspots. The boundary between the Sundaland Hotspot and the Indo-Burma Hotspot to the northwest is here taken as the Kangar-Pattani Line, which crosses the Thailand-Malaysia border. Wallacea lies immediately to the east of the Sundaland Hotspot, separated by the famous Wallace's Line, while the 7,100 islands of the Philippines Hotspot lie immediately to the northeast. Lowland rainforests are dominated by the towering trees of the family Dipterocarpaceae. Sandy and rocky coastlines harbor stands of beach forest, while muddy shores are lined with mangrove forests, replaced inland by large peat swamp forests. In some places the ancient uplifted coral reefs support specialized forests tolerant of the high levels of calcium and magnesium in the soils. Infertile tertiary sandstone ridges support heath forest. Higher elevations boast montane forests thick with moss, lichens, and orchids, while further up, scrubby subalpine forests are dominated by rhododendrons. At the very tops of the highest mountain peaks, the land is mostly rocky and without much vegetation.

PLANTS

Sundaland is one of the biologically richest hotspots on Earth, holding about 25,000 species of vascular plants, 15,000 (60%) of which are found nowhere else. One plant family, the Scyphostegiaceae, is confined to the hotspot and is represented by a single tree species, *Scyphostegia borneensis* from Borneo. There are at least 117 endemic plant genera in the hotspot; 59 of these endemic genera are found in Borneo, 17 in Sumatra, and 41 on the Malay Peninsula.

Borneo boasts a spectacular diversity of trees. There are about 3,000 species, including more than 265 species of dipterocarps; no less than 155 of these are endemic to the island. Borneo also has more than 2,000 species of orchids. The other islands are less diverse than Borneo but still boast an impressive variety of plant life. Sumatran forests include more than 100 dipterocarp species, nearly a dozen of which are endemic, and Java has more than 270 endemic orchids. Notable plants in the hotspot include members of the genus **Rafflesia**, represented by 16 species with very large flowers. One of these, **Rafflesia arnoldii**, has the largest flowers in the world, measuring up to one meter in diameter.

THREATS

Human Impacts

The most significant threat facing Sundaland's biodiversity is forest destruction. Most deforestation has occurred in just the last three decades, a result of commercial logging and major agricultural projects in combination with government policies and small-scale agriculture. Some of the threats to the region's forests include rubber production, pulp production, and commercial and illegal logging. In Sumatra, illegal and unsustainable logging and non-timber forest product extraction are widespread, fueled by high demand from China, North America, Europe, and Japan. The military and police are sometimes involved, as are paper industries, which obtain most of their wood from forests rather than plantations. Oil palm plantations are also an increasing threat to forests in the hotspot. Increasing prices for palm oil led the government of Jambi Province, in

Sumatra, to plan for the conversion of one million hectares of forest to oil palm; similar development is planned in other parts of Sumatra. Furthermore, the infamous Indonesian Transmigration Program, which moved people from more crowded areas of the country, such as Java, to the less populated islands, has accelerated pressures on biodiversity in some places. Rapid road construction increases the extent and speed of deforestation, by providing access for loggers, settlers, and miners.

Particularly hard hit have been the more accessible lowland forests: recent estimates show that Kalimantan's protected lowland forests declined by 56% between 1985 and 2001, primarily from logging, and that less than 33% of lowland forest and peat swamp remains across all of Indonesian Borneo. At current deforestation rates, lowland forest in Sumatra and Kalimantan may soon disappear completely.

Logging has been extensive in some protected areas; for example, forest loss averaged around 2% per year within Bukit Barisan Selatan National Park between 1985 and 1999, and as much as 9.5% per year in GunungPalung National Park between 1999 and 2002. In recent years, fires have become a major threat to the forests of Sundaland. Tropical forests do not naturally burn, but logging operations create flammable conditions by leaving fuelwood on the forest floor and by exposing the understory to drying. Fires are also sometimes intentionally lit to convert forests to oil palm plantations. Because few tropical plants are adapted to periodic fires, tropical forests are very slow to regenerate after burning. Under the intense exploitation pressure in the region, these forests may never return. In 1997, 15,000 square km in Sumatra and 30,000 km in Kalimantan were lost to fire. Today, only around 700,000 km of forest remains, much of it highly fragmented. Only about 100,000 km remains in more or less intact condition, representing approximately 7% of the original extent of the forest. Most of this remaining primary habitat is montane, and lies in the interior of Borneo and within a few protected areas in Sumatra, Peninsular Malaysia, and the southernmost portion of Thailand. Even these areas are under threat. In Sumatra, protected area management has been severely hampered due political developments in 2001: decentralization has delegated power to 78 local governmental structures, but responsibility for protected areas has remained with the central government, which has little authority or capacity for real enforcement or management.

One of the most insidious threats to the fauna of Sundaland is the wildlife trade. Orang-utan numbers were severely reduced in the past because of the pet trade. Today, tigers and rhinoceroses are the most visible targets of hunting for the Chinese medicine market, for skins, body parts, and horns. Turtles, snakes, geckos, pangolins, bear, and monkeys are exported by the ton from the region on a daily basis. Indonesia has long been the region's leading producer and exporter of snake leather. This trade has been surpassed in recent years by the export of live turtles to East Asia. Most turtle populations throughout the Sundaland hotspot are either in decline or have collapsed. Indonesia's massive cage bird trade has also placed a number of species such as Bali Starling and Straw-headed bulbul (**Pycnonotus zeylanicus**, VU) under serious threat; the latter species, once common across its range, is now confined largely to remote areas.

4. WESTERN GHATS AND SRI LANKA

Faced with tremendous population pressure, the forests of the Western Ghats and Sri Lanka have been dramatically impacted by the demands for timber and agricultural land. Remaining forests of the Western Ghats are heavily fragmented; in Sri Lanka, only 1.5% of the original forest remains. Population levels are also applying increased stress on the fringes of protected areas where many farms, loggers, and poachers use the resources illegally. Due in part to the varying effect of the yearly monsoons and the high mountain regions, this hotspot is home to a rich endemic assemblage of plants, reptiles, and amphibians. Sir Lanka alone may be home to as many as 140 endemic species of amphibians. The region also houses important populations of Asian Elephants, Indian Tigers, and the Endangered Lion-tailed Macaque. Freshwater fish endemism is extremely high as well, with over 140 native species.

OVERVIEW

The Western Ghats of southwestern India and the highlands of southwestern Sri Lanka, separated by 400 kilometers, are strikingly similar in their geology, climate and evolutionary history. The Western Ghats, known locally as the Sahyadri Hills, are formed by the Malabar Plains and the chain of mountains running parallel to India's western coast, about 30 to 50 kilometers inland. They cover an area of about 160,000 km² and stretch for 1,600 km from the country's southern tip to Gujarat in the north, interrupted only by the 30 km Palakkad Gap.

Sri Lanka is a continental island separated from southern India by the 20-meter-deep Palk Strait. The island, some 67,654 km² in size, has been repeatedly connected with India between successive inter-glacial, most recently until about 7,000 years ago by a land bridge up to about 140 kilometers wide.

The Western Ghats mediates the rainfall regime of peninsular India by intercepting the southwestern monsoon winds. The western slopes of the mountains experience heavy annual rainfall (with 80 % of it falling during the southwest monsoon from June to September), while the eastern slopes are drier; rainfall also decreases from south to north. Dozens of rivers originate in these mountains, including the peninsula's three major eastward-flowing rivers. Thus, they are important sources of drinking water, irrigation, and power.

The wide variation of rainfall patterns in the Western Ghats, coupled with the region's complex geography, produces a great variety of vegetation types. These include scrub forests in the lowlying rain shadow areas and the plains, deciduous and tropical rainforests up to about 1,500 m, and a unique mosaic of montane forests and rolling grasslands above 1,500 m. Precipitation across Sri Lanka is dependent on monsoonal winds, resulting in much of the island experiencing relatively low rainfall (less than 2,000 millimeters per year), except for the southwestern "wet zone" quarter, where precipitation ranges to as much as 5,000 millimeters per year. While dry evergreen forests occupy almost the entirety of the "dry zone," dipterocarp-dominated rainforests dominate the lowlands of the wet zone, and some 220 km² of tropical montane cloud forest still persist in the central hills, which rise to a maximum altitude of 2,524 m.

PLANTS

There are a minimum of 6,000 vascular plant species in the Western Ghats and Sri Lanka hotspot, of which more than 3,000 (52%) are endemic. There are also more than 80 endemic plant genera, many of which have only one species. The Western Ghats harbors approximately 5,000 species of vascular plants belonging to nearly 2,200 genera; about 1,700 species (34%) are endemic. There are also 58 endemic plant genera, and, while some are remarkably species (like Niligrian thus, which has 20 species), nearly three quarters of the endemic genera have only a single species. Some prominent genera and families are represented by large numbers of endemic species, such as Impatiens with 76 of 86 species endemic, Dipterocarpus with 12 of 13 species endemic, and Calamus with 23 of 25 species endemic. Of the 490 tree species recorded from

low- and midelevation forests, 308 species are endemic. The only gymnosperm tree, Podocarpus (= Nageia) wallichianus, is also endemic. Of the 267 species of orchids, 130 are endemic. Similarly, plant diversity and endemism in Sri Lanka are quite high, with 3,210 flowering plant species in 1,052 genera, of which 916 species and 18 genera are endemic. Amazingly, all but one of the island's more than 55 dipterocarp species is found nowhere else in the world. In addition, the island's ferns (although not recently assessed) are estimated to number about 350 species. Approximately 433 plant species, and at least five genera, are confined to Sri Lanka and the Western Ghats combined.

In the Western Ghats, the Agasthyamalai Hills in the extreme south are believed to harbor the highest levels of plant diversity and endemism at the species level. Nearly 87% of the region's flowering plants are found south of the Palakkad Gap (37% being exclusive to this sub-region); these figures decrease to about 60% and 5%, respectively, in the Nilgiri Hills. In Sri Lanka, diversity, richness, and endemism across all taxa are much higher in the wet (including the montane) zone than in the dry zone. Indeed, the wet zone, which accounts for only a quarter of Sri Lanka's territory, contains 88% of the flowering plants occurring in the island, and 95% of its angiosperm endemics.

THREATS

Human Impacts

Extremely high population pressure in both countries of this hotspot has seriously stressed the region's biodiversity. There are more than one billion people in India and almost 20 million in Sri Lanka. Nearly 50 million people occur in the hotspot overall, at a density of 260 people/km² (one of the highest in hotspots). It is likely that no more than about 25% of the extent of original native vegetation remains in relatively pristine condition today.

The forests of the Western Ghats have been selectively logged and highly fragmented throughout their entire range. Forests have been converted to agricultural land for monoculture plantations of tea, coffee, rubber, oil palm, teak, eucalyptus, and wattle, and are also cleared for building reservoirs, roads, and railways. Encroachment into protected areas further reduces the extent of forests. Grazing by cattle and goats within and near protected areas causes severe erosion on previously forested slopes. Much of the remaining forest cover consists of timber plantations or disturbed secondary growth. Today, approximately 20% of the original forest cover remains in

more or less pristine state, with forest blocks larger than 200 km² found in the Agasthyamalai Hills, Cardamom Hills, Silent Valley- New Amarambalam Forests, and southern parts of the South Kannada District in Karnataka State.

Remaining forest patches are subject to intense hunting pressure and the extraction of fuelwood and non-timber forest products. Uncontrolled tourism and forest fires are additional concerns.
The growth of populations around protected areas and other forests has led to increasing human wildlife conflict. Raiding elephants because crop loss and leopards kill livestock. Compensation for farmers is generally inadequate, and wild animals are often killed or injured in an attempt to reduce further damage.

Source: Conservation International: www.conservation.org; www.cepf.net

Natural Terrestrial Ecosystems

India, due to its varied physical features and its geographical location, experiences almost all kinds of climate, from tropical to alpine and from desert to humid. On the basis of temperature, the landmass of India can be broadly classified into four zones:

A. Tropical zone, which is very hot round the year and does a. not have a winter,
B. Sub-tropical zone, which is hot for most of the year but with a cool winter,
C. Temperate zone, which has a warm summer and a pronounced winter, and,
D. Arctic or Alpine zone, which has a short summer and a long and severe winter.

(*Natural Terrestrial Ecosystems Thematic BSAP, 2002*)

Natural terrestrial ecosystems are of the following broad kinds: forests, grasslands, deserts and permanently snow-bound areas. Within each of these, there is an immense diversity, which is briefly described below.

Forests Diversity

Nearly 25 percent (one fourth) of India's total land area is now under forest and tree cover. However, there is still a long way to go – more than a decade, admits the government – before India reaches its target of having 33 percent of its total area under forest and tree cover. The latest 'India State of Forest Report (ISFR, 2021) released by the country's environment minister, revealed that the total forest and tree cover of the country is 807,276 square kilometres (which is 24.62 percent of the geographical area of the country). While the overall forest and tree cover marked an increase on a national level, the report highlighted a decrease in the forest area in the country's northeast region. This decline in forest area in the northeast has been an ongoing trend with the region witnessing a loss of about 3,199 sq. km. of forest area since 2009.

ISFR 2021 is a biennial report published by the Forest Survey of India (FSI) and is the 17th such report published. The calculations are largely based on satellite data. It includes information on forest cover, tree cover, mangrove cover, growing stock inside and outside the forest areas, carbon stock in India's forests, forest types and biodiversity, forest fire monitoring and forest cover in different slopes and altitudes.

Defined simply as tree-or bush-dominated ecosystems, forests are what most people think of when talking about a natural ecosystem. They are believed to contain most of the earth's terrestrial species biodiversity. Yet, though classified as one category for the sake of convenience, they display an internal diversity that is so large that often one forest type has almost no resemblance to another forest type. Indeed the term 'forests' may even cover grassland and desert areas with sparse tree cover, resulting in some confusion over ecological categorization of India's terrestrial ecosystem.

There have been various approaches to classifying forest ecosystems. One of the most comprehensive and detailed classifications of forests has been by **Champion and Seth (1968),** which is still in vogue in India.

They adopted a hierarchical system, which has five major forest types:

1. Tropical forests,
2. Montane sub-tropical forests,
3. Montane temperate forests,
4. Sub-alpine forests, and,
5. Alpine scrub.

These are in turn classified into 16 major forest-type groups and 221 minor forest-type groups. Brief descriptions and their extent of the 16 major forest type-groups are given in Table (*Natural Terrestrial Ecosystems Thematic BSAP*). The recorded forest areas of the country have been classified as Reserve Forests (55%), Protected Forests (29%) and Unclassed Forests (16%). But the vegetation of forests varies according to climate, rainfall, soil topography and other habitat factors (http://envfor.nic.in/nfap/forest-distribution.html).

SN	Vegetation Type	Area (Million ha.)	Percentage of forest Area (%)
1.	Tropical wet-evergreen forest	4.5	5.8
2.	Tropical semi-evergreen forest	1.9	2.5
3.	Tropical moist deciduous forest	23.3	30.3
4.	Littoral and swamp forest	0.7	0.9
5.	Tropical dry deciduous forest	29.4	38.2
6.	Tropical thorn forest	5.2	6.7
7.	Tropical dry evergreen forest	0.1	0.1
8.	Sub tropical broad leaved forest	0.3	0.4
9.	Sub tropical pine forest	3.7	5.0
10.	Sub tropical dry evergreen forest	0.2	0.2

SN	Vegetation Type	Area (Million ha.)	Percentage of forest Area (%)
11.	Montane wet temperate forest	1.6	2.0
12.	Himalayan moist temperate forest	2.6	3.4
13.	Himalayan dry temperate forest	0.2	0.2
14.	Sub-alpine forest	3.3	4.3
15.	Moist alpine forest	-	-
16.	Alpine forest	-	-
	Total	**77.0**	**100.0**
Source: MoFE,1999			

Due to certain deficiencies in the classification system used by Champion and Seth (including the problem that it was based on extrapolation from some selected areas rather than on vegetation mapping of the whole country, and that it incorrectly distinguishes between southern and northern types).

Grasslands Diversity

Grasslands, variously called steppes, prairies, cerrados, pampas, savannahs, velds and rangelands in different parts of the world, are vegetation types with predominance of grass and grass-like species. In India, high-altitude grasslands of the Himalaya have been referred to as *marg* or *bugiyal*, and in Ladakh as *tsang*. Grasslands are plant communities with a more or less continuous layer of graminoids (grasses and grass-like plants), with or without a discontinuous layer of trees or shrubs. Grasslands are often associated with marked seasonality in precipitation, occurrence of fire and grazing by ungulates. Bamboo forests, though technically dominated by grasses, are not included under grasslands as they physically and in other respects resemble forests, and are usually mixed with a significant number of trees. Some research on this ecosystem was done by Yadava and Singh (1977), Singh and Gupta (1993), Pandey and Singh (1991), Melkania and Singh (1989) and Singh *et al.*, (1983). The grassland community builds an entirely different type of soil as compared to a forest, even when both start with the same parent material. Since grass-plants are short-lived as compared to trees, a large amount of organic matter is added to the soil. The first phase of decay is rapid, resulting in little litter, but much humus. Humification is rapid but mineralization is slow. Consequently grassland soils may contain 5-10 times as much humus as forest soils (Odum 1971). As of 1992, the grassland coverage of the earth's terrestrial area was about 27% (Groombridge 1992). For India, Olson *et al.*, (1983) put the cover of grass and shrub land at 12% of the total landmass; however, the

Planning Commission (PC 1988) estimates grassland coverage at 3.7%, and scientists at the Indian Grasslands and Fodder Research Institute, Jhansi, give an estimate of 3.9%, or about 120 lakh (12 million) hectares (Singh and Misri 1993). The discrepancy in figures between Indian sources and Olson may not be due only to the difference in period of estimation (a full decade's gap), but also due to difference in definition (Olson has included shrubland in his category). The working figure for *this* report will be the 12 million ha given by Singh and Misri (1993).

The distribution of grasslands in India is quite uneven. For instance, in the western region, Rajasthan and Gujarat have 5.4% and 3.5% respectively of their land area under grasslands. In the eastern region, grasslands and pastures comprise less than 1% of the area, except in Sikkim, where they cover 13.3% of the land (IIPA 1996). The grasslands include such dissimilar ecosystems as the semi-arid pastures of the western part of the Deccan peninsula, the humid, semi-waterlogged tall grassland of the Terai belt, the rolling *shola* grasslands of the Western Ghats hilltops, and the high-altitude alpine pastures of the Himalayas.

The vast majority of grasslands in India with the possible exception of those abutting the *shola* forests of the Western Ghats, those occurring in the alpine region of the Himalaya, and the *Lasiurus sindicus* grasslands of western India owe their origin to destruction of forests and abandonment of cultivation, and have become widespread in a variety of habitats as seral communities maintained under the impact of such biotic factors as grazing, cutting and burning. Some ecologists point out, however, that the presence of grassland dependent species like Nilgiri tahr, floricans etc. is evidence of the *natural* presence of grasslands (Asad Rahmani, personal communication 2002). Extensive areas in the sal belt, which have been prevented from regeneration into forest by fire, grazing, cutting and general deterioration of soil, now carry high savannah grasses, as on the higher *phantas* of Kheri and the *chaors* of Haldwani in Uttar Pradesh (both terms mean grass clearings within forests). Extensive grasses downs are found in Nilgiri, Palni and Annamalai plateaus in South India, where grazing and burning are regularly practiced.

Marked differences in habitats (e.g. physico-chemical characteristics of soil, topography, etc.), age and mode of origin, and intensity of biotic processes all result in an array of very diverse grassland communities. Because of their occurrence within and adjoining forest and savannah lands, the grasslands are especially valuable habitats for wildlife, and support an extremely high

population of livestock (*Natural Terrestrial Ecosystems Thematic BSAP*). For example, alluvial grasslands support hog deer, wild water buffalo, swamp deer or *barasingha* and Indian rhinoceros; arid grasslands support black buck, wild ass and *chinkara*; high-altitude grasslands support ibex,Tibetan wild ass, *tahr*, *goral*, *argali*, *urial*, *chiru*, Tibetan gazelle and *bharal*; secondary grasslands support black buck, *chi- tal*, *gaur* and *chinkara*. Grasslands also occupy canopy gaps in open forests and form distinct associations. In arid and semi-arid regions, the association of grasslands with thorn forests and shrub vegetation often imparts a savannah-like aspect to the landscape.

Grasslands are closely related to agro-ecosystems as they provide a rich gene pool, including species which serve as collateral hosts for many plant diseases, insects, and nematodes. Also, most of the agriculture in India depends on animal power, which gets its energy supply from the grasslands through grazing or stall-feeding of dried and cured herbage.

On the basis of a country-wide survey of grasslands in India, Dabadghao and Shankarnarayan (1973) have recognized five broad grass cover types:

1. **Sehima-Dichanthium Type:** Spread over peninsular India, southwest Bengal, southern Bihar, and the southern hilly plains of Uttar Pradesh and Rajasthan, this cover type consists of 24 perennial grasses, several annual grasses, and 129 other herbaceous species including 56 legumes. Key species include *Sehima nervosum*, *Heteropogon contortus*, *Dichanthium annulatum* and *Themeda triandra*. As Rahmani (1992) notes, *Sehima- Dichanthium* cover occupies the largest area of grasslands in the country. The rainfall varies from 300 mm in Kachchh to 6,350 mm in the Western Ghats.The best development of *Sehima-Dichanthium* cover is seen with a rainfall of 500 to 900 mm.Therefore, the semi-arid tracts of Maharashtra, Gujarat, Andhra Pradesh, Karnataka and Tamil Nadu are typical examples of this cover type. When the *Sehima- Dichanthium* cover is subjected to grazing, these communities are replaced by *Chrysopogon* and *Bothriochloa* communities. respectively. Rollapadu grassland of Andhra, Gnanganga dry grassland of Buldhana district in Maharashtra, Sailana grassland in Ratlam district of Madhya Pradesh and Velavadar salt grassland of Gujarat are some of the important sites in this zone. As these grasslands are not at the climax stage and are affected by various edaphic factors, floral species composition varies. The floral composition also depends on the degree of protection to the grassland from fire and livestock grazing.

2. **Dichanthium-Cenchrus-Lasiurus Type:** Spread over northern parts of Gujarat, Rajasthan, western Uttar Pradesh, Delhi, and semi-arid Punjab, this type contains 11 perennial grasses, 19 legumes and 26 other herbaceous plants. Key species include *Dichanthium annulatum*, *Cenchrus ciliaris, C. biflorus, Lasiurus sindicus* and *Atylosia scarabaeoides*.The rainfall ranges from about 100 mm in the extreme west to about 750 mm towards the eastern boundary of this cover type. Several plant communities occur, depending upon the habitat conditions and intensity of biotic pressure. Rahmani (1992) notes that one of the largest extant grasslands of the country is present in this area the Sewan (*Lasiurus sindicus*) grassland in Jaisalmer, which is 170 km long and 25 to 35 km wide. Another important grassland is Banni in Kachchh district.
3. **Phragmites-Saccharum-Imperata Type:** Spread over the alluvial plains of the Ganga and the delta plains of West Bengal and the Assam Valley, this consists of 19 perennial grasses, 16 legumes and 40 other herbaceous plants. Key species include *Phragmites australis, Saccharum spontaneum, Imperata cylindica* and *Desmostachya bipinnata*. The water table is high and soil is poorly drained. Rainfall is moderate (500 mm) to high (up to 5000 mm) in this region. Though this region contains some of the wet grasslands of the Terai and Bhabar, some areas are semi-arid, especially in southern Uttar Pradesh and Bihar due to the north-south moisture gradient. The wet grasslands of the seasonally flooded valleys of the Terai and northeast India are very ancient, which is proven by the presence of diverse herbivore fauna: elephant, rhinoceros, *barasingha* and hog deer, indicating the grassland's stable history (Rahmani 1992).
4. **Themeda-Arundinella Type:** Covering the northern plains to the outer humid hills of the Himalayas, in Assam, Manipur, West Bengal, Uttar Pradesh, Punjab, Himachal Pradesh, and Jammu and Kashmir, this type contains 16 characteristic perennialgrasses and 34 other herbaceous plants including 9 legumes. Key species include *Themeda anaethera, Arundinella bengalensis, Bothriochloa bladhii, B. pertusa, Heteropogon contortus* and *Chrysopogon fulvus*.
5. **Temperate-Alpine Type:** Spread over the higher altitudes of Jammu and Kashmir, Uttaranchal, Himachal Pradesh, West Bengal, and Assam, this contains 35 characteristic perennial grasses, 6 legumes, and 62 other herbaceous plants. Key species include *Dactylis glomerata, Bromus inermis, Festuca pratense* and *Themeda anaethera*. Based on the altitude

gradient, several community types have been recognized. In the Central Himalaya, five distinct types of *bugiyals* (high-altitude grasslands) have been identified locally by the seminomadic *bhotias* (Melkania 1983, Melkania and Tandon 1988). These are:

- ✓ *Dug or dudh bugiyal* - dominated by *Euphorbia stracheyii* (*Dudh bug*), common on drier slopes;
- ✓ *Bas bugiyal* - dominated by *Sassurea graminicola* (*Bas bug*) on east facing slopes above 4200 m elevation;
- ✓ *Mot bugiyal* - dominated by *Danthonia cachemyriana* (*Mot bug* or *phiji ghas*) and *Phleum alpinum* on slopes above 3200 m;
- ✓ *Dhania bugiyal* - predominated by *Cortia lindleyi* (*Dhania bug*) in shady and marshy locations; and;
- ✓ *Dhati bugiyal* - characterized by preponderance of *Kobresia* spp. (*Dhati bug*) between 3000 to 4000 m.

In India, grasses form the largest family of flowering plants. Out of an estimated 17500 species of flowering plants, about 1200 are grasses. About 360 grass taxa (almost 30%), are endemic to India. 172 endemics occur in the peninsular region, 56 in the north-east, 30 in the north-west, 5 in the western arid regions, 12 in the lower Gangetic plain, 4 in the Andaman and Nicobar Islands, and 50 spread over more than one of the above regions. It has been estimated that presently about 1055 species occur naturally in India and about 130 other species have been introduced; some of the latter are now naturalized (Jain 1986).

Current Status of Indian grasslands

Unfortunately, due to a greater neglect than even that suffered by forests, the status of grasslands is not so well known. Worldwide, it is estimated that from an original coverage of about 40% of the earth's land surface, grasslands have come down to anything between 16 and 27% (Groombrige 1992). Parallel figures for India are not available, largely because no base data exists for grassland coverage in the past, but also because grassland monitoring has been virtually non-existent even in the recent past. It is well-known that the semi-arid grasslands of western India are severely threatened by 'development' projects (like the Indira Gandhi Canal) and overgrazing, and are now restricted to a few small protected tracts only. This is also the case with the tall swamp grassland of the *Terai* belt, which has been seriously threatened with fragmentation and conversion to various human dominated land uses. Because of the large

livestock population, most of the grasslands remain under severe grazing pressure throughout the year. Many areas, especially the high-altitude grasslands and the grasslands of the arid and semi-arid regions, suffer from seasonal grazing stress caused by migrating livestock.

Levels of Biodiversity

India is very rich in terms of biological diversity due to its unique biogeographic location, diversified climatic conditions and enormous eco-diversity and geo-diversity. India embraces three major biological realms, viz., Indo-Malayan, Eurasian and Afro-tropical and is adorned with 10 biogeographic zones and 26 biotic provinces.

This country possesses diversified ecosystems from snow clad high mountain ranges to sea coasts of all categories (sandy, muddy, rocky, shingle, coralline) including deserts and semi-arid regions, almost all "types" of forests, grass lands, lakes, and rivers, estuaries, lagoons, islands and the ocean. The climate ranges from arctic in the Himalayas to very hot in the Thar Desert of Rajasthan while annual rainfall varies from 100 mm in the deserts to 5000 mm in the Cherrapunji hills. It is, therefore, quite necessary to study the world's known flora & fauna in different levels.

The definition places emphasis on variability or heterogeneity, rather than on the objects displaying that variability. It addresses this variability at three hierarchical levels - genes, species and ecosystems.

1. ***Species diversity:*** The species is the basic unit of classification in biology. Although a species might be defined as a group of similar organisms that interbreed or share a common lineage of descent, there is no universal agreement on how to define a species. Even when the species is the basic unit, it represents only one level of a complex phylogenetic hierarchy: related species are grouped in genera, related genera in families, families in orders, and so on, up to the highest level, the kingdom, of which five are generally recognised at present (animals, plants, fungi, bacteria and protoctists).

   Species richness measures the number of species within a given area, giving equal weight to each one. This measure can be used at different geographical levels (a given area, a country and, ultimately, the world). It is still the most straightforward and, in many ways, the most useful measure of biodiversity. World-wide, just 175 million of the estimated 13 to 14 million species have so far been described. Most of these described species are only

poorly known in biological terms. There is no comprehensive catalogue on the known species.

The number or richness of species is obviously a most incomplete measure of biodiversity. It is complemented by:

- Species diversity, which measures the species in an area, adjusting for both sampling effects and species abundance.
- Taxic (taxonomic) diversity, which measures the taxonomic dispersion of species, thus emphasizing isolated evolutionary species. The basic idea behind this measure is that biodiversity might be better measured at higher taxonomic levels (e.g. genera or families). The explanation is that an area with, say, ten species in the same genus is less diverse than an area with ten species, each belonging to a different genus.
- Functional diversity, which assesses the richness of functional features and interrelations in an area, identifying food webs along with keystone species and guilds.

However, not only diversity is of importance. Species endemism, that is whether a species is restricted to ("endemic to") an area under discussion, is equally vital. For example, islands typically have fewer species than equivalent-sized continental areas. They also usually have a higher percentage of species found nowhere else. In other words, they have lower species richness and higher species endemism.

2. ***Genetic diversity:*** Genetic diversity is the variation of the set of genes carried by different organisms: it occurs on a small scale among organisms of the same species, among closely related species such as those in the same genus, and among more distantly related species, in different families, orders, or kingdoms. Genetic diversity might be characterized by a range of techniques: by observation of inherited genetic traits, by studying the chromosomes and their species specific karyotype, and by analyzing the DNA information using molecular technology.

Global genetic diversity is extremely large. It has been estimated that there are some 10^9 different genes present in the world's biota. The number of possible combinations of gene-sequence variants in a population is so great that it cannot even be expressed in a meaningful way. This amazing variation in the genetic code offers opportunities for

evolutionary change, the survival of species, adaptations to a changing environment, and the formation of new species. More recently, biotechnology and crop or breed improvement programmes rely on the identification of genetic material giving rise to desirable traits, and the incorporation of this material in appropriate organisms.

3. ***Ecosystem diversity:*** Species exist in natural settings, within functioning communities and ecosystems, interacting with other species and the abiotic environment. Ecosystems function as entities with system-wide properties. Care about diversity must, therefore, also focus on system-wide aspects, such as dying coral reefs. Different classification systems exist to describe ecosystem diversity. On a world scale, bio-geographic zones, biomes, eco-regions, and oceanic realms are used. On a smaller scale, one deals with landscapes, ecosystems and communities. Qualification of ecosystems on a global scale faces problems. A major reason for this is that they do not have a clearly delineated identity. They do not, in general, exist as discrete units, but represent different parts of a highly variable natural continuum. To study ecosystem diversity at different levels, geographic information systems (GIS) are increasingly used, both during assessment and as a basic management tool.

Conserving Biodiversity in India/ Conservation Movements

Biodiversity Conservation

India, a mega diverse nation, is one of the richest nations in terms of biological diversity. India owes this to its position in the tropical and subtropical latitudes. India has a great diversity of natural ecosystems ranging from the cold and high Himalayan regions to the sea coasts; from the wet north-eastern green forests to the dry northwestern arid deserts; with different types of forests, wetlands, islands and the oceans. India consists of fertile river plains and high plateaus and several major rivers, including the Ganges, Brahmaputra and Indus. The diverse physical features and climatic situations have formed ecological habitats like forests, grasslands, wetlands, coastal and marine ecosystems and desert ecosystems, which harbour and sustain immense biodiversity. The country is also one of the 12 primary centers of origin of cultivated plants and domesticated animals.

Why Conserve Biodiversity?

As we all know by now, Biodiversity is essential for maintaining the ecological functions, including stabilizing of the water cycle, maintenance and replenishment of soil fertility, pollination and cross-fertilization of crops and other vegetation, protection against soil erosion and stability of food producing and other ecosystems. Conservation of biological diversity leads to conservation of essential ecological diversity to preserve the continuity of food chains. Biodiversity provides the base for the livelihoods, cultures and economies of several hundred millions of people, including farmers, fisher folk, forest dwellers and artisans. It provides raw material for a diverse medicinal and health care systems. It also provides the genetic base for the continuous up-gradation of agriculture, fisheries, and for critical discoveries in scientific, industrial and other sectors. The rapid erosion of biodiversity in the last few decades has impacted on the health of the land, water bodies and people.

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 heritage 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 including conservation of biodiversity during the 21st century. Conservation and sustainable use of biological resources based on local knowledge systems and practices is ingrained in Indian ethos. The country has a number of alternative medicines, like *Ayurveda*, *Unani*, *Siddha* and Homeopathic systems which are predominantly based on plant based raw materials in most of their preparations and formulations. Herbal preparations for various purposes including pharmaceutical and cosmetic form part of traditional biodiversity uses in India.

Benefits of Biodiversity conservation

- Conservation of biological diversity leads to conservation of essential ecological diversity to preserve the continuity of food chains.
- The genetic diversity of plants and animals is preserved.
- It ensures the sustainable utilization of life support systems on earth.
- It provides a vast knowledge of potential use to the community.
- A reservoir of wild animals and plants is preserved, thus enabling them to be introduced, if need be, in the surrounding areas.

- Biodiversity conservation assures sustainable utilization of potential resources.

There are several strategies which are adapted for conservation of Biodiversity

1. Legislation
2. In-situ Conservation
3. Ex-situ Conservation
4. Recording Indigenous Knowledge
5. Community Participation in Biodiversity Conservation
6. International Conservation Strategies

Legislation: A number of acts and policies have been made under legislative strategies from time to time, by state as well as union government for biodiversity conservation. Formal policies and programmes for conservation and sustainable utilization of biodiversity resources date back to several decades. The concept of environmental protection is enshrined in the Indian constitution in articles 48a and 51a (g). Major **a**cts & policies relevant to biodiversity include:

- ✓ Madras Wildlife Elephant Preservation Act, 1873
- ✓ All India Elephant Preservation Act, 1879
- ✓ The Wild Birds and Animals Protection Act, 1912
- ✓ Bengal Rhinoceros Preservation Act, 1932
- ✓ Assam Rhinoceros Preservation Act, 1954
- ✓ Indian Board of Wildlife (IBWL), 1952
- ✓ Environment Protection Act, 1986
- ✓ Fisheries Act, 1897
- ✓ Forest Act, 1927
- ✓ Forest (Conservation) Act, 1980
- ✓ Forest Policies – 1894, 1954 and 1988
- ✓ Wildlife (Protection) Act 1972 and Wildlife (Protection) Amendment Act 1991
- ✓ Indian National Man and the Biosphere Committee, 1972
- ✓ National Wildlife Action Plan, 1982 endorsed by IBWL
- ✓ India became a party to CITES (Convention of International trade in Endangered Species) in 1972
- ✓ Project to conserve individual endangered species like crocodile (1975), Lion (1972), Tiger (1973), Elephant (1992), Ghariyal Rehabilitation (1977), Rhinoceros (1987), Chitaah, (2022) etc.

The various central Acts are supported by a number of state laws and statutes concerning forests and other natural resources. The policies and strategies directly relevant to biodiversity include National Forest Policy amended in 1988, National Conservation Strategy and Policy Statement for Environment and Sustainable Development, National Agricultural Policy, National Land Use Policy, National Fisheries Policy, National Policy and Action Strategy on Biodiversity, National Wildlife Action Plan and Environmental Action Plan.

In-situ Conservation: Conserving the animals and plants in their natural habitats is known as *in situ* conservation. The established natural habitats are:

- ✓ National parks and sanctuaries
- ✓ Biosphere reserves
- ✓ Nature reserves
- ✓ Reserved and protected forests
- ✓ Preservation plots
- ✓ Reserved forests

The first such initiative was the establishment of the Corbett National Park in 1936. National Parks are highly protected by law. No human habitation, private land holding or traditional human activity such as firewood collection or grazing is allowed within the park. Sanctuaries are also protected but certain types of activities are permitted within these areas.

Biosphere Reserves are another category of protected areas. Under this, a large area is declared as a Biosphere Reserve where wildlife is protected, but local communities are allowed to continue to live and pursue traditional activities within the Reserve. The Government of India has set up seven biosphere reserves: Nokrek (Meghalaya), Nilgiri (Kamataka, Kerala, Tamil Nadu), Namdapha (Arunachal Pradesh), Nanda Devi (Uttar Pradesh), Sundarbans (West Bengal), Great Nicobar (Andaman & Nicobar Islands), Gulf of Mannnar (Tamil Nadu).

Several special projects have also been launched 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 Lion, Project Elephant, Project Crocodile, Project Chitaah, Save the Barasingha campaign are examples of this initiative. Other strategies include off loading pressure from reserve forests by alternative measures of fuel-wood and fodder need satisfaction by afforestation of degraded areas and wastelands.

A programme "Eco-development" for *in-situ* conservation of biological diversity involving local communities was initiated. It integrates the ecological and economic parameters for sustained conservation of ecosystems by involving local communities with maintenance of earmarked regions surrounding protected areas. Approximately 5.26 % (Report, 2022) of the total geographical area of the country has been earmarked for extensive *in-situ* conservation of habitats and ecosystems. A protected area network of 106 national parks and 564 wildlife sanctuaries has been created (As on December, 2021). The results of this network have been significant in restoring viable population of large mammals such as tiger, lion, rhinoceros, crocodiles and elephants.

Ex-situ Conservation: Ex-situ conservation of plants and animals preserve/ or protect them away from their natural habitat. This could be in zoological parks and botanical gardens or through the forestry institutions and agricultural research centres. A lot of effort is under way to collect and preserve the genetic material of crops, animal, bird and fish species. This work is being done by institutions such as the National Bureau of Plant Genetic Resources, New Delhi, the National Bureau of Animal Genetic Resources, etc. Reintroduction of an animal or plant into the habitat from where it has become extinct is another form of *ex situ* conservation. For example, the Gangetic *Gharial* has been reintroduced in the rivers of Uttar Pradesh, Madhya Pradesh and Rajasthan where it had become extinct. Seed banks, botanical, horticultural and recreational gardens are important centres for ex *situ* conservation. *Ex-situ* conservation measures complement *in-situ* conservation.

Recording Indigenous Knowledge: The lives of local communities are closely interwoven with their environment, and are dependent upon their immediate resources for meeting their needs. These communities have a vast knowledge about local flora and fauna which is very important for biodiversity conservation. Much of this knowledge is orally passed on from generation to generation. Such indigenous knowledge needs to be recorded and preserved before it is lost. Several organizations have recognized this and are working to record the knowledge and preserve it for posterity.

Community Participation in Biodiversity Conservation: It is being recognized that no legal provisions can be effective unless local communities are involved in planning, management and

monitoring conservation programmes. There are several initiatives to do this, both by government as well as non-governmental organizations. For example, the Joint Forest Management philosophy stresses involvement of village communities in regenerating and protecting degraded forest land in the vicinity of villages. Successful conservation strategies will have to have the confidence and participation of the local communities.

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:

- **The Convention on Biological Diversity:** This was signed during the Earth Summit in 1992. It focuses not only on conserving biodiversity but also on sustainable use of biological resources and equitable sharing of benefits arising from its use.
- **The Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES):** This is an international treaty which is designed to protect wild plants and animals affected by international trade. The treaty, in force since 1975, controls the export, import and re-export of endangered and threatened wildlife.
- **The Convention on Wetlands of International Importance:** This Convention, also known as the Ramsar Convention, was signed in Ramsar (Iran) in 1971 and came into force in December 1975. It provides a framework for international cooperation for the conservation of wetland habitats which have been designated to the 'List of Wetlands of International Importance'.

Programmes have also been launched for scientific management and wise use of wetlands, mangroves and coral reef ecosystems. 64 wetlands sites (MOEF, 2022) and mangrove areas and four coral reef areas have been identified for intensive conservation and management purposes. Mangroves conservation is one of the thrust areas of the Ministry of Environment and Forests. Under the World Heritage Convention 7 natural sites (MOEF, 2020) have been declared as "World Heritage Sites".

To conserve the representative ecosystems, a Biosphere Reserve Programme is being implemented. 18 biodiversity rich areas of the country have been designated as Biosphere

Reserves (as on 2014). These reserves aim at conserving the biological diversity and genetic integrity of plants, animals and microorganisms in their totality as part of the natural ecosystems, so as to ensure that self-perpetuation and unhindered evolution of the living resources.

The Ministry of Environment and Forests constituted the National Afforestation and Eco-development Board (NAEB) in 1992. NAEB has evolved specific schemes for promoting afforestation and management strategies which help the states in 4 developing specific afforestation and management strategies and eco-development packages for augmenting biomass production through a participatory planning process of joint forest management and microplanning.

A detailed National Biodiversity Strategy and Action Plan (NBSAP) using participatory planning approach has been prepared, which is currently being implemented. India's richness in biological resources and related indigenous knowledge is well recognized. One of the major challenges before the country lies in adopting an instrument which helps realize the objectives of equitable benefit sharing enshrined in the convention.

Conservation of Wetlands: Wetlands are areas of land where the water level remains near or above the surface of the ground for most of the year. The association of man and wetlands is ancient, with the first signs of civilization originating in wetland habitats such as the flood plains of the Indus. Wetlands cover about 6% of the earth's land surface.

There are several kinds of wetlands such as marshes, swamps, lagoons, bogs, fens and mangroves. They are home to some of the richest, most diverse and fragile of all natural resources. As they support a variety of plants and animal life, biologically they are one of the most productive ecosystems. Wetland systems directly and indirectly support lakhs of people, providing goods and services to them. They help to preserve water quality and increase biological productivity for both aquatic life as well as human communities of the region. India has a wealth of wetland ecosystems spread over different geographical regions. At present, only 50 percent of India's wetlands remain. They are disappearing at the rate of 2% to 3% every year. The loss of wetlands leads to environmental and ecological imbalances, which have a direct impact on the biodiversity. Wetlands are important as a genetic reservoir for various species of plants including rice, which is a staple food for 3/4th of the world's population. India is a

signatory to the Ramsar Convention. Some Ramsar sites which are located in India are: Wular Lake Jammu & Kashmir), Sambhar Lake (Rajasthan), Keoladeo National Park (Rajasthan), Harike Lake (Punjab), Chilika Lake (Orissa), and Loktak Lake (Manipur) etc.

Conservation of Medicinal Plants: In India, 7,000 species of plants found in various ecosystems are used for medicine. During the Buddhist period, plants, vegetables and fruits were in use for treating different ailments. The great works of *Ayurveda* - *Charaka Samhita, Sushruta Samhita* and *Ashtanga Hridaya* - mention about 600 species of plants that were in use. The traditional system of medicine in India dates back to the age of the *Rigveda*.

In 1978, the World Health Organization (WHO) drew up a list of 240 absolutely essential medications. All these medications can be obtained only from plants. Every year, nearly two hundred Indian medicinal plants are being tested in the research laboratories of several prestigious drug companies the world over.

Apart from the practitioners of *Ayurveda*, most women are aware of the medicinal properties of certain plants which they come across in their daily life. In the past people generally collected medicinal plants from forest areas because a variety of medicinal plants were found there. Due to urbanization and also for cultivation, these forests have dwindled. The present immediate need is to conserve the medicinal plants. Over-exploitation of several herbs is endangering the species. In order to retrieve the situation, these important herbs must be conserved either in the nurseries, gardens or cultured laboratories.

Apart from propagating medicinal plants, villagers can be encouraged to set up kitchen gardens where medicinal plants can be grown for their domestic use. Organic farming using medicinal plants as botanical pesticides can be encouraged to replace chemical pesticides. A gene pool of herbal and medicinal plants can be established. Conservation strategies based on present demands and immediate future needs need to be prioritized.

Role of Communities in Biodiversity conservation: Protecting the environment is everyone's responsibility. There is an increased awareness among the people towards the conservation of ecologically sensitive areas. There are many conservation movements and initiative in India, which have saved the precious natural resources. Despite all threats, diversity of the species and

diversity within the species still continue to survive. Their continued existence is due to farmers and other communities living within the forest. Their cultural practices and knowledge systems have helped nurture biodiversity.

Nature worship is a tribal belief based on the premise that all creations of nature have to be protected. Such beliefs have helped preserve several virgin forests in pristine form called **Sacred Groves** (the forests of God and Goddesses). These patches of forest or parts of large forests have been left untouched by the local people and any interference with them is banned. The practice dates back to about 3000 to 5000 B.C. Indian society comprises of several cultures, each with its own set of traditional methods of conserving nature and its creations.

Green India Mission: The National Mission for a Green India, recently announced by the Prime Minister, is one of the eight National Missions under India's National Action Plan on Climate Change. Its major focus is to increase cover and density of India's medium density forests and degraded forests. This mission will have repercussions for livelihoods of people and biodiversity.

Saving biodiversity - Saving life

Following are some conservation actions that we can take up:

- ✓ Plant trees. Grow native species of plants (trees, shrubs and climber) where possible, this would attract local wildlife such as birds, butterflies and insects.
- ✓ Grow local vegetables in your school garden that are not usually available in the markets. This would allow help conserve them for generations to come.
- ✓ Initiate, organize and participate in responsible citizen action against existing or proposed activities that harm or are likely to harm local biodiversity.
- ✓ Make a list of different kinds of trees in your campus or locality. For each one find out the names, uses, flowering season, animals and birds that depends on it. Present this information in an interesting way, and put it up by the tree. Many people will stop by to read this information and know more about the tree.
- ✓ Curb our greed for products made out of animal parts like skin, fur, ivory, bones, nails, etc., to discourage wildlife traders and poachers, and spare the lives of the remaining animals.

- ✓ Adopt vegetarianism which would require fewer animals to be fattened for slaughtering and more plants to be grown for food.
- ✓ Avoid using insecticides, pesticides and inorganic fertilizers and try to use natural plant-based substitutes wherever possible. Paper and cloth should replace non-biodegradable plastic and polyester which damage the ecosystem.
- ✓ Make children aware of their surroundings and the need for biodiversity. Promote bio-farming which is less intensive and environmental-friendly.
- ✓ Make use of sustainable technologies like smokeless chulhas, ground water recharging unit, wind energy, solar power, etc.
- ✓ Set up 'Community Sanctuaries' for free ranging animals, migratory birds and endemic species. Establish voluntary 'Village Reserves' for plants and animals.
- ✓ Assist National level Bodies in recording and preserving rare and endemic species.
- ✓ Create 'Biodiversity Registers' in communities, schools, villages.

Biodiversity Register: Students can inventory and maintain records of all living beings in their locality. A biodiversity register is a compilation of day-to-day observations of the immediate environment. It is a documentation of knowledge of diversity of life known to local people. It is a means of recording the wealth of biodiversity of a region. The register may include minute details about plants and animals, both wild and domesticated. The record may include traditional knowledge regarding use of the various species.

A biodiversity register has many uses. It helps make the complete inventory of all organisms of an area. It makes us familiar with the biodiversity of an area. It helps understand the inter-linkages between plants and animals and the direct and indirect benefits they offer to humans. It allows us to analyze the reasons for depletion of biodiversity and plan conservation measures. 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.

Major Environmental Movements in India

The contemporary India experiences an almost unrestricted exploitation of resources because of the lure of new consumerist lifestyles. The balance of nature is disrupted. This has led to many conflicts in the society. We discuss the major environmental movements in India.

1. Bishnoi Movement

- ✓ Year: 1700s
- ✓ Place: Khejarli, Marwar region, Rajasthan state.
- ✓ Leaders: Amrita Devi along with Bishnoi villagers in Khejarli and surrounding villages.
- ✓ Aim: Save sacred trees from being cut down by the king's soldiers for a new palace.

What was it all about: Amrita Devi, a female villager could not bear to witness the destruction of both her faith and the village's sacred trees? She hugged the trees and encouraged others to do the same. 363 Bishnoi villagers were killed in this movement. The Bishnoi tree martyrs were influenced by the teachings of Guru Maharaj Jambaji, who founded the Bishnoi faith in 1485 and set forth principles forbidding harm to trees and animals. The king who came to know about these events rushed to the village and apologized, ordering the soldiers to cease logging operations. Soon afterwards, the maharajah designated the Bishnoi state as a protected area, forbidding harm to trees and animals. This legislation still exists today in the region.

2. Chipko Movement

- ✓ Year: 1973
- ✓ Place: In Chamoli district and later at Tehri-Garhwal district of Uttarakhand.
- ✓ Leaders: Sundarlal Bahuguna, Gaura Devi, Sudesha Devi, Bachni Devi, Chandi Prasad Bhatt, Govind Singh Rawat, Dhoom Singh Negi, Shamsher Singh Bisht and Ghanasyam Raturi.
- ✓ Aim: The main objective was to protect the trees on the Himalayan slopes from the axes of contractors of the forest.

What was it all about: Mr. Bahuguna enlightened the villagers by conveying the importance of trees in the environment which checks the erosion of soil, cause rains and provides pure air. The women of Advani village of Tehri-Garhwal tied the sacred thread around trunks of trees and they

hugged the trees, hence it was called 'Chipko Movement' or 'hug the tree movement'. The main demand of the people in these protests was that the benefits of the forests (especially the right to fodder) should go to local people. The Chipko movement gathered momentum in 1978 when the women faced police firings and other tortures. The then state Chief Minister, Hemwati Nandan Bahuguna set up a committee to look into the matter, which eventually ruled in favor of the villagers. This became a turning point in the history of eco-development struggles in the region and around the world.

3. Save Silent Valley Movement

- ✓ Year: 1978
- ✓ Place: Silent Valley, an evergreen tropical forest in the Palakkad district of Kerala, India.
- ✓ Leaders: The Kerala Sastra Sahitya Parishad (KSSP) an NGO, and the poet-activist Sughathakumari played an important role in the Silent Valley protests.
- ✓ Aim: In order to protect the Silent Valley, the moist evergreen forest from being destroyed by a hydroelectric project.

What was it all about: The Kerala State Electricity Board (KSEB) proposed a hydroelectric dam across the Kunthipuzha River that runs through Silent Valley. In February 1973, the Planning Commission approved the project at a cost of about Rs 25 crores. Many feared that the project would submerge 8.3 sq km of untouched moist evergreen forest. Several NGOs strongly opposed the project and urged the government to abandon it. In January 1981, bowing to unrelenting public pressure, Indira Gandhi declared that Silent Valley will be protected. In June 1983 the Center re-examined the issue through a commission chaired by Prof. M.G.K. Menon. In November 1983 the Silent Valley Hydroelectric Project was called off. In 1985, Prime Minister Rajiv Gandhi formally inaugurated the Silent Valley National Park.

4. Jungle Bachao Andholan

- ✓ Year: 1982
- ✓ Place: Singhbhum district of Bihar
- ✓ Leaders: The tribals of Singhbhum.
- ✓ Aim: Against governments decision to replace the natural **sal forest** with **Teak**.

What was it all about: The tribals of Singhbhum district of Bihar started the protest when the government decided to replace the natural sal forests with the highly-priced teak. This move was called by many as "Greed Game Political Populism". Later this movement spread to Jharkhand and Orissa.

5. Appiko Movement

- ✓ Year: 1983
- ✓ Place: Uttara Kannada and Shimoga districts of Karnataka State
- ✓ Leaders: Appiko's greatest strengths lie in it being neither driven by a personality nor having been formally institutionalised. However, it does have a facilitator in Pandurang Hegde. He helped launch the movement in 1983.
- ✓ Aim: Against the felling and commercialization of natural forest and the ruin of ancient livelihood.

What was it all about: It can be said that Appiko movement is the southern version of the Chipko movement. The Appiko Movement was locally known as "Appiko Chaluvali". The locals embraced the trees which were to be cut by contractors of the forest department. The Appiko movement used various techniques to raise awareness such as foot marches in the interior forest, slide shows, folk dances, street plays etc. The second area of the movement's work was to promote afforestation on denuded lands. The movement later focused on the rational use of ecosphere through introducing alternative energy resourceto reducece pressure on the forest. The movement became a success. The current status of the project is – stopped.

6. Narmada Bachao Andholan (NBA)

- ✓ Year: 1985
- ✓ Place: **Narmada** River, which flows through the states of Gujarat, Madhya Pradesh and Maharashtra.
- ✓ Leaders: Medha Patker, Baba Amte, adivasis, farmers, environmentalists and human rights activists.
- ✓ Aim: A social movement against a number of large dams being built across the **Narmada** River.

What was it all about: The movement first started as a protest for not providing proper rehabilitation and resettlement for the people who have been displaced by the construction of **Sardar Sarovar Dam.** Later on, the movement turned its focus on the preservation of the

environment and the eco-systems of the valley. Activists also demanded the height of the dam to be reduced to 88 m from the proposed height of 130m. World Bank withdrew from the project.

The environmental issue was taken into court. In October 2000, the Supreme Court gave a judgment approving the construction of the Sardar Sarovar Dam with a condition that height of the dam could be raised to 90 m. This height is much higher than the 88 m which anti-dam activists demanded, but it is definitely lower than the proposed height of 130 m. The project is now largely financed by the state governments and market borrowings. The project is expected to be fully completed by 2025.

Although not successful, as the dam could not be prevented, the NBA has created an anti-big dam opinion in India and outside. It questioned the paradigm of development. As a democratic movement, it followed the Gandhian way 100 per cent.

7. Tehri Dam Conflict

- ✓ Year: 1990's
- ✓ Place: Bhagirathi River near Tehri in Uttarakhand.
- ✓ Leaders: Sundarlal Bahuguna
- ✓ Aim: The protest was against the displacement of town inhabitants and environmental consequence of the weak ecosystem.

Tehri dam attracted national attention in the 1980s and the 1990s. The major objections include, seismic sensitivity of the region, submergence of forest areas along with Tehri town etc. Despite the support from other prominent leaders like Sunderlal Bahuguna, the movement has failed to gather enough popular support at national as well as international levels.

8. Navdanya Movement, 1982

Whether it's about empowering women or anti-globalisation campaigns,environmental activist Vandana Shiva has always had an upper hand in her fights against the authorities. Her ecofeministmovement reinstated a farming system centred on engaging women,changing the current system.She founded Navdanya in 1982, an organisation promoting biodiversity conservation and organic farming.The organisation has not only helped create markets for farmers, but also promoted quality food for consumers, connecting the seed to the cooked food.

9. **Tarun Bharat Sangh, 1985**

In Alwar's Hamirpur village, he is addressed as Ram.

Rajinder Singh, founder of Tarun Bharat Sangh and winner of the 2001 Ramon Magsaysay Award Rajinder Singh, founder of Tarun Bharat Sangh and winner of the 2001 Ramon Magsaysay Award acquiring the position wasn't a cakewalk. He brought water to about 850 parched villages in Rajasthan and motivated villagers to harvest rainwater."He advocated small ponds and check dams but did not oppose big dams or canal networks blindly," said *India Today* in December 2003.

10. **Saving the Western Ghats, 1988**

Home to sanctuaries like Bandipur and Nagarhole, Western Ghats, a biological treasure trove, was struck by an epidemic— deforestation in the 1980s. "The Union Government's Forest Department estimates that within the last three decades, 4.5 million hectares of forests or an area the size of Tamil Nadu has vanished," said *India Today* in March 1982. The Kailash Malhotraled Save the Western Ghats march, a 100-day padayatra across the hills, succeeded in imparting the message of environmental degradation and human rights.

11. Protesters up in arms against NHAI decision to build six-lane highway cutting through eastern part of park. July -October 2018,

Gurugram: Over 1,200 residents of Gurugram and Delhi made their way to the Aravali Biodiversity Park early Sunday morning to protest against the National Highways Authority of India (NHAI) and Gurugram Metropolitan Development Authority's (GMDA) decision to construct a six-lane, 2-km expressway cutting through the eastern half of the forest cover.

The proposed two-part highway, plans for which were first floated by the NHAI in 2016, is set to link the Mehrauli-Gurugram Road to NH-8 and the Nelson Mandela Marg in Vasant Kunj to the Gurugram-Faridabad road, effectively using the biodiversity park as a short-cut to decongest traffic.

A team of NHAI officials visited the park in July to map the site for size, alignment and other technical details. Most recently, ecologist Vijay Dhasmana, responsible for selecting the indigenous shrub and plant species in the park, also discovered detailed tenders of the project on the NHAI website.

Wildlife Conservation Initiatives by Indian Government

In 1894, Rudyard Kipling's famous collection of stories got published and the rest is history. Kipling's incisive eyes and 6 years of hard work not only created a composition that excited kids but indirectly boasts the rich wildlife in India. Even though it was just a fable it did show the diversity of animals in the country. To really talk about diversity, India is one of the 17 mega diversities in the world and is home to 7.6% of all mammal, 12.6% of bird, 6.2% of reptile, and 6.0% of flowering plant species. The country also has some of the most biodiverse regions on the planet and it comprises of four of 35 biodiversity hotspots of the world like the Western Ghats, the Eastern Himalayas, Indo-Burma and Nicobar Islands in Sundaland. So far, the country's wildlife is preserved in 120+ national parks, 515 wildlife sanctuaries, 26 wetlands, and 18 Bio-Reserves, out of which 10 are part of the World Network of Biosphere Reserves. Evidently, this large biodiverse land needs protection, and inarguably conservation is a mandatory measure.

Keeping in view the recent human encroachment, the Indian Government did take effective initiatives to conserve wildlife in the country, and amongst it, most commendable initiatives is the Wildlife Protection Act of 1972, which prohibits trade of rare and endangered species. However, this is not the only laudatory measure taken by the Government of India (GOI), there is so much more that needs to be told about the schemes and projects that have helped the country maintain its rich wildlife. Here is a glance at the important wildlife conservation initiatives that GOI has taken:

Important Wildlife Protection Projects by Indian Government

1. **Project Tiger:** One of the most successful wildlife conservation ventures 'Project Tiger' which was initiated way back in 1972, has not only contributed to the conservation of tigers but also of the entire ecosystem. This project is sponsored by Ministry of Environment Forest and Climate Change. About 47 tiger reserves situated in more than 17 regions including Corbett National Park and Ranthambore National Park are part of this project which conducts assessments of number of tigers, their habitat, hunting habits under the supervision of the Tiger Task Force. Project Tiger has seen significant success in recovery of the habitat and increase in the population of the tigers in the reserve areas, from a scanty 268 in 9 reserves in 1972 to above 1000 in 28 reserves in 2006 to 2000+ tigers in 2016.
2. **Project Elephant:** Initiated in 1992 by the Government of India Project Elephant aims at conserving elephants and their habitat and of migratory routes by developing scientific and planned management measures. Under the project welfare of the domestic elephants is also considered, issues like mitigation of human-elephant conflict are also taken care of. The project's endeavour is to strengthen the measures for protection of elephants against poachers and unnatural death.
3. **Crocodile Conservation Project:** This project is yet another successful venture by Government of India to conserve the Indian Crocodiles, whose species were on the verge of extinction once. The project also contributes towards the conservation in a plethora of related fields. The main objectives of the crocodile project is to protect the remaining population of crocodiles and their natural habitat by establishing sanctuaries; to promote captive breeding; to improve management; and to involve the local people in the project intimately. It is worth noticing that with the initiation of Crocodile Conservation Project, 4000 gharial/aligator, 1800 mugger/crocodile and 1500 saltwater crocodiles could be restocked.
4. **UNDP Sea Turtle Project:** With an objective to conserve the Olive Ridley Turtles, the UNDP Sea Turtle Project was initiated by Wildlife Institute of India, Dehradun as the Implementing Agency in November 1999. The project is for 10 coastal state in India especially Odisha where it has contributed towards the preparation of a map of breeding

sites of Sea Turtles; identification of breeding places and habitats along the coast line, and migratory routes taken by Sea Turtles. The project also helped in the development of guidelines to safeguard the turtle mortality rate and for tourism in sea turtle areas. Amongst the major achievements of the project is the demonstration of use of Satellite Telemetry to locate the migratory route of sea turtles in the sea. Apart from these projects, GOI also has been handling projects like Vulture Conservation and India Rhino Vision (IRV) 2020.

Steps Taken By Indian Government to Protect Biodiversity

Along with above specified conservation projects of the wild animals, GOI has also initiated few schemes that are worked upon to protect the biodiversity and minimize the mortality of critically endangered, endangered and threatened animals. Here are few important steps that Government of India has taken for the wildlife protection:

- In the Wildlife Protection Act of 1972, GOI created Protected Areas like National Parks, Sanctuaries, Conservation Reserves and Community Reserves for the wildlife and imposed punishments on those indulged in illegal act of hunting.
- Wetland (Conservation and Management) Rules 2010 have been drafted to protect of wetlands in India. The Central Government has also initiated the scheme, National Plan for Conservation of Aquatic Eco-System that lends assistance to the states for the sound management of all wetlands.
- In order to curb the illegal trade of wildlife and that of endangered species, Wildlife Crime Control Bureau has been established.
- Special organizations like Wildlife Institute of India, Bombay Natural History society and Salim Ali Centre for Ornithology and Natural History are formed to conduct research on conservation of wildlife.
- To check the dwindling population of Gyps vulture in India, Government of India has banned the veterinary use of diclofenac drug.
- For restocking of the endangered species, the Central Government first initiated Integrated Development of Wildlife Habitat Scheme and later modified it by including a new component, Recovery of Endangered Species which included animals like Hangul/stag deer in Jammu & Kashmir, Vultures in Punjab, Haryana and Gujarat, Snow Leopard in Jammu & Kashmir, Himachal Pradesh, Uttarakhand and Arunachal Pradesh,

Swiftlet in Andaman & Nicobar Islands, Nilgiri Tahr in Tamil Nadu, Sangai Deer in Manipur. Financial and technical assistance is also extended to the state government to provide better means of protection and conservation for the specified species.

- The State Governments have been asked to strengthen the field formations and increase patrolling in and around the Protected Areas.
- GOI intensified anti-poaching activities and initiated special patrolling strategy for monsoon season. Also, deployment of anti-poaching squad.
- In order to strengthen tiger conservation, National Tiger Conservation Authority is constituted by Government of India.
- A Special Tiger Protection Force (STPF) has also been constituted and is deployed in Karnataka, Maharashtra and Odisha.
- E-Surveillance has been started in Kaziranga National Park in Assam and borders of Ratapani Wildlife Sanctuary in Madhya Pradesh.

Important Environment and Biodiversity Acts Passed by Indian Government

- Fisheries Act 1897
- Indian Forests Act 1927
- Mining And Mineral Development Regulation Act 1957
- Prevention of Cruelty To Animals 1960
- Wildlife Protection Act 1972
- Water (Prevention and Control of Pollution) Act 1974
- Forest Conservation Act 1980
- Air (Prevention and Control of Pollution) Act 1981
- Environment Protection Act 1986
- Biological Diversity Act 2002
- Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Rights) Act 2006

Not only this, there are a few International schemes and projects that India has signed drafted with its neighbours, Nepal and Bangladesh related to illegal wildlife species trade and conservation of tigers and leopards. Apart from this, there are plenty of other legal, administrative and financial steps that Government of India has taken for effective wildlife conservation in the country. And apparently the success of its some projects and schemes related

to Indian Rhinos, tigers and poaching have earned it immense confidence to continue working towards a prosperous and intact wildlife.

Steps Taken By Government for Biodiversity Protection

Indian Government has taken various biodiversity protection steps. Important measures include:

1. The Central Government has enacted the **Wild Life (Protection) Act, 1972**. The Act, inter alia, provides for the creation of Protected Areas for the protection of wildlife and also provides for punishment for hunting of specified fauna specified in the schedules I to IV thereof.
2. **Wetland (Conservation and Management) Rules 2010** have been framed for the protection of wetlands, in the States.
3. The Centrally Sponsored Scheme of **National Plan for Conservation of Aquatic Eco-System** also provides assistance to the States for the management of wetlands including Ramsar sites in the country.
4. **Wildlife Crime Control Bureau** has been established for control of illegal trade in wildlife, including endangered species.
5. Wildlife Institute of India, Bombay Natural History society and Salim Ali Centre for Ornithology and Natural History are some of the research organisations undertaking research on conservation of wildlife.
6. The Indian Government has banned the veterinary use of diclofenac drug that has caused the rapid population decline of Gyps vulture across the Indian Subcontinent. Conservation Breeding Programmes to conserve these vulture species have been initiated at Pinjore (Haryana), Buxa (West Bengal) and Rani, Guwahati (Assam) by the Bombay Natural History Society.
7. The Centrally Sponsored Scheme '**Integrated Development of Wildlife Habitats**' has been modified by including a new component namely '**Recovery of Endangered Species**' and 16 species have been identified for recovery viz. Snow Leopard, Bustard (including Floricans), Dolphin, Hangul, Nilgiri Tahr, Marine Turtles, Dugong, Edible Nest Swiftlet, Asian Wild Buffalo, Nicobar Megapode, Manipur Brow-antlered Deer, Vultures, Malabar Civet, Indian Rhinoceros, Asiatic Lion, Swamp Deer and Jerdon's Courser.

8. Under the 'Recovery of Endangered Species' component of the Centrally Sponsored Scheme 'Integrated Development of Wildlife Habitats' for the recovery of endangered species viz. **Hangul** in Jammu and Kashmir, **Snow Leopard** in Jammu and Kashmir, Himachal Pradesh, Uttarakhand and Arunachal Pradesh, **Vulture** in Punjab, Haryana and Gujarat, **Swiftlet** in Andaman and Nicobar Islands, **Nilgiri Tahr** in Tamil Nadu, **Sangai Deer** in Manipur, the government has to spend lakhs of rupees.
9. Protected Areas, viz, National Parks, Sanctuaries, Conservation Reserves and Community Reserves all over the country covering the important habitats have been created as per the provisions of the Wild Life (Protection) Act, 1972 to provide better protection to wildlife, including threatened species and their habitat.
10. Financial and technical assistance is extended to the State Governments under various Centrally Sponsored Schemes, viz, 'Integrated Development of Wildlife Habitats', 'Project Tiger' and 'Project Elephant' for providing better protection and conservation to wildlife.
11. The Central Bureau of Investigation (CBI) has been empowered under the Wild Life (Protection) Act, 1972 to apprehend and prosecute wildlife offenders.
12. The State Governments have been requested to strengthen the field formations and intensify patrolling in and around the Protected Areas

Important Indian Acts passed related to Environment and Bio Diversity

1. Fisheries Act 1897.
2. Indian Forests Act 1927.
3. Mining and Mineral Development Regulation Act 1957.
4. Prevention of cruelty to animals 1960.
5. Wildlife protection act 1972.
6. Water (prevention and control of pollution) act 1974.
7. Forest Conservation Act 1980.
8. Air(prevention and control of pollution) act 1981.
9. Environment Protection Act 1986.
10. Biological Diversity Act 2002.

Policies related to Environment and Bio Diversity

1. National Forest Policy.
2. National Conservation Strategy and Policy statement on Environment and Development.
3. National Policy and macro-level action strategy on Biodiversity.
4. National Biodiversity Action Plan (2009).
5. National Agriculture Policy.
6. National Water Policy.
7. National Environment Policy (2006).

Conserving biodiversity: International efforts

Md. Mahfujur Rahman

Biodiversity is disappearing from the natural ecosystems of forests, savannahs, pastures and rangelands, deserts, tundras, rivers, lakes and seas .This is largely the result of human activity and represents a serious threat to human development. To protect these precious resources for human kind various environmental conservation organisations are working world-wide.

1. World Conservation Union (IUCN) is the world's largest and most important conservation network that brings together 83 States, 110 government agencies, more than 800 non-governmental organizations (NGOs), and some 10,000 scientists. Experts from 181 countries work for conservation of natural resources under IUCN's various programmes in a unique worldwide partnership. The World Commission on Protected Areas, Species Survival Commission and Commission on Ecosystem Management of IUCN directly address biodiversity crisis.

2. United Nations Environment Programme (UNEP) collaborates with a wide range of partners throughout the UN system and beyond to provide information on the state of the planet's natural resources and their contribution to sustainable development. The UNEP has been at the forefront of assessing and monitoring global biodiversity issue. The Convention on Biological Diversity was negotiated under the auspices of the UNEP.

3. **World Conservation Monitoring Centre (WCMC)** of the United Nations Environment Programme or UNEP-WCMC is an executive agency of the United Nations Environment Programme, based in Cambridge in the United Kingdom. UNEP-WCMC has been part of UNEP since 2000, and has responsibility for biodiversity assessment and support to policy development

and implementation. WCMC monitors the effectiveness of biodiversity conservation efforts especially made by UNEP, IUCN and WWF throughout the world.

4. The World Wide Fund for Nature (WWF) is an international non-governmental organisation for the conservation, research and restoration of the natural environment. Formerly named the World Wildlife Fund. WWF is one of the world's largest and most experienced independent conservation organisations, with almost 5 million supporters and a global network active in more than 100 countries. It is a charity, with approximately 90 percent of its funding coming from voluntary donations by private individuals and businesses. WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature. One of three goals of WWF is conserving the world's biological diversity.

5. Global Environment Facility (GEF) was established by donor governments in 1991 to provide conservation finance proposed at the Earth Summit. It helps beneficiary nations to fund projects and programmes that aim to protect the global environment. GEF grants support projects related to biodiversity, climate change, international waters, land degradation, the ozone layer, and persistent organic pollutants.

6. United Nations Educational, Scientific and Cultural Organisation (UNESCO) headquartered in Paris, France, was founded in 1945, to act as U.N.'s lead agency on matters relating to education, the sciences, culture, and communications. The Man and the Biosphere Programme (MAB) is one of the major scientific programmes of the UNESCO, dedicated to conservation of biodiversity through designation of biosphere reserves throughout the world.

7. The World Resources Institute (WRI) is an environmental think tank that goes beyond research to find practical ways to protect the earth and improve people's lives. Its mission is to move human society to live in ways that protect Earth's environment and its capacity to provide for the needs and aspirations of current and future generations. The WRI works for sustainable use of biodiversity through ecosystem approach. Its objective is to maintain as much pristine condition of natural ecosystems as possible by its 'People & Ecosystems' working area so that ecosystems can provide natural goods and services .The Institute was launched on June 3, 1982.

Major events

1. **World Conservation Strategy (WCS)** was formulated by IUCN in cooperation with UNEP, WWF, FAO and UNESCO. It explains the contribution of living resource conservation to human survival and to sustainable development and identifies the priority conservation issues along with the main requirements for dealing with them and proposes ways for effectively achieving the Strategy aim. The WCS was launched in 1980 in 30 countries, and now many countries are adopting conservation strategies formulated within the guidelines suggested.
2. **Global Biodiversity Assessment (GBA)** is an independent, critical, peer reviewed scientific analysis of the current issues, theories and views regarding the main aspects of biodiversity. According to the Global Biodiversity Assessment, it is estimated that the total number of species on Earth is between 13 and 14 million, of which only 1.75 million have been described. Enormous diversity exists between these species, ranging from common annual herbs to bacteria of deep ocean trenches. Their arrangement into classifications reflect their phyletic relationships, and the complex patterns of variation and distribution. Groups of plants, birds, mammals, fishes, reptiles and amphibians the species with which we are most familiar and utilize for economic purpose is only 3 percent of the estimated total. The majority of species belong to groups such as insects, arachnids, fungi, nematodes and microorganisms.
3. **Convention on Biological Diversity (CBD)** was negotiated under the auspices of the UNEP. It entered into force on 29 December 1993. As of October 1998, more than 170 countries had become parties. The three goals of the CBD are to promote the conservation of biodiversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising out of the utilisation of genetic resources. The CBD Secretariat is located in Montréal, Canada. The Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA), which advises the Conference of the Parties (COP), meets several months prior to each COP.
4. **Man and the Biosphere Program (MAB)** was launched in 1970 and was formally endorsed by U.N. Member States at the U.N. Conference on the Environment in 1972. Since its early days, MAB has initiated programmes and activities focusing on the diversity and the resources provided by nature, humans' impacts on biodiversity, as well as how

biodiversity affects human activities. The original objective of MAB was to establish protected areas representing the main ecosystems of the planet. A 'biosphere reserve' under MAB is a unique kind of protected area. It differs from a national park, wilderness area, national forest or wildlife refuge in having three equal aims: conservation of genetic resources, species, and ecosystems; scientific research and monitoring; and promoting sustainable development in communities of the surrounding region.

Recent progresses

Global Biodiversity Challenge: In April 2002, the Parties to the Convention committed themselves to achieve by 2010 a significant reduction in the current rate of biodiversity loss at the global, regional and national level. This target was subsequently endorsed by the World Summit on Sustainable Development and the United Nations General Assembly and was incorporated as a new target under the Millennium Development Goals. In February 2004 the Parties of Convention on Biological Diversity at the seventh Conference identified a role for UNEP-WCMC in eight decisions, including work on assessing progress in achieving the internationally-agreed target of achieving a significant reduction in the rate of biodiversity loss globally by 2010, on monitoring implementation of the Global Strategy for Plant Conservation, and of the World Database on Protected Areas.

Global Biodiversity Outlook: The second edition of the Global Biodiversity Outlook (GBO-2) was published by the Secretariat of the Convention on Biological Diversity in 2006.GBO-2 assesses the current status and trends of biodiversity and the key drivers of biodiversity loss. It provides a powerful case for the importance of biodiversity to human well-being. The report contains a succinct overview of the status of the implementation of the Convention on Biological Diversity, progress towards the 2010 Biodiversity Target and its contribution to the achievement of the Millennium Development Goals.

Conclusion

Biodiversity, the variety of life on Earth, is disappearing at an unprecedented rate. This situation contradicts the international "2010 Biodiversity Target", which aims at significantly reducing the rate of biodiversity loss by 2010. Science and governance for conserving and sustainably and equitably using biodiversity are key elements to decrease the rate of its loss.

Source: Md. Mahfujur Rahman studies Environmental Sciences at Jahangirnagar University.

Causes of Biodiversity Losses

The causes of biodiversity loss are grouped in two major categories-

A. Natural causes

1. Climate changes
2. Volcanic eruption
3. Collision of earth with celestial bodies (meteors)
4. Continental drift and fragmentation
5. Drought and famine

B. Anthropogenic causes

1. Habitat loss
2. Fragmentation
3. Over-exploitation
4. Intensive agriculture
5. Diseases
6. Environmental pollution
7. Genetics transformation
8. Tourism industry

1. **Habitat loss and destruction**: This is one of the greatest threats to biodiversity. Habitat loss is directly linked to human induced pressures on land.
2. **Alterations in ecosystem composition**: Assemblages of species and their interactions with their ecosystems is critical for not only saving the species, but also for their successful future evolution. In the event of alterations, either ecosystems can begin to change. Alterations to ecosystems are critical factor contributing to species and habitat loss.
3. **Over-exploitation**: Over-hunting, over-fishing or over-collecting of a species can quickly lead to its decline. Changing consumption patterns of human is often cited as the key reason for this unsustainable exploitation of natural resources.
4. **Invasive alien species**: The introduction of exotic species that replace local and native species is cited as the second largest of biodiversity loss. Alien invasive species replace, and offer result in the extinction of native species. The annual economic damage caused by invasive plant and animal species is estimated to be in the region of US$1.4 trillion.
5. **Pollution and contamination**: Biological systems respond slowly to changes in their surrounding environment. Pollution and contamination cause irreversible damage to species.
6. **Global climate change**: Both climate variability and climate change cause biodiversity loss. Species and populations may be lost permanently, if they are not provided with enough time to adapt to changing climate conditions.

Causes of recent declines in biodiversity

The major causes of biodiversity decline are land use changes, pollution, changes in atmospheric CO_2 concentrations, changes in the nitrogen cycle and acid rain, climate alterations, and the

introduction of exotic species, all coincident to human population growth. For rainforests, the primary factor is land conversion. Climate will probably change least in tropical regions, and nitrogen problems are not as important because growth in rainforests is usually limited more by low phosphorus levels than by nitrogen insufficiency. The introduction of exotic species is also less of a problem than in temperate areas because there is so much diversity in tropical forests that newcomers have difficulty becoming established (Sala, *et al.*, 2000).

12. ***Human population growth***: The geometric rise in human population levels during the twentieth century is the fundamental cause of the loss of biodiversity. It has led to an unceasing search for more arable land for food production and livestock grazing, and for wood for fuel, construction, and energy. Previously undisturbed areas are being transformed into agricultural or pasture land, stripped of wood, or mined for resources to support the energy needs of an ever-growing human population. Humans also tend to settle in areas of high biodiversity, which often have relatively rich soils and other attractions for human activities. This leads to great threats to biodiversity, especially since many of these areas have numerous endemic species. Balmford, *et al.*, (2001) have demonstrated that human population size in a given tropical area correlates with the number of endangered species, and that this pattern holds for every taxonomic group. Most of the other effects mentioned below are either consequent to the human population expansion or related to it.

    Due to high pressure of population can birds continue to migrate, can larger organisms have space (habitat) to forage, can ecosystems survive in anything like their present form, or are they doomed to impoverishment and degradation.

13. ***Habitat destruction****:* Habitat destruction is the single most important cause of the loss of biodiversity and is directly related to human population growth. As forest land is converted to ranches, agricultural land, urban areas and other human usages, habitat is lost for forest organisms. Many species are widely distributed and thus, initially, habitat destruction may only reduce local population numbers. Species which are local, endemic, or which have specialized habitats are much more vulnerable to extinction, since once their particular habitat is degraded or converted for human activity, they will disappear. Most of the habitats being destroyed are those which contain the highest levels of biodiversity, such as lowland tropical wet forests. In this case, habitat loss is caused by clearing, selective logging, and burning etc.

14. ***Pollution****:* Industrial, agricultural and waste-based pollutants can have catastrophic effects on many species. Those species which are more tolerant of pollution will survive; those requiring pristine environments (water, air, food) will not. Thus, pollution can act as a selective agent. Pollution of water in lakes and rivers has degraded waters so that many freshwater ecosystems are dying. Since almost 12% of animal species live in these ecosystems, and most others depend on them to some degree, this is a very serious matter. In developing countries approximately 90% of wastewater is discharged, untreated, directly into waterways.

15. ***Agriculture****:* The dramatic increase in the number of humans during the twentieth century has instigated a concomitant growth in agriculture, and has led to conversion of wild lands to croplands, massive diversions of water from lakes, rivers and underground aquifers, and, at the same time, has polluted water and land resources with pesticides,

fertilizers, and animal wastes. The result has been the destruction, disturbance or disabling of terrestrial ecosystems, and polluted, oxygen-depleted and atrophied water resources.

Earlier agricultural systems were integrated with and co-evolved with technologies, beliefs, myths and traditions as part of an integrated social system. Generally, people planted a variety of crops in different areas, in the hope of obtaining a reasonably stable food supply. These systems could only be maintained at low population levels, and were relatively nondestructive. More recently, agriculture has in many places lost its local character, and has become incorporated into the global economy. This has led to increased pressure on agricultural land for exchange commodities and export goods. More land is being diverted from local food production to "cash crops" for export and exchange; fewer types of crops are raised, and each crop is raised in much greater quantities than before. Thus, ever more land is converted from forest for agriculture for export, rather than using land for subsistence crops. The introduction of monocropping and the use of relatively few plants for food and other uses at the expense of the wide variety of plants and animals utilized by earlier peoples and indigenous peoples is responsible for a loss of diversity and genetic variability. The native plants and animals adapted to the local conditions are now being replaced with "foreign" (or "exotic") species which require special inputs of food and nutrients, large quantities of water. Such exotic species frequently drive out native species. There is pressure to conform to crop selection and agricultural techniques all is driven by global markets and technologies.

16. ***Global warming*:** There is recent evidence that climate changes are having effects on forest ecology. Warming in general (as distinct from the effects of increasing concentrations of CO_2 and other greenhouse gases) can increase primary productivity, yielding new plant biomass, increased organic litter, and increased food supplies for animals and soil flora (decomposers). Temperature changes can also alter the water cycle and the availability of nitrogen and other nutrients. Basically, the temperature variations which are now occurring affect all parts of forest ecosystems, some more than others. These interactions are unimaginably complex. While warming may at first increase net primary productivity (NPP), in the longer run, because plant biomass is increasing, more nitrogen is taken up from the soil and sequestered in the plant bodies. This leaves less nitrogen for the growth of additional plants, so the increase in NPP over time (due to a rise in temperature or CO_2 levels) will be limited by nitrogen availability. The same is probably true of other mineral nutrients. The consequences of warming-induced shifts in the distribution of nutrients will not be seen rapidly, but perhaps only over many years. These events may affect changes in species distribution and other ecosystem processes in complex ways. We know little about the reactions of tropical forests, but they may differ from those of temperate forests.

    In tropical forests, warming may be more important because of its effects on evapotranspiration and soil moisture levels than because of nutrient redistribution or NPP (which is already very high because tropical temperatures are close to the optimum range for photosynthesis and there is so much available light energy). And warming will obviously act in concert with other global or local changes increases in atmospheric CO_2 (which may modify plant chemistry and the water balance of the forest) and land clearing

(which changes rainfall and local temperatures), for examples. (For an excellent discussion of these issues, see Shaver, *et al.*, 2000.)

The migratory patterns of some birds which live in both tropical and temperate regions during the year seem to be shifting, which is dangerous for these species, as they may arrive at their breeding or wintering grounds at an inappropriate time. Or they may lose their essential interactions with plants which they pollinate or their insect or plant food supplies. Perhaps for these reasons, many migratory species are in decline, and their inability to coordinate migratory clues with climatic actualities may be partly to blame. The great tit, which still breeds at the same time as previously, now misses much of its food supply because its plant food develops at an earlier time of year, before the birds have arrived from their wintering grounds. Also, as temperatures rise, some bird populations have shifted, with lowland and foothill species moving into higher areas. The consequences for highland bird populations are not yet clear. And many other organisms, both plant and animal, are being affected by warming.

An increase in infectious diseases is another consequence of climate change, since the causative agents are affected by humidity, temperature change, and rainfall. Many species of frogs and lizards have declined or disappeared, perhaps because of the increase in parasites occasioned by higher temperatures. As warming continues, accelerating plant growth, pathogens may spread more quickly because of the increased availability of vegetation and because of increased humidity under heavier plant cover. In addition, the geographical range of pathogens can expand when the climate moderates, allowing pathogens to find new, nonresistant hosts. On the other hand, a number of instances of amphibian decline seem to be due to infections with chrytid fungi, which flourish at cooler temperatures.

17. ***Forest fragmentation****:* The fragmentation of forests is a general consequence of the haphazard logging and agricultural land conversion which is occurring everywhere, but especially in tropical forests. When forests are cut into smaller and smaller pieces, there are many consequences, some of which may be unanticipated.

    - ✓ Fragmentation decreases habitat simply through loss of land area, reducing the probability of maintaining effective reproductive units of plant and animal populations. When a forest becomes fragmented, trees of many species are isolated because their pollinators cannot cross the unforested areas. Under these conditions, the trees in the fragments will then become inbred and lose genetic variability and vigor. Other species, which have more wide-ranging pollinators, may suffer less from fragmentation. For instance, the pollen of several species of strangler figs (the fruit of which is an essential element in the diets of many animals) is dispersed by wasps over distances as great as 14.2 km (Nason, Herre, & Hamrick, 1998). Thus "breeding units" of these figs are extremely large, comprising hundreds of plants located in huge areas of forest. Isolated fig populations seem to survive and help to maintain frugivore numbers, so long as the number of trees within the range of the wasps does not fall below a critical minimum.

      Most species are not so tolerant, however. Animals, particularly large ones, cannot maintain themselves in small fragmented forests. Many large mammals

have huge ranges and require extensive areas of intact forest to obtain sufficient food, or to find suitable nesting sites. Additionally, their migrations may be interrupted by fragmentation. These animals are also much more susceptible to hunting in forest fragments, which accounts for much of the decline in animal populations in rainforests. Species extinctions occur more rapidly in fragments, for these reasons, and also because species depend upon each other. The absence of large predator species leads to imbalances in prey populations and since many of the prey species are seed-eaters, to declines in the population levels of many plant species. The preys, now at high population levels, consume most available seeds, leaving few to germinate.

- ✓ When forests are cut down or burned, the resulting gaps are too large to be filled in by the normal regeneration processes. This permits the ascendancy of rapid-growing, light-tolerant species and grasses. Large gaps may then be converted to scrub or grassland.
- ✓ The "edge" effect: The cutting of forest into fragments creates many "edges" where previously there was deep forest. Many effects are consequent upon this. Edges are lighter, warmer and windier than the forest interior. These changes in microclimate alter plant reproduction, animal distribution, the biological structure and many other features of the forest. Tree mortality is much greater near edges, and climax species will be replaced by pioneer species. These effects can be seen as far as one kilometer into the forest. The drier and warmer conditions also make the fragment more flammable, with a concomitant increase in the frequency of fires. Without further stress, the forest may regenerate. However, if the fragment is surrounded by a human-dominated landscape, it may be inhibited from regeneration.
- ✓ Fire is particularly frequent in fragments. Recently, many forests have been subjected to deliberately-set and accidental fires, to which they have little resistance, and to which they are rarely naturally subjected. People often set fire to cut-over areas adjacent to forests to clear them of debris. These fires often get out of control and burn large areas, extend into the forest interior, and inhibit edge regeneration by killing pioneer forest vegetation. If conditions remain severe, the forest will recede and be replaced by scrub.
- ✓ The use of herbicides and the introduction of exotic species into areas surrounding forest fragments are detrimental to forest health. Herbicides blow from cleared agricultural areas into forests, and exotic species introduced by farmers and ranchers spread, often displacing native species. These exotic organisms interrupt the forest ecosystem and, since they have few or no natural enemies in their new environment, they are difficult to eradicate.
- ✓ For unknown reasons, fragmentation leads to the death of large canopy trees, even in the interior of fragments. Canopy trees dominate the forest structure, and they provide fruits and shelter for many animals. The mortality of trees in fragmented patches in Brazil has been found to be twice that of similar trees in the forest interior (Laurance, *et al.*, 2000). Not only that, but tree mortality is confined disproportionately to large trees (an almost 40% increase in mortality). Large

trees may be more vulnerable in fragmented forests because they are not as well buffered from wind and natural forces, because there are more tree parasites and because they are more subject to desiccation at forest edges. Loss of these largest trees has several corollary effects the alteration of biogeochemical cycles, the reduction of species complexity, and the reduction of fecundity. As mentioned above, large trees are essential habitats and food sources for many other organisms, both plant and animal; they are the source of much of the primary productivity of the forest; and they are responsible for many effects on the water and nutrient cycles. They are irreplaceable in the forest ecosystem.

- ✓ The fragmentation of forests by logging and agricultural conversion also exaggerates the probability of major epidemics. Pathogens introduced through human activities by land use practices in areas surrounding the forest can be lethal to forest plants and animals.

    - ✓ Rainforests are losing species, not only because of the disappearance of their habitat, but also because essential ecological processes are being interrupted by fragmentation. Fragments are much more easily accessible to human incursions than are intact forests. This leads to a variety of extractive activities within the forest interior. Intensive hunting, by depleting animal populations, inhibits plant reproduction, since many seeds can neither be dispersed, nor flowers be pollinated without them. Where these seed dispersers have been eliminated, are at low population densities, or cannot move between forest fragments, seed dispersal will be very limited, and as a result tree species dependent upon animal dispersers may become locally extinct. In the remnants of the Atlantic forest of Brazil, the seeds of 71% of tree species are dispersed by vertebrates (birds and mammals), and about 48% of these dispersers are birds which are deep-forest dwellers. As this forest becomes more and more fragmented, these birds are disappearing, so eventually the trees dependent upon them will be unable to replace themselves. In some fragments, all large vertebrates (including seed-eaters) have been hunted to extinction, and in some places the fragments are so distant from each other that these animals cannot pass from one to another.

    In addition, in fragmented forests, seeds will frequently land in deforested areas (where they are in the open, and exposed to heat, light and desiccation) in which they cannot germinate, and the seedlings cannot survive.

18. ***Hunting, fishing and gathering***: Many forests which appear intact are in fact "empty forests," since most large animals have been hunted to unsustainable levels. These animals are mainly hunted for meat, but also for skins (Jaguar, Ocelot) or medicinal/chemical properties (poison-arrow frogs, collected to provide poisons for arrow tips, and the midwife toad, which in the Amazon is thought to have medicinal value). Turtles are heavily harvested for meat and their eggs are collected for food almost everywhere in the tropics and subtropics. Asian tropical freshwater turtles are in serious decline because they are extensively hunted for food or for use in traditional Chinese medicines. Thousands of tons of live turtles are caught or sent to China annually, a completely unsustainable level of collection. There are apparently no turtles left in the

wild in Vietnam for this reason (Gibbons, *et al.*, 2000). More than 80 species of Asian turtles are at such low population numbers that they will become extinct unless emergency measures restrictions on international trade, increased habitat protection, captive breeding programs are taken immediately.

Some of the hunting is done for subsistence purposes by villagers; some by farmers, miners and loggers, who live in the forest and use forest animals as a major food source; some by commercial hunters to supply urban markets. This is a major source of income in many rural tropical areas. Part of the remedy for overexploitation of wildlife resources, then, lies with improving the income levels of local residents in increasing the costs of hunting, and in lowering the prices of alternative protein sources.

Many animals are trapped for the pet trade (tropical fish, birds, reptiles, monkeys) or for zoos or medical research. Other animals are trapped for their hides or furs, and some are killed because they live too close to human habitation and impinge on human activities. For instance, ocelots and other small carnivores may be shot when they attempt to prey on chickens or other domestic animals.

Many tropical animals are hunted mercilessly for their value in traditional Asian medicines. Tigers, bears, deer, snakes, and many other animals are near extinction in many places because of this trade. Tigers in India are almost gone and only 3,000 tigers still exist in the wild. Many of these animals, or their parts, are smuggled illegally from Southeast Asian countries to China and other countries with large Chinese populations for these uses.

The effects of hunting are not just on the animals "taken." Many animals which are human prey eat fruits and seeds, and are major seed dispersers in tropical forests (see above), and the seeds of certain species of trees must pass through the gut of an animal in order to germinate. In these ways many tropical plants and trees depend upon animals, for, without them, they will not be able to reproduce. This can be very detrimental to forests, which generally have high genetic diversity, because more homogeneous plants are generally less fit. The loss of elephants in African countries due to hunting has led to a loss of reproductive ability in many valuable tree species.

Fish and aquatic animals are killed indiscriminately by fishing techniques which employ insecticides and/or dynamite. These techniques not only catch the few desired specimens, but kill all of the other animals in the area. Commercial fishing operations are not sensitive to issues of sustainability. They catch as many marketable fish as possible, and intensify their efforts when fish populations drop (declines due in the first place to overfishing). Such unsustainable fishing operations have led and are leading to severe declines in fish in major river systems within tropical forests.

Fragmentation may be more serious than previously imagined because the consequences of fragmentation are not static, but progressive. The edges of cut areas do not remain "in place" but gradually recede, further reducing the size of the fragments. Eventually fragments may disappear altogether or undergo ecological collapse.

Why do people heedlessly decimate the precious biodiversity of their planet? Some of them feel they have no economic alternative, while others are driven by the desire for short-term profit. Still others are uncomprehending. Unfortunately, so much of the

depredation which is being inflicted upon areas of great biodiversity is, in the long run, and often in the short run, in vain. While tropical forests now occupy less than half of their former range, and much of what remains is damaged or fragmented, the net profit to humanity is slight. Clearing of tropical forests has provided only a relatively small percentage of total agricultural land, since much of the land converted for farms becomes rapidly degraded and is abandoned. Logging results in a one-time profit, mainly to large companies. Ranching is an activity which, on former rainforest land, is uneconomical, requires subsidizing, and is eventually abandoned. But the damage is permanent and the forest irreplaceable, so forest destruction has dire consequences. It degrades aquatic fisheries, causes floods and has many other consequences (see below) so much harm for so little benefit.

MAN AND BIOSPHERE PROGRAMME (MAB PROGRAMME)

- Biosphere Reserve programme was launched by UNESCO in 1971 under its " **MAN** and the **Biosphere Programme**" (MAB)
- A major step was taken by enactment of Indian Wildlife (Protection) Act in 1972 with a view to conserve flora and fauna of the country. Such efforts were supplemented by national MAB Committee.
- Indian MAB committee in 1979 has identified a network of the 13 representative ecosystems to be protected as biosphere reserves.
- Obviously, biosphere reserves programme is an excellent method for implementation of world conservation strategy.
- In 1985 in the world there were 243 biosphere reserves in 65 countries covering an area of over 15 million ha.
- Later introduced in India, the first Biosphere Reserve came in to being in 1986. This was Nilgiri Biosphere Reserve, covering an area of 5520sq.km.
- The second reserve, the Nanda Devi Biosphere Reserve, covering an area of 1560 sq.km was formally designated with effect from 18th January, 1988.
- The third reserve, Nokrek was also set up in 1988 and the fourth, great Nicobar in 1989.
- Thus till to date of June, 1992 the total seven Biosphere Reserves have been set up in the country.

Aim

- Studying the effects of human interference and pollution on the biotic and abiotic components of ecosystems.
- Conservation the ecosystems for the present as well as future.

The main objects of MAB programme are to:

- Conserve representative samples of ecosystem.
- Provide long term in situ conservation of genetic diversity.
- Provide opportunities for education and training.
- Provide appropriate sustainable managements of the living resources.
- Promote and facilitate basic and applied research and monitoring
- Promote international co-operation.

In brief, we may say that special feature of a biosphere reserve is that it combines four major groups of objectives, (1) Conservation (2) Research (3) Education and (5) Local involvement.

BIOSPHERE RESERVE AREA

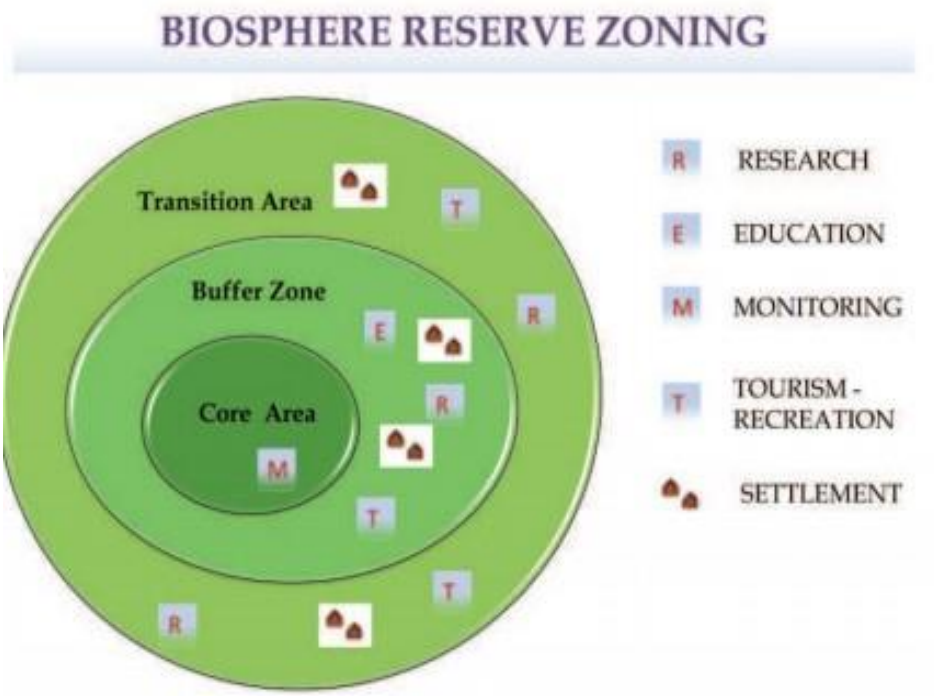
Biosphere reserves include natural, minimally disturbed, man-modified and degraded ecosystems. Large areas of protected land for conservation of wildlife, plant and animal resources and traditional life of the tribal living in the area. May have one or more national parks or wildlife sanctuaries in it. For management purposes, biosphere reserves areas are divided into

1. **Core area:** It represents natural and minimally disturbed ecosystems. Comprises a strictly protected ecosystem for conserving ecosystems, species and genetic variation. In core or natural zone human activity is not allowed.
2. **Manipulation (Forestry Zone):** It includes the man-made forests and selected felling areas.
3. **Manipulation (Tourism Zone):** It includes areas earmarked for tourism, Monitoring, training and education purposes. It is used also for scientific research study.
4. **Manipulation (Agriculture Zone):** It includes tribal settlements and other cultivated lands.
5. **Restoration Zone:** It includes degraded areas selected for restoration to natural or near natural conditions.

Transition area

- Ecologically sustainable human settlements and economic activities (tourism) are permitted.

- With the cooperation of reserve management and local people, several human activities like settlements, cropping, recreation, and forestry are carried out without disturbing the environment.



List of Biosphere Reserves in India

SN	Name of Biosphere Reserve	Date of Notification	Area (km^2)	State	Geographic Zone	Key fauna
1	Nilgiri B. R.	1.9.1986	5520 (Core 1240 & Buffer 4280)	TN, Kerala and Karnataka	Western Ghats	Nilgiri tahr, lion-tailed macaque
2	Nanda Devi B.R.	18.01.1988	5860.69 (Core 712.12, Buffer 5,148.570) & Tran. 546.34)	Uttarakhand	Western Himalayas	Snow Leopard, Himalayan Black Bear
3	Nokrek B. R.	01.09.1988	820 (Core 47.48 & Buffer 227.92, Tran Zone 544.60)	Meghalaya (Part of Garo Hills)	East Himalayas	Red panda
4	Great Nicobar B. R.	06.01.1989	885 (Core 705 & Buffer 180)	Andaman &Nicobar Islands	Islands	Saltwater crocodile
5	Gulf of Mannar B.R.	18.02.1989	10,500 km2 Total Gulf area (area of Islands 5.55 km2)	Tamil Nadu	Coasts	Dugong or sea cow
6	Manas B. R.	14.03.1989	2837 (Core 391 & Buffer 2,446)	Assam (Terai region)	East Himalayas	Golden langur, red panda
7	Sundarbans B. R.	29.03.1989	9630 (Core 1700 & Buffer 7900)	West Bengal	Gangetic Delta	Royal Bengal tiger
8	Simlipal B. R.	21.06.1994	4374 (Core 845, Buffer 2129 & Tran 1400	Odisha	Deccan Peninsula	Gaur, royal Bengal tiger, elephant
9	Dibru-Saikhowa B. R.	28.07.1997	765 (Core 340 & Buffer 425)	Assam	East Himalayas	Golden langur

10	Dihang-Dibang B. R.	02.09.1998	5111.50 (Core 4094.80 &Buffer 1016.70)	Arunachal Pradesh	Eastern Himalaya	
11	Pachmarhi B. R.	03.03.1999	4926	MP	Semi-Arid	Giant squirrel, flying squirrel
12	Khangchendzonga B. R.	07.02.2000	2619.92 (Core 1819.34 & Buffer 835.92)	Sikkim	East Himalayas	Snow leopard, red panda
13	Agasthyamalai B. R.	12.11.2001	1828	Kerala & TN	Western Ghats	Nilgiri Tahr, elephants
14	Achanakmar-Amarkantak B. R.	30.3.2005	3835.51 (Core 551.55 & Buffer 3283.86)	MP & CG	Maikala Hills	Four-horned antelope, Indian wild dog, Sarus crane, White-rumped vulture
15	Great Rann of Kachchh B. R	29.01.2008	12,454	Gujarat	Desert	Indian wild ass
16	Cold Desert B. R.	28.08.2009	7770	HP	Western Himalayas	Snow leopard
17	Seshachalam Hills B. R.	20.09.2010	4755.997	AP	Eastern Ghats	
18	Panna B. R.	25.08.2011	2998.98	MP	Catchment Area of the Ken River	Tiger, Chital, C hinkara, Sambh ar and Sloth bear

(Source: Wildlife Institute of India, as on 2014)

The International Union for Conservation of Nature (IUCN)

IUCN is a membership Union composed of both government and civil society organizations. It harnesses the experience, resources and reach of its more than1,300 Member organizations and the input of more than 15,000 experts. This diversity and vast expertise makes IUCN the global authority on the status of the natural world and the measures needed to safeguard it.

Salient features of IUCN

- IUCN's strength and mandate come from its diverse and powerful membership; more than 1,300 Member organizations which provide the vision and oversight for the Union and its work.
- Every four years, IUCN convenes the IUCN World Conservation Congress where **IUCN Members set the global conservation agenda** by voting on recommendations and guide the Secretariat's work by passing resolutions and the IUCN Programme.
- The IUCN Council is the **principal governing body**of IUCN between sessions of the World Conservation Congress. IUCN Members elect Commission chairs and representatives from Member organizations to serve four-year terms on the Council.
- The IUCN Secretariat works with Member organizations and IUCN Commissions to **move the vision of IUCN's membership into action**. The Secretariat includes around 900 staff and projects in over 160 countries.
- IUCN is a democratic Union that brings together the world's most influential organizations and top experts in a combined effort to conserve nature and accelerate the transition to sustainable development.
- **IUCN Member organizations** set the direction of the Union's work, and global conservation efforts more broadly, every four years at the IUCN World Conservation Congress.
- **Six** IUCN Commissions made up of over ten thousands experts inform IUCN's knowledge and help produce its work.

Secretariat

The **IUCN Secretariat** focuses its work on key themes and is organized into 11 operational regions in order to anchor its knowledge locally and better serve Members' needs. IUCN has

offices in more than 50 countries and runs projects all around the world. We have Member organizations and State Members in more than 160 countries and a network of over 10,000 voluntary scientists and experts spanning the globe.

IUCN in India

India, a mega diverse country with only 2.4% of the world's land area, accounts for 7-8% of all recorded species, including over 45,000 species of plants and 91,000 species of animals. The country's diverse physical features and climatic conditions have resulted in a variety of ecosystems such as forests, wetlands, grasslands, and desert, coastal and marine ecosystems which harbour and sustain high biodiversity and contribute to human well-being. Four of 34 globally identified biodiversity hotspots: The Himalayas, the Western Ghats, the North-East, and the Nicobar Islands, can be found in India. India became a State Member of IUCN in 1969, through the Ministry of Environment, Forest and Climate Change (MoEFCC).

The IUCN India Country Office was established in 2007 in New Delhi. IUCN India works with Members and Commissions to reduce ecosystem and species loss by providing the necessary tools and knowledge to value, conserve and use biodiversity sustainability; enhance governance and policy for better management of ecosystems and habitats, including protected areas; and address challenges related to poverty alleviation, food security and climate change.

Source: www.iucn.org/asia/countries/india

Concepts of RED Data Book

What is Red Data Book?

The Red Data Book is a public document which is created for recording endangered and rare species of plants, animals, fungi as well as some local subspecies which are present in a particular region. The Red Data Book helps us in providing complete information for research, studies and also for monitoring the programs on rare and endangered species and their habits. This book is mainly created to identify and protect those species which are on the verge of extinction.

Brief History of the Red Data Book

The name of this book has its origins from Russia; it was originally known as the Red Data Book of the Russian Federation or the RDBRF. The book was based on research conducted between 1961 and 1964 by biologists in Russia. Hence, it is also called as the Russian Red Data Book.

Currently, the International Union for Conservation of Nature maintains the Red Data Book. IUCN is the world's most detailed inventory centre of the global conservation status of biological species. The **International Union for Conservation of Nature** (**IUCN**) was founded in 1964 with an aim to maintain a complete record of every species that ever lived. The Red Data Book contains the complete list of threatened species. The main aim behind this documentation is to provide complete information for research and analysis of different species.

The Red Data Book contains colour-coded information sheets, which are arranged according to the extinction risk of many species and subspecies.

- ✓ Black represents species which are confirmed to be extinct.
- ✓ Red represents species that are endangered
- ✓ Amber for those species whose status is considered to be vulnerable
- ✓ White is assigned for species that are rare
- ✓ Green for species that were formerly endangered, but their numbers have started to recover
- ✓ Grey colored for the species that are classified as vulnerable, endangered, or rare but sufficient information is not available to be properly classified.

In a nutshell, the Red Data Book indexes species as:

- ✓ Threatened
- ✓ Not threatened
- ✓ Unknown

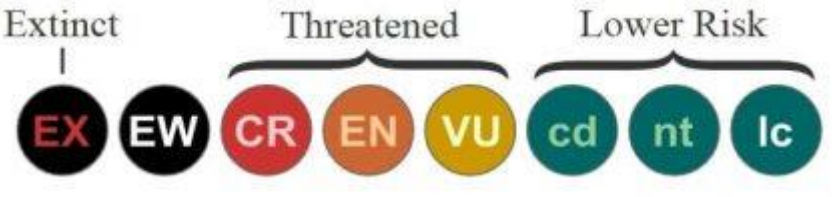
Furthermore, The Red Data Book also has information as to why a species has become extinct along with the population trends and the extent of its range (distribution).

International Union for Conservation of Nature

- (IUCN) is an international organization (**NGO**) working in the field of **nature conservation** and **sustainable use of natural resources**.
- It is involved in data gathering and analysis, research, field projects, advocacy, lobbying and education.
- The organization is best known for compiling and publishing the **IUCN Red List**, which assesses the conservation status of species worldwide.
- Its headquarters are in **Gland, Switzerland**.

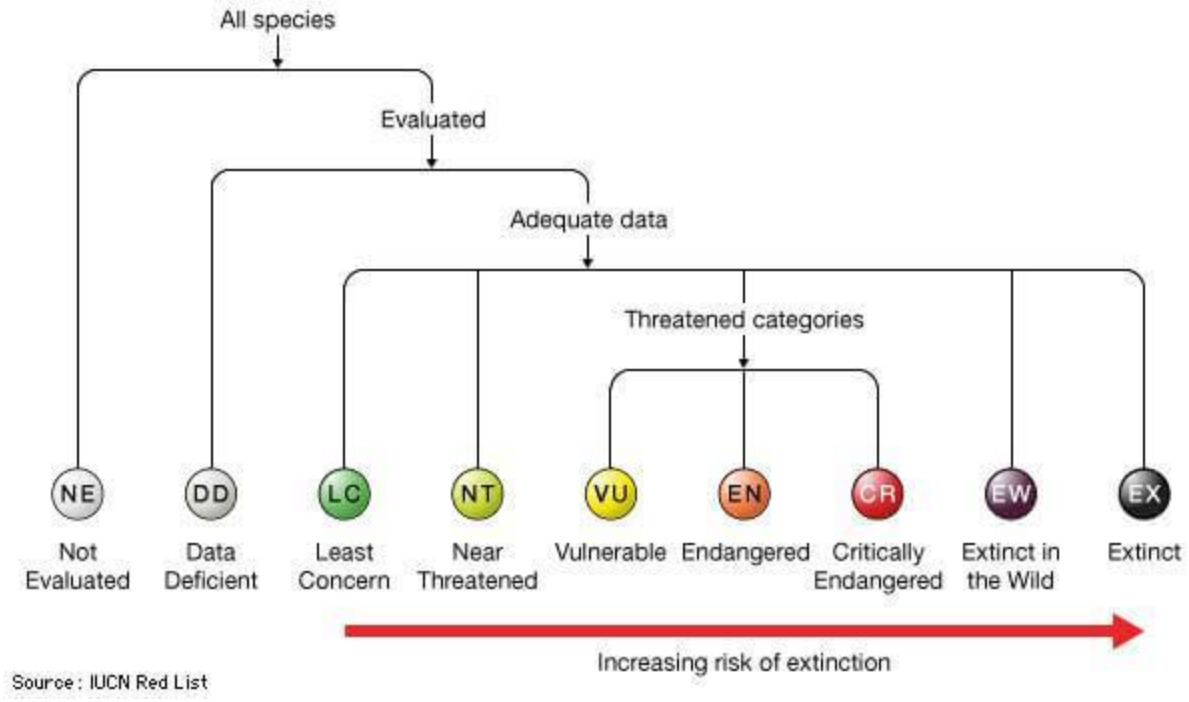
IUCN Red List or Red Data List or Red Book

- The IUCN Red List of Threatened Species, founded in 1964, is the world's most comprehensive inventory of the global conservation status of biological species.
- When discussing the IUCN Red List, the official term **"threatened"** is a grouping of three categories: **Critically Endangered, Endangered, and Vulnerable**.



- The **pink pages** in this publication include the **critically endangered species**.
- As the status of the species changes, new pages are sent to the subscribers.
- **Green pages** are used for those species that were **formerly endangered but have now recovered to a point where they are no longer threatened**.
- With passing time, the numbers of pink pages continue to increase.

Species are classified by the IUCN Red List into nine groups



Nine Groups in IUCN Red List

Nine Groups in IUCN Red List

1. **Extinct (EX) -** No known individuals remaining.
2. **Extinct in the wild (EW) -** Known only to survive in captivity, or as a naturalized population outside its historic range.
3. **Critically endangered (CR) -**
    - ✓ Extremely high risk of extinction in the wild.
    - ✓ reduction in population (greater than 90% over the last 10 years),
    - ✓ population size (number less than 50 mature individuals),
    - ✓ quantitative analysis showing the probability of extinction in wild in at least 50% in their 10 years, and
    - ✓ It is therefore considered to be facing an extremely high risk of extinction in the wild.
4. **Endangered (EN) -** High risk of extinction in the wild.
5. **Vulnerable (VU) -** High risk of endangerment in the wild.
6. **Near threatened (NT) -** Likely to become endangered in the near future.
7. **Least concern (LC) -**
    - ✓ Lowest risk. Does not qualify for a more at-risk category.
    - ✓ Widespread and abundant taxa are included in this category.
8. **Data deficient (DD) -** Not enough data to assess its risk of extinction.
9. **Not evaluated (NE) -** Has not yet been evaluated against the criteria.

Advantages of the Red Data Book

- ✓ It helps in identifying all animals, birds and other species about their conservation status.

- ✓ It is used to evaluate the population of a particular species.
- ✓ The data available in this book can be used to evaluate the taxa at the global level.
- ✓ With the help of this book, we can estimate the risk of taxa becoming globally extinct.
- ✓ Provides a framework or guidelines for implementing protective measures for endangered species.

Disadvantages of the Red Data Book

- ✓ The information available in the Red Data Book is incomplete. Many species, both extinct and extant are not updated in this book.
- ✓ The source of the book's data has been speculated and has been mired in controversy.
- ✓ This book maintains the complete record of all animals, plants, other species but it has no information about the microbes.

Red Data Book of India

Red Data Book of India includes the conservation status of animals and **plants** which are endemic to the Indian subcontinent. The data for this book is provided through surveys which are conducted by the Zoological Survey of India and the Botanical Survey of India under the guidance of the Ministry of Environment, **Forest** and Climate Change.

Critically endangered mammals as per the Red Data List of India include:

- Kondana Rat
- Malabar Civet
- Kashmir Stag
- River Dolphins

Critically endangered arthropods include:

- Rameshwaram Parachute spider
- Peacock Tarantula

Critically endangered fish include:

- Pookode Lake barb
- Ganges River shark
- Pondicherry shark

Critically endangered amphibians and reptiles include:

- Gharial
- White-spotted bush frog
- Toad-skinned frog

(Source : www.pmfias.com)

Protected Area Network in India

India is one of the 17 mega diverse countries of the world. With only 2.4% of the world's land area, 16.7% of the world's human population and 18% livestock, it contributes about 8% of the known global biodiversity, however, putting enormous demands on our natural resources. India is home to world's largest wild tigers population and has got unique assemblage of globally important endangered species like Asiatic lion, Asian Elephant, One-horned Rhinoceros, Gangetic River Dolphin, Snow Leopard, Kashmir Stag, Dugong, Gharial, Great Indian Bustard, Lion Tailed Macaque etc.

Protected Areas of India (As on December, 2021, MOFE)

SN	Name of Protected Area	Number	Total Area (km^2)	Area coverage % of Country
1.	National Parks	106	44,372.42	1.35
2.	Wildlife Sanctuaries	564	1,22,509.33	3.73
3.	Conservation Reserves	99	4,726.24	0.14
4.	Community Reserves	216	1,445.71	0.04
Total Areas (PAs)		**987**	**1,73,053.69**	**5.26**

A National Board for Wildlife (NBWL), chaired by the Prime Minister of India provides for policy framework for wildlife conservation in the country. The National Wildlife Action Plan (2002-2016) was adopted in 2002, emphasizing the people's participation and their support for wildlife conservation. India's conservation planning is based on the philosophy of identifying and protecting representative wild habitats across all the ecosystems. The Indian Constitution entails the subject of forests and wildlife in the Concurrent list. The Federal Ministry acts as a guiding torch dealing with the policies and planning on wildlife conservation, while the provincial Forest Departments are vested with the responsibility of implementation of national policies and plans.

As per report of ISFR, 2022, a network of 987 Protected Areas (PAs) has been established, extending over 1, 73,053.69 sq. km. (5.26% of total geographic area), comprising 106 National Parks, 564 Wildlife Sanctuaries, 99 Conservation Reserves and 218 Community Reserves. The State/Union Territory wise details of PAs in the country with year of notification and area is given in table. 52 Tiger Reserves and 28 Elephant Reserves have been designated for species

specific management of tiger and elephant habitats. UNESCO has designated 8 Protected Areas as World Heritage Sites. As the ecosystems and species do not recognize political borders, the concept of Trans boundary

Protected Areas has been initiated for coordinated conservation of ecological units and corridors with bilateral and/or multilateral cooperation of the neighbouring nations. There are 4 categories of the Protected Areas *viz*, National Parks, Sanctuaries, Conservation Reserves and Community Reserves.

Sanctuary is an area which is of adequate ecological, faunal, floral, geomorphological, natural or zoological significance. The Sanctuary is declared for the purpose of protecting, propagating or developing wildlife or its environment. Certain rights of people living inside the Sanctuary could be permitted. Further, during the settlement of claims, before finally notifying the Sanctuary, the Collector may, in consultation with the Chief Wildlife Warden, allow the continuation of any right of any person in or over any land within the limits of the Sanctuary.

Wildlife Sanctuaries or wildlife refuges

- ✓ Wildlife Sanctuaries or wildlife refuges are home to various endangered species.
- ✓ They are safe from hunting, predation or competition.
- ✓ They are safeguarded from extinction in their natural habitat.
- ✓ Certain rights of people living inside the Sanctuary could be permitted.
- ✓ Grazing, firewood collection by tribals is allowed but strictly regulated.
- ✓ Settlements not allowed (few exceptions: tribal settlements do exist constant; efforts are made to relocate them).
- ✓ A Sanctuary can be promoted to a National Park.
- ✓ There are more than 500 wildlife sanctuaries in India.

National Park is an area having adequate ecological, faunal, floral, geomorphological, natural or zoological significance. The National Park is declared for the purpose of protecting, propagating or developing wildlife or its environment, like that of a Sanctuary. The difference between a Sanctuary and a National Park mainly lies in the vesting of rights of people living inside. Unlike a Sanctuary, where certain rights can be allowed, in a National Park, no rights are allowed. No grazing of any livestock shall also be permitted inside a National Park while in a Sanctuary; the

Chief Wildlife Warden may regulate, control or prohibit it. In addition, while any removal or exploitation of wildlife or forest produce from a Sanctuary requires the recommendation of the State Board for Wildlife, removal etc., from a National Park requires recommendation of the National Board for Wildlife (*However, as per orders of Hon'ble Supreme Court dated 9th May 2002 in Writ Petition (Civil) No. 337 of 1995, such removal/ exploitation from a Sanctuary also requires recommendation of the Standing Committee of National Board for Wildlife*).

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.

Regulations/ laws relating to Protected Areas (PAs):

The PAs are constituted and governed under the provisions of the Wild Life (Protection) Act, 1972, which has been amended from time to time, with the changing ground realities concerning wildlife crime control and PAs management. Implementation of this Act is further complemented by other Acts viz. Indian Forest Act, 1927, Forest (Conservation) Act, 1980, Environment (Protection) Act, 1986 and Biological Diversity Act, 2002 and the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006. The Wildlife Crime Control Bureau of the Central Government supplements the efforts of provincial governments in wildlife crime control through enforcement of CITES and control of wildlife crimes having cross-border, interstate and international ramifications. In order to strengthen and

synergise global wildlife conservation efforts, India is a party to major international conventions viz. Convention on International Trade in Endangered Species of wild fauna and flora (CITES), International Union for Conservation of Nature (IUCN), International Convention for the Regulation of Whaling, UNESCO-World Heritage Committee and Convention on Migratory Species (CMS).

Main issues concerning the management of Protected Areas: Wildlife conservation and management in India is currently facing a myriad of complex challenges that are both ecological and social in nature. Issues such as habitat loss/fragmentation, overuse of biomass resources in the context of biotic pressures, increasing human-wildlife conflicts, livelihood dependence on forests and wildlife resources, poaching and illegal trade in wildlife parts and products, need for maintaining a broad base of public support for wildlife conservation exemplify and characterize the contemporary wildlife conservation scenario in India. The government and the civil society are taking several measures to address these issues. Improved synergies and better coordination amongst the wide array of stakeholders are needed to meet the challenges of conserving India's diverse wilderness resources.

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

SN	State/UT	No of NPs	No of WSs	No of CRs	No of CRs
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.	Chhattisgarh	3	11	0	0
6.	Goa	1	6	0	0
7.	Gujarat	4	23	1	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	5	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	Odisha	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**
NP= National Park, WS= Wildlife Sanctuary, CR= Conservation Reserve, CR= Community Reserves					

Protected Areas of India from 2000 to 2013

Year	No. of National Parks	Area Under National Parks	No. of Wild Life Sanctuaries	Area Under Wild Life Sanctuaries	No. of Community Reserves	Area Under Community Reserves	No. of Conservation Reserves	Area Under Conservation Reserves	No. of Protected Areas	Total Area under Protected Areas
2000	89	37593.94	489	117881.68	-	-	-	-	578	155475.63
2006	96	38183.01	506	120244.39	-	-	4	42.87	606	158470.27
2007	98	38219.72	510	120543.95	4	20.69	7	94.82	619	158879.19
2008	99	39232.58	513	122138.33	4	20.69	45	1259.84	661	162651.45
2009	99	39232.58	513	122138.33	4	20.69	45	1259.84	661	162651.45
2010	102	40074.46	516	122585.56	4	20.69	47	1382.28	669	164062.99
2011	102	40074.46	517	122615.94	4	20.69	52	1801.29	675	164512.37
2012	102	40074.46	524	123548.33	4	20.69	56	1998.15	686	165641.62
2013	102	40074.46	526	124234.52	4	20.69	57	2017.94	689	166347.60
2014	102	40074.46	528	125295.30	4	20.69	57	2017.94	691	167408.29

Source: National Wildlife Database Cell, Wildlife Institute of India

** All areas are in km^2*

** Community Reserves have been established in India from 2007 onwards and Conservation Reserves from 2005 onwards. Hence these values are zero.*

National Parks of India

There are 102 existing national parks in India covering an area of 44,372.42 km2, which is 1.35% of the geographical area of the country (National Wildlife Database, Dec. 2021). In addition to the above 75 National Parks covering an area of 16,608 km2 are proposed in the Protected Area Network Report (Rodgers & Panwar 1988). The network of parks will go up 177 after full implementation of the above report.

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

Name of State & Union Territory	State Area km²	No. of NPs	Areakm²	% of StateArea
1. Andhra Pradesh	2,75,069	6	1,388.39	0.50
2. Arunachal Pradesh	83,743	2	2,290.82	2.74
3. Assam	78,438	5	1,977.79	2.52
4. Bihar	94,163	1	335.65	0.36
5. Chhattisgarh	1,35,191	3	2,929.50	2.17
6. Goa	3,702	1	107.00	2.89
7. Gujarat	1,96,022	4	479.67	0.24
8. Haryana	44,212	2	48.25	0.11
9. Himachal Pradesh	55,673	5	2,271.78	4.08
10. Jammu & Kashmir	2,22,236	4	3,925.00	1.77
11. Jharkhand	79,714	1	226.33	0.28
12. Karnataka	1,91,791	5	2,628.42	1.37
13. Kerala	38,863	6	558.16	1.44
14. Madhya Pradesh	3,08,245	9	3,656.36	1.19
15. Maharashtra	3,07,713	6	1,273.60	0.41
16. Manipur	22,327	1	40.00	0.18
17. Meghalaya	22,429	2	267.48	1.19
18. Mizoram	21,081	2	150.00	0.71
19. Nagaland	16,579	1	202.02	1.22
20. Orissa	1,55,707	2	990.70	0.64
21. Punjab	50,362	0	0.00	0.00
22. Rajasthan	3,42,239	5	3,947.07	1.15
23. Sikkim	7,096	1	1,784.00	25.14
24. Tamil Nadu	1,30,058	5	307.85	0.24
25. Tripura	10,486	2	36.71	0.35
26. Uttar Pradesh	2,40,928	1	490.00	0.20
27. Uttarakhand	53,483	6	4,915.44	9.19
28. West Bengal	88,752	5	1,693.25	1.91
29. Andaman & Nicobar	8,249	9	1,153.94	13.99
30. Chandigarh	114	0	0.00	0.00

Name of State & Union Territory	State Area km²	No. of NPs	Areakm²	% of StateArea
31. Dadra & Nagar Haveli	491	0	0.00	0.00
32. Daman & Diu	112	0	0.00	0.00
33. Delhi	1,483	0	0.00	0.00
34. Lakshadweep	32	0	0.00	0.00
35. Pondicherry	480	0	0.00	0.00
India	**32,87,263**	**102**	**40,075**	**1.22**

Wildlife Sanctuaries of India

There are 564 existing wildlife sanctuaries in India covering an area of 1, 22,509.33 km2, which is 3.73% of the geographical area of the country (National Wildlife Database, Dec. 2022). Another 218 sanctuaries are proposed in the Protected Area Network Report covering an area of 16,829 km2.

State-wise break up of Wildlife Sanctuaries in India

Name of State & Union Territory	State Area km²	No. of WLS	Area km²	% of State Area
Andhra Pradesh	2,75,069	21	11,618.12	4.22
Arunachal Pradesh	83,743	11	7,487.75	8.94
Assam	78,438	18	1,840.14	2.35
Bihar	94,163	12	2,851.67	3.03
Chhattisgarh	1,35,191	11	3,760.37	2.78
Goa	3,702	6	6,47.91	17.50
Gujarat	1,96,022	23	16,619.81	8.48
Haryana	44,212	8	2,33.21	0.53
Himachal Pradesh	55,673	32	7,745.48	13.91
Jammu & Kashmir	2,22,236	15	10,243.11	4.61
Jharkhand	79,714	11	1,955.82	2.45
Karnataka	1,91,791	25	5,555.39	2.90
Kerala	3,88,63	17	1,853.24	4.77
Madhya Pradesh	3,08,245	25	7,158.41	2.32
Maharashtra	3,07,713	40	14,915.38	4.85
Manipur	22,327	1	184.40	0.83
Meghalaya	22,429	3	34.20	0.15
Mizoram	21,081	8	1,090.75	5.17
Nagaland	16,579	3	20.34	0.12
Orissa	1,55,707	18	6,969.15	4.48
Punjab	50,362	12	3,23.79	0.64
Rajasthan	3,42,239	25	5,592.38	1.63

Name of State & Union Territory	State Area km²	No. of WLS	Area km²	% of State Area
Sikkim	7,096	7	3,99.10	5.62
Tamil Nadu	1,30,058	22	5,018,16	3.86
Tripura	10,486	4	5,66.93	5.41
Uttar Pradesh	2,40,928	23	5,221.88	2.17
Uttarakhand	53,483	7	2,688.64	5.03
West Bengal	88,752	16	1,658.63	1.24
Andaman & Nicobar	8,249	96	389.39	4.72
Chandigarh	114	2	26.01	22.82
Dadra & Nagar Haveli	491	1	92.16	18.77
Daman & Diu	112	1	2.19	1.96
Delhi	1,483	1	27.82	1.88
Lakshadweep	32	1	0.01	0.03
Pondicherry	480	1	3.90	0.81
India	**3287263**	**528**	**125295.30**	**3.78**

State-wise break up of Conservation Reserves in India

State	SN	Name	Area (km²)	District
Gujarat	1.	Chharidhandh Wetland	227	Kachchh
Haryana	2.	Bir Bara Ban	4.19	Jind
	3.	Saraswati	44.53	Kurukshetra & Kaithal
Jammu & Kashmir	4.	Ajas (WL)	1	Bandipora
	5.	Ajas	48	Bandipora
	6.	Bahu	19.75	Jammu
	7.	Boodh Karbu	12	Kargil
	8.	Brain-Nishat	15.75	Srinagar
	9.	Chatlam, Pampore (WL)	0.25	Pulwama
	10.	Gharana (WL)	0.75	Jammu
	11.	Hokera (Ramsar Site) (WL)	13.75	Srinagar
	12.	Hygam (WL)	7.25	Baramula
	13.	Jawahar Tunnel	18	Doda
	14.	Khanagund	15	Pulwama
	15.	Khimber/Dara/Sharazbal	34	Srinagar
	16.	Khiram	15.75	Anantnag
	17.	Khonmoh	67	Pulwama

State	SN	Name	Area (km^2)	District
	18.	Khrew	50.25	Pulwama
	19.	Kukarian (WL)	24.25	Jammu
	20.	Malgam (WL)	4.5	Baramula
	21.	Manibugh (WL)	4.5	Pulwama
	22.	Mirgund (WL)	4	Budgam
	23.	Naganari	22.25	Baramula
	24.	Nanga (WL)	15.25	Jammu
	25.	Narkara (WL)	3.25	Budgam
	26.	Norrichain (WL)	2	Leh
	27.	Panyar	10	Pulwama
	28.	Pargwal (WL)	49.25	Jammu
	29.	Sabu	15	Leh
	30.	Sangral-Asa Chak (WL)	7	Jammu
	31.	Shallabugh (WL)	16	Srinagar
	32.	Shikargah	15.5	Pulwama
	33.	Sudhmahadev	142.25	Udhampur
	34.	Thein	19	Kathua
	35.	Tsomoiri (Ramsar Site) (WL)	120	Leh
	36.	Wangat/Chatergul	12	Srinagar
	37.	Zaloora, Harwan	25.25	Srinagar
Karnataka	38.	Afghanashini	299.52	Uttara Kannanda
	39	Bedthi	57.3	Uttara Kannanda
	40	Bankapur Peacock	0.56	Haveri
	41	Basur Amruth Mahal Kaval	7.36	Chikmagalur
	42	Hornbill Con Res	52.5	Uttara Kannanda
	43	Jayamangali Blackbuck	3.23	Tumkur
	44	Shalmale Ripariam Bio-System	4.89	N.A
Maharashtra	45	Bhorkada (Bhorgad)	3.49	Nashik
Punjab	46	Rakh Sarai Amanat Khan	4.95	Taran Taran
Rajasthan	47	Bisalpur	48.31	Tonk
	48	Jor Beed Gadwala Bikaner	56.47	Bikaner
	49	Sundha Mata	117.49	Jalore, Sirohi
	50	Gudha Vishnoi	2.32	Jodhpur
	51	Shakambhari	131.00	Sikar & Jhunjhunu
	52	Umedganj Bird	2.72	Kota
	53	Jawai Band Leopard		Pali
Tamil Nadu	54	Tiruppadaimarathur		Tirunelveli
Uttarakhand	55	Asan Wetland		Dehradun
	56	Jhilmi Jheel		Haridwar

State	SN	Name	Area (km^2)	District
	57	Pawalgarh		Nanital

Community Reserves of India

SN	Name	Year of Estd.	Area (km^2)	Distt./State Location
1.	Keshopur Chhamb	2007	3.40	Gurdaspur, Punjab
2.	Lalwan	2007	12.67	Hoshiarpur, Punjab
3.	Kadalundi	2007	1.50	Malappuram, Kerala
4.	Kokkare Bellur	2007	3.12	Mandya, Karnataka

Protected Area Network Conservation Strategy of Chhattisgarh State

The State has a long history of intentional introduction of exotic species in livestock, Agriculture and forestry, proven to be productive elsewhere and offering potential economic benefits to the State. Many invasive species have found a place in literally every terrestrial ecosystem, including forests, grassland, croplands, and residential areas in cities.

PA's are the store houses of the maximum Biodiversity amongst wild ecosystems. In Chhattisgarh 10.6 % of the forest area is covered under P.A. network which is distributed amongst 11 WLS and 3 National Parks. These areas are most sensitive indicators of environmental changes. Slight change in the any of components of meteoric or edaphic or aquatic factors gets reflected in this typical ecosystem at comparatively faster pace than in other ecosystems. So P.As in the State is the most Biodiversity sensitive areas to be addressed. The strategy and action plan for the conservation of P.A.s need to incorporate the components of rich germplasm protection, sustainable conservation of rich species diversity; reducing man-animal conflicts and eco-development in P.A.s

Sanctuary is an area which is of adequate ecological, faunal, floral, geomorphological, natural or zoological significance. The Sanctuary is declared for the purpose of protecting, propagating or developing wildlife or its environment. Certain rights of people living inside the Sanctuary could be permitted. Further, during the settlement of claims, before finally notifying the Sanctuary, the Collector may, in consultation with the Chief Wildlife Warden, allow the continuation of any right of any person in or over any land within the limits of the Sanctuary.

A sanctuary is a protected area which is reserved for the conservation of only animal and human activities like harvesting of timbers; collecting minor forest products and private ownership right are allowed as long as they do not interference with well-being of animals. Boundaries of sanctuaries are not well defined and controlled interference is permitted. Total number of Sanctuary in Chhattisgarh is Eleven (11). “Sanctuary” means an area declared, whether under sec. [26(A) or sec 38, or deemed, under sub section (3) of Sec.66 to be declared, as a wildlife sanctuary. Name of Sanctuary, Year of Notification and Total Area is given below.

S N	Name of Wildlife Sanctuary	Year of Notification	Total Area(km^2)
1	Achanakmar Wildlife Sanctuary	1975	551.55
2	Badalkhol Wildlife Sanctuary	1975	104.45
3	Barnawapara Wildlife Sanctuary	1976	244.66

4	Bhairamgarh Wildlife Sanctuary	1983	138.95
5	Bhoramdev Wildlife Sanctuary	2001	163.8
6	Sarangarh-Gomardha Wildlife Sanctuary	1975	277.82
7	Pamed Wild Buffalo Wildlife Sanctuary	1985	262.12
8	Semarsot Wildlife Sanctuary	1978	430.36
9	Sitanadi Wildlife Sanctuary	1974	553.36
10	Tamor Pingla Wildlife Sanctuary	1978	608.53
11	Udanti Wild Buffalo Wildlife Sanctuary	1985	247.59

Source: Wildlife Institute of India, Dehradun

Total number of National Parks in Chhattisgarh is Three (3). "National Park" means an area declared, whether under sec. 35 or sec. 38 or deemed, under sub-section (3) of sec. 66 to be declared, as a National park. Every specified plant or part or National park is an area which is strictly reserved for the betterment of the wildlife & biodiversity, and where activities like developmental, forestry, poaching, hunting and grazing on cultivation are not permitted. Their boundaries are well marked and circumscribed. National Park declared by the Central Government such animal or any article, trophy, uncured trophy or meat [derived from such animal or any vehicle, vessel, weapon, trap, or tool used in such hunting, shall be the property of Central Government.

National park is an area which is strictly reserved for the betterment of the wildlife & biodiversity and where activities like developmental, forestry, poaching, hunting and grazing on cultivation are not permitted. In these parks, even private ownership rights are not allowed. Their boundaries are well marked and circumscribed. They are usually small reserves spreading in an area of 100 sq. km to 500 sq. km. in national parks; the emphasis is on the preservation of a single floral or faunal species. Every specified plants or part or derivative thereof, in respect of which any offence against this Act or any rule or order made there under has been committed, shall be the property of the state Government, and where such plant or derivative thereof has been collected or acquired from a sanctuary or National park declared by the central Government. Name of National Parks, Year of Notification and Total Area is given below.

S. N.	Name of National Park	Year of Notification	Total Area (km^2)
1	Indravati (Kutru) National Park	1982	1,258.37
2	Kanger Valley National Park	1982	200
3	Guru Ghasi Das (Sanjay) National Park	1981	1,440.71

Source – Wildlife Institute of India, Dehradun

Project Tiger and Tiger Reserves

Project Tiger

Project Tiger is the most famous wildlife conservation project of India, which was launched in 1972 to protect the diminishing population of Indian tigers. As recently as 1970, the hunting of tigers was legal in India and this majestic animal was hunted by the erstwhile royals and elites for pleasure and its beautiful skin. According to various estimates, during the 1950s and early 1960s, over 3,000 tigers lost their lives to trophy hunters. In the beginning of the 1970s, the tiger population in India was estimated to be around 1,800, shocking and jolting the concerned authorities to formulate an immediate plan to save Indian tigers and the result was the launch of Project Tiger in 1972. India is home to the largest number of wild tigers in the world and shelters approximately 60% of the world's wild tiger population. Initially 9 Tiger reserves covering an area of 16,339 sq km were chosen for Project Tiger. Corbett National Park was the first national park of India to be covered under Project Tiger on April 1st, 1973. Now as many as 52 Tiger Reserves, covering an area of 37, 761 sq km, are included in Project Tiger.

The main aim of Project Tiger was to create a safe haven and ideal environmental conditions for the survival and growth of tigers and its prey to ensure maintenance of a viable population of this wonderful animal in the country. From its inception in 1972, Project Tiger was aimed at saving the tiger and to identify and eliminate the factors responsible for the decline of tiger population in the country. The factors recognized by Project Tiger included habitat destruction, forestry disturbance, loss of prey, poaching and competition with local villagers and domestic animals.

The Project tiger was launched in India in 1972 as conservation program for saving the Indian Tiger Population. Some of the best examples of this programs success can be seen in the national parks situated in the high Himalayan region, to the mangrove swamps of the Sundarbans and the thorny scrubs of Rajasthan. But more wildlife conservation laws and awareness among people is still required to make Indian sanctuaries a safe haven for tigers.

Tiger Reserves of India (as on February, 2022)

S N	Name of Tiger Reserve	State	Area of the core / critical tiger habitat (In Sq. Kms.)	Area of the buffer / peripheral (In Sq. Kms.)	Total area (In Sq.Km)
1.	Nagarjunsagar Srisailam (part)*	Andhra Pradesh	2595.72*	700.59*	3296.31*
2.	Namdapha	Arunachal Pradesh	1807.82	245	2052.82
3.	Kamlang Tiger Reserve	Arunachal Pradesh	671	112	783
4.	Pakke	Arunachal Pradesh	683.45	515	1198.45
5.	Manas	Assam	840.04	2310.88	3150.92
6.	Nameri	Assam	200	144	344
7.	Orang Tiger Reserve	Assam	79.28	413.18	492.46
8.	Kaziranga	Assam	625.58	548	1173.58
9.	Valmiki	Bihar	598.45	300.93	899.38
10	Udanti-Sitanadi	Chattisgarh	851.09	991.45	1842.54
11.	Achanakmar	Chattisgarh	626.195	287.822	914.017
12.	Indravati	Chhattisgarh	1258.37	1540.7	2799.07
13.	Palamau	Jharkhand	414.08	715.85	1129.93
14.	Bandipur	Karnataka	872.24	584.06	1456.3
15.	Bhadra	Karnataka	492.46	571.83	1064.29
16.	Dandeli-Anshi	Karnataka	814.884	282.63	1097.514
17.	Nagarahole	Karnataka	643.35	562.41	1205.76
18.	Biligiri Ranganatha Temple	Karnataka	359.1	215.72	574.82
19.	Periyar	Kerala	881	44	925
20.	Parambikulam	Kerala	390.89	252.772	643.662
21.	Kanha	Madhya Pradesh	917.43	1134.361	2051.791
22.	Pench	Madhya Pradesh	411.33	768.30225	1179.63225
23.	Bandhavgarh	Madhya Pradesh	716.903	820.03509	1598.1
24.	Panna	Madhya Pradesh	576.13	1021.97**	1578.55
25.	Satpura	Madhya Pradesh	1339.264	794.04397	2133.30797

S N	Name of Tiger Reserve	State	Area of the core / critical tiger habitat (In Sq. Kms.)	Area of the buffer / peripheral (In Sq. Kms.)	Total area (In Sq.Km)
26.	Sanjay-Dubri	Madhya Pradesh	812.571	861.931	1674.502
27.	Melghat	Maharashtra	1500.49	1268.03	2768.52
28	Tadoba-Andhari	Maharashtra	625.82	1101.7711	1727.5911
29.	Pench	Maharashtra	257.26	483.96	741.22
30.	Sahyadri	Maharashtra	600.12	565.45	1165.57
31.	Nawegaon-Nagzira	Maharashtra	653.674	-	653.674
32.	Bor	Maharashtra	138.12	-	138.12
33.	Dampa	Mizoram	500	488	988
34.	Similipal	Odisha	1194.75	1555.25	2750
35.	Satkosia	Odisha	523.61	440.26	963.87
36.	Ramgarh Vishdhari	Rajasthan	--	--	1052.12
37.	Ranthambore	Rajasthan	1113.364	297.9265	1411.291
38.	Sariska	Rajasthan	881.1124	332.23	1213.342
39.	Mukandra Hills	Rajasthan	417.17	342.82	759.99
40.	Kalakad-Mundanthurai	Tamil Nadu	895	706.542	1601.542
41.	Anamalai	Tamil Nadu	958.59	521.28	1479.87
42.	Mudumalai	Tamil Nadu	321	367.59	688.59
43.	Sathyamangalam	Tamil Nadu	793.49	614.91	1408.4
44.	Kawal	Telangana	893.23	1125.89	2019.12
45.	Amrabad	Telangana	2166.37*	445.02*	2611.39*
46.	Dudhwa	Uttar Pradesh	1093.79	1107.9848	2201.7748
47.	Pilibhit	Uttar Pradesh	602.798	127.4518	730.2498
48.	Amangarh (Buffer of Corbett TR)	Uttar Pradesh	-	80.6	80.6
	Corbett	Uttarakhand	821.99	466.32	1288.31
49.	Rajaji TR	Uttarakhand	255.63	819.54	1075.17
50.	Sunderbans	West Bengal	1699.62	885.27	2584.89
51.	Buxa	West Bengal	390.5813	367.3225	757.9038

S N	Name of Tiger Reserve	State	Area of the core / critical tiger habitat (In Sq. Kms.)	Area of the buffer / peripheral (In Sq. Kms.)	Total area (In Sq.Km)
52.	Srivilliputhur Megamalai	Tamil Nadu	641.86	374.7	1016.57

(Source: National Tiger Conservation Authority, New Delhi)

Current Population of Tigers in India

Last year Prime Minister Narendra Modi had released the four-yearly tiger census report according to which the tiger population in the country had grown from 1,400 in 2014 to 2,967 in 2019. India's tiger population has nearly doubled in 12 years

The tiger tally in the country stands at 2,967. The tiger population in the country has grown from 1,400 in 2014 to 2,967 in 2019. Madhya Pradesh has the maximum number of tigers at 526.

- As per the report, Madhya Pradesh has the maximum number of tigers, followed by Karnataka.
- Last year, Prime Minister Narendra Modi released a tiger estimation report as per which India recorded 2,967 tigers, more than double the number from 1,411 in 2006.
- Currently, the tiger population within the reserves is 1,923 (65 percent of the total tiger population of India), the report said.
- India is home to 8% of the world's biodiversity, including 70% of the world's tiger population, Union Minister Prakash Javadekar said while releasing a report about the status of Tigers in India, ahead of Global Tigers Day.
- In 1973, there were just nine tiger reserves which have now increased to 50. It is important to know that none of these reserves are of poor quality. Either they are good or the best," Union Minister Prakash Javadekar said.
- He added, "Despite India's constraint of 2.5% of global land, 4% of rainfall and 16 % of world's human population, India is home to 8% of world's biodiversity, which includes 70% of the world's tiger population."
- Currently, the tiger population within the reserves is 1,923 (65 percent of the total tiger population of India), the report said.

- The 'Status of Tigers, Co-predators and Prey in India report for 2018' showed that out of the 50 tiger reserves in the country, three reserves - Mizoram's Dampa reserve, West Bengal's Buxa reserve and Jharkhand's Palamau reserve - have no tigers left.
- According to the population estimation of tigers in reserves for 2018-19, Corbett has 231 tigers, followed by Nagarhole and Bandipore reserves in Karnataka with 127 and 126 tigers respectively, reported PTI.
- International Tiger's Day is held every year on 29th July to raise public awareness and support regarding several issues related to tiger conservation. The idea behind such an event came up at the St. Petersburg Tiger Summit in 2010. It was also decided that 29th July would also be known as Global Tiger Day. During the summit, a panel of experts declared a goal towards tiger conservation, which was to double its population by 2022.

India is ready to work with other tiger range countries

- According to Javadekar, India is ready to take a leadership role and work with all tiger range countries for the management of the reserves and the conservation of the big cat.
- There are currently 13 tiger range countries — India, Bangladesh, Bhutan, Cambodia, China, Indonesia, Lao PDR, Malaysia, Myanmar, Nepal, Russia, Thailand and Vietnam.
- According to the report, in the state-wise distribution of tigers, Madhya Pradesh was found with maximum tigers at 526 followed by Karnataka at 524 and 442 in Uttarakhand.

Project Tiger Scheme

Project Tiger Scheme has been under implementation since 1973(1st April) as a Centrally Sponsored Scheme of Government of India. The aim of Project Tiger is to ensure a viable population of tiger in India for economic, aesthetic, cultural and ecological values and to preserve areas of biological importance as natural heritage. Project tiger scheme includes wildlife management, protection measures and site specific eco development to reduce the dependency on tiger reserve resources.

At the turn of the century, the estimated tiger population in India was placed at 40,000 but the first ever all India tiger census in 1972 shockingly revealed the existence of only 1827 tigers. Before that a ban on tiger hunting was imposed in the year 1970 and in 1972 the Wildlife Protection Act came into force. Thereafter a 'Task Force' was set up to formulate a project for tiger conservation.

With the launch of Project tiger in 1973, various tiger reserves were created in different parts of the country on a 'core-buffer' strategy. Under this strategy, the core areas were freed from all human activities and the buffer areas were to have 'conservation oriented land use'. Initially, 9 tiger reserves were established in different States during the period 1973-74. These nine Tiger reserves were Manas (Assam), Palamau (Bihar), Similipal (Orissa), Corbett (U.P.), Kanha (M.P.), Melghat (Maharashtra), Bandipur (Karnataka), Ranthambore (Rajasthan) and Sunderbans (West Bengal).

The main achievements of this project are excellent recovery of the habitat and consequent increase in the tiger population in the reserve areas, from a mere 268 in 9 reserves in 1972 to 1576 in 27 reserves in 2003.

Objective

The main objective of Project Tiger is to ensure a viable population of tiger in India for scientific, economic, aesthetic, cultural and ecological values and to preserve for all time, areas of biological importance as a natural heritage for the benefit, education and enjoyment of the people. Main objectives under the scheme include wildlife management, protection measures and site specific eco-development to reduce the dependency of local communities on tiger reserve resources.

Initially, the Project started with 9 tiger reserves, covering an area of 16,339 sq.km., with a population of 268 tigers. At present there are 27 tiger reserves covering an area of 37761 sq.km., with a population of 1498 tigers. This amounts to almost 1.14% of the total geographical area of the country. The selection of reserves was guided by representation of eco-typical wilderness areas across the biogeographic range of tiger distribution in the country. Project Tiger is undisputedly a custodian of major gene pool. It is also a repository of some of the most valuable ecosystem and habitats for wildlife.

Tiger 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 their impact on the core. Except for the National Parks portion

if contained within, normally no relocation of villages is visualized in the buffer area, and forestry operations, NTFP collection and other rights and concessions to the local people are permitted in a regulated manner to complement the initiatives in the core unit.

Project Tiger has put the tiger on an assured course of recovery from the brink of extinction, and has resurrected the floral and faunal genetic diversity in some of our unique and endangered wilderness ecosystem. The population of tigers in the country has increased significantly to about 4000 from less than 2000 at the time of launch of the project. The effective protection and concerted conservation measures inside the reserves have brought about considerable intangible achievements also, viz. arresting erosion, enrichment of water regime thereby improving the water table and overall habitat resurrection. Labour intensive activities in tiger reserves have helped in poverty alleviation amongst the most backward sections, and their dependence on forests has also reduced. The project has been instrumental in mustering local support for conservation programme in general.

Approach:

- Elimination of all forms of human exploitation and disturbance from the core and rationalization of such activities in the buffer.
- Limitation of the habitat management to repair damage done by man.
- Researching facts about habitat and wild animals and carefully monitoring changes in flora and fauna.

Tiger Reserves

- Same as sanctuaries. But they are monitored by NTCA under Project Tiger.
- The various tiger reserves were created in the country based on 'core-buffer' strategy.

Core area

- The core areas are freed of all human activities.
- It has the legal status of a national park or wildlife sanctuary.
- Collection of minor forest produce, grazing, and other human disturbances are not allowed.

Buffer areas

- Twin objectives:

- Providing habitat supplement to spill overpopulation of wild animals from core area.
- Provide site-specific co-developmental inputs to surrounding villages for relieving their impact on core area.
- Collection of minor forest produce and grazing by tribals is allowed on a sustainable basis**.**
- The Forest Rights Act passed by the Indian government in 2006 recognizes the rights of some forest dwelling communities in forest areas.

Tiger Reserves:

Project Tiger was launched by the Government of India in the year 1973 to save the endangered species of tiger in the country. Starting from nine (9) reserves in 1973-74 the number is grown up to forty seven (52).

Tiger population estimate for the year 2006 & 2010

State	Tiger Population			Tiger km2		
	2006	2010	Increase/Decrease/Stable	2006	2010	Increase/Decrease/Stable
Shivalik- Gangetic Plain Landscape Complex						
Uttarakhand	178 (161-195)	227 (199-256)	Increase	1,901	3,476	Increase
Uttar Pradesh	109 (91-127)	118 (113-124)	Stable	2,766	2,511	Stable
Bihar	10 (7-13)	8 (-)	Stable	510	750	Increase
Shivalik-Gangetic	297 (259-335)	353 (320-388)	Stable	5,177	6,712	Increase
Central Indian Landscape Complex and Eastern Ghats Landscape Complex						
Andhra Pradesh	95 (84-107)	72 (65-79)	Decrease	14,126	4,495	Decrease
Chhattisgarh	26 (23-28)	26 (24-27)	Stable	3,609	3,514	Stable
Madhya Pradesh	300 (236-364)	257 (213-301)	Stable	15,614	13,833	Decrease
Maharashtra	103 (76-131)	168 (155-183)	Increase	4,273	11,960	Increase
Orissa	45 (37-53)	32 (20-44)	Stable	9,144	3,398	Decrease
Rajasthan	32 (30-35)	36 (35-37)	Stable	356	637	Increase
Jharkhand	-	10 (6-14)	-	1,488	1,180	Decrease
Central India	601 (486-718)	601 (518-685)	Stable	48,610	39,017	Decrease
Western Ghats Landscape Complex						
Karnataka	290 (241-339)	300 (280-320)	Stable	18,715	14,414	Decrease

Kerala	46 (39-53)	71 (67-75)	Increase	6,168	6,804	Stable
Tamil Nadu	76 (56-95)	163 (153-173)	Increase	9,211	8,389	Stable
Western Ghats	412 (336-487)	534 (500-568)	Increase	34,094	29,607	Decrease
North Eastern Hills and Brahmaputra Flood Plains						
Assam	70 (60-80)	143 (113-173)	Increase	1,164	2,381	Increase
ArunachalPradesh	14 (12-18)	-	-	1,685	1,304	Decrease
Mizoram	6 (4-8)	5	Stable	785	416	Decrease
Northern West Bengal	10 (8-12)	-	-	596	799	Increase
North East Hills,andBrahmaputra	100 (84-118)	148 (118-178)	Increase	4,230	4,900	Increase
Sundarbans	-	70 (64-90)	-	1,586	1,645	Stable
TOTAL	**1,411 (1,165-1,657)**	**1,706 (1,520-1,909)**		**93,697**	**81,881**	

(Source: Status of tigers, co-predators and prey in India, WII, 2010)

Crocodiles and Gharial in India

The crocodiles are large aquatic tetrapod reptiles. They live throughout the tropics in Africa, Asia, the Americas and Australia. They are cold-blooded creatures. The crocodiles occur mostly in freshwater habitats such as rivers, lakes, wetlands and sometimes in brackish water. They feed mostly on vertebrates – fish, reptiles, and mammals. They first appeared during the Eocene epoch, about 55 million years ago. In terms of evolution, they are called great survivors as they have persisted unchanged since prehistoric period. However, 17 out of the 23 species of crocodilians around the world are endangered today due to man's folly.

In India, crocodiles are both revered and loathed as some consider them religious and others consider them a menace. In the 1960s and 1970s, some fishermen considered crocodiles as friends because they kept the rivers clean by eating carcasses. Some considered them enemies because they presumed crocodiles eat away their fish stock, pets and were man-eaters.

India does not have alligators, instead we have **three species** of crocodiles and one of which is unique to Indian subcontinent is the **Gharial** (*Gavialis gangeticus*). The adult male has a bump at the end of the snout resembling an earthen pitcher or Ghara, hence the name Gharial. The other two are the Mugger or Marsh crocodiles and the salt water or estuarine crocodiles.

About Gharial

Gharial is evolutionarily the most unique crocodilian in the world being a specialized river dwelling fish-eater, but harmless to humans. It lives in deep fast-flowing rivers. Gharials are endemic to the Indian sub-continent. Once found abundantly in all the major river systems of South Asia, the Gharial is now extinct in Pakistan, Bangladesh, Burma and Bhutan. Nepal has only a remnant breeding population. In India too, the major breeding populations are confined to two rivers only, Girwa and the Chambal. The two rivers run along the borders of Uttar Pradesh, Madhya Pradesh and Rajasthan. A few non-breeding populations exist in small pockets in other rivers in India.

Gharial is listed as 'Critically Endangered' in the IUCN Red List of Endangered Species. Between 2007 and 2008, over 100 Gharials in the Chambal perished in a mystery die-off attributed to a nephro-toxin possibly originating from contaminated fish in the Yamuna.

The Gharial is under increasing pressure for survival due to a combination of factors like:

- **Habitat alteration and destruction:** A combination of land-use changes and exploitation such as sand-mining, riverside agriculture, livestock grazing, and hydrological modifications such as building of dams for water diversion.
- **Prey depletion:** Over harvesting of fish stocks. Construction of dams and barrages obstructing dispersal and migration of fish.
- **Direct mortality:** Drowning of Gharial in fishing nets. Its nest destruction and local egg-collection.
- **Pollution and siltation:** Pollution and siltation of rivers damage fish stocks, and are also believed to be the direct cause of the catastrophic dieoff of 2007-2008 in the Chambal.
- **Hunting:** In the past, Gharial was hunted for skin, trophies and use in indigenous medicine.

Conservation efforts in India

In 1970, it was estimated that a mere 100 Gharials survived in the wild. Getting alarmed, the Government of India subsequently accorded the highest level of protection to Gharial by bringing it under Schedule I of the Wild Life Protection Act, 1972. By the time crocodile hunting was banned in India in 1972, Gharials were on the verge of extinction. In 1976, Project Crocodile was initiated with support from the United Nations Development Programme and Food and Agriculture Organization. The project included an intensive captive rearing and breeding programme intended to restock depleted Gharial habitats.

By the time the primary project ended in 1982, more than 1,000 Gharials had been raised and released into sanctuaries, increasing the total population. But in recent years, human-crocodile conflict has once again drastically affected the population of crocodiles in the country.

What more is needed?

- Revive and rejuvenate our rivers
- Without fail, make local communities co-beneficiaries of all conservation initiatives.
- Secure the National Chambal Sanctuary and other Gharial range areas through coordinated planning and action by the three states, i.e., Uttar Pradesh, Madhya Pradesh and Rajasthan.
- Re-evaluate environmentally sensitive schemes of river-linking, and large irrigation projects.
- Base conservation plans on sound scientific study and monitoring of Gharial.

Project Elephant

Background and History

Project Elephant was launched in 1991-92 to assist states having ranging populations of wild elephants to ensure long term survival of identified viable population of elephants in their natural habitats. States are being given financial as well as technical and scientific assistance in achieving the objectives of the project.

Objectives

The main objectives of Project Elephant are:

- Ecological restoration of existing natural habitats and elephant migration routes;
- Development of scientific and planned management for conservation of elephant habitats and viable population of wild Asiatic elephants in India;
- Promotion of measures for mitigation of man elephant conflict in crucial habitats and moderating pressures of human and domestic stock activities in crucial elephant habitats;
- Strengthening of measures for protection of Wild elephants form poachers and unnatural causes of death;
- Research on Project Elephant management related issues;
- Public education and awareness programmes;
- Eco-development
- Veterinary care

Elephant Reserves of India

The Indian elephant *Elephas maximus* occurs in the central and southern Western Ghats, North-east India, eastern India and northern India and in some parts of southern peninsular India. It is included in Schedule I of the Indian Wildlife (Protection) Act, 1972 and in Appendix I of the Convention on International Trade in Endangered Species of Flora and Fauna (CITES). It occurs in 16 of the 28 states in the country and is showing an increasing trend across its distributional range. Its population in 2007 was estimated to be in the range from 27,657 to 27,682, whereas in 2012 the population was estimated to be between 27,785 and 31,368. The state-wise population estimates are given in table below:

Elephant (*Elephas maximus*) population estimates for 2007 and 2012

S N	States	Elephant Population	
		2007	**2012**
1	Arunachal Pradesh	1690	1690*
2	Assam	5281	5281*
3	Meghalaya	1811	1811*
4	Nagaland	152	212
5	Tripura	59	59*
6	West Bengal	325-350	325-350*
7	Jharkhand	624	688
8	Odisha	1862	1930
9	Chattisgarh	122	215
10	Uttarakhand	1346	1346*
11	Uttar Pradesh	380	380
12	Tamil Nadu	3867	3726
13	Karnataka	4035	3900-7458**
14	Kerela	6068	6177
15	Andhra Pradesh	28	41
16	Maharshtra	7	4
		27657-27682	**27785-31368**

(Source: MoEF, 2013)

****Census figure as per 2007. The census report of 2012 is still awaited from the States***
*****3900-7458 (Confidence Limits)***

List of Landscape and Elephant Reserves in India with 2005 Census Population

SN	Elephant Range	Elephant Reserve	Date of Notification	State	Total Area (Sq. Km)	P.A. in ER (Sq. Km)	Population in 2005
1	**East-Central Landscape**	1. Mayurjharna ER	24.10.02	West Bengal	414		96
	(South-West Bengal-	2. Singhbhum ER	26.9.01	Jharkhand	4530	193	371
	Jharkhand - Orissa)	3. Mayurbhanj ER	29.9.01	Orissa	3214	1309	465
		4. Mahanadi ER *	20.7.02	Orissa	1038	964	464
		5. Sambalpur ER *	27.3.02	Orissa	427	427	284
		6. Baitami ER #		Orissa	1755		108
		7. South Orissa ER #		Orissa	4216	750	138
		8. Lemru ER #		Chhattishgarh	450		-
		9. Badalkhol - Tamorpingla ER		Chhattishgarh	1048.3	1154.93	-
	Total				**17092.3**	**4797.93**	**1926**
2	**Kameng-Sonitpur Landscape**	10. Kameng ER	19.6.02	Arunachal	1892	748	
	(Arunachal - Assam)	11. Sonitpur ER *	6.3.03	Assam	1420	420	612
	Total				**3312**	**1168**	**612**
3	**Eastern-South Bank Landscape**	12. Dihing-Patkai ER	17.4.03	Assam	937	345	295
	(Assam - Arunachal)	13. South Arunachal ER	29.2.08	Arunachal	1957.5	378.13	129
	Total				**2894.5**	**723.13**	**424**
4	**Kaziranga-Karbi Anglong-Intanki Landscape**	14. Kaziranga-Karbi Anglong ER	17.4.03	Assam	3270	1073	1940
	(Assam - Nagaland)	15. Dhansiri-Lungding ER	19.4.03	Assam	2740		275
		16. Intanki ER	28.2.05	Nagaland	202	202	30
	Total				**6212**	**1275**	**2245**

5	**North Bengal- Greater Manas Landscape**	17. Chirang-Ripu ER	7.3.03	Assam	2600	526	658
	(Assam - West Bengal)	18. Eastern Dooars ER	28.8.02	West Bengal	978	484	300-350
	Total				**3578**	**1010**	**1008**
6	**Meghalaya Landscape**	19. Garo Hills ER	31.10.01	Meghalaya	3500	402	1047
	(Meghalaya)	20. Khasi-hills ER #		Meghalaya	1331		383
	Total				**4831**	**402**	**1430**
7	**Brahmagiri-Nilgiri-Eastern Ghat Landscape**	21. Mysore ER	25.11.02	Karnataka	6724	3103	4452
	(Karnataka - Kerala-	22. Wayanad ER	2.4.02	Kerala	1200	394	636
	Tamilnadu- Andhra)	23. Nilgiri ER	19.9.03	Tamil Nadu	4663	716	2862
		24. Rayala ER	9.12.03	Andhra	766	525	12
		25. Nilambur ER	2.4.02	Kerala	1419	90	281
		26. Coimbatore ER	19.9.03	Tamil Nadu	566	482	329
	Total				**15338**	**5310**	**8572**
8	**Anamalai-Nelliampathy-High Range Landscape**	27. Anamalai ER	19.9.03	Tamil Nadu	1457	300	179
	(Tamilnadu - Kerala)	28. Anamudi ER	2.4.02	Kerala	3728	780	1726
	Total				**5185**	**1080**	**1905**
9	**Periyar-Agasthyamalai Landscape**	29. Periyar ER	2.4.02	Kerala	3742	1058	1100
	(Kerala - Tamilnadu)	30. Srivilliputhur ER	19.9.03	Tamil Nadu	1249	568	638
	Total				**4991**	**1626**	**1738**
10	**North-Western Landscape**	31. Shivalik ER	28.10.02	Uttarakhand	5405	1340	1510
	(Uttarakhand - Uttar Pradesh)	32. Uttar Pradesh ER	9.9.09	U.P.	744		NA
	Total				**6149**	**1340**	**1510**
	TOTAL				**69,582.80**	**18,732.06**	**21,370**

	# Approved by Govt. of India, but not yet notified by the State Government
	***** Proposal for extension approved by GOI, but not yet notified by the state

Rhino Rehabilitation Project

Among the grave threats faced by the greater one-horned rhinoceros today is the uneven population distribution along its home range. Kaziranga National Park in the northeast Indian state of Assam is home to more than 1800 individuals, about three quarters of the world's greater one-horned rhinoceros population distributed in India and Nepal. Chitwan National Park in Nepal has the second-largest population of about 400 individuals, which is less than one-fourth of the Kaziranga population. Conservationists are wary of this situation and liken it to the "all eggs in one basket" syndrome, since the survival of the species is more or less pegged on the wellbeing of the Kaziranga rhino population. For long-term conservation of the species, the need to expand its distribution is the unanimous assertion. New population of rhinos have been established in Bardia National Park and Suklaphanta Wildlife Reserve in Nepal and in Dudhwa National Park in India. Manas National Park in western part of Assam along the Indo-Bhutan border also offers an ideal location for this conservation venture. Once home to about 100 rhinos, Manas lost its entire population to poachers by 2000, but still retains habitat suitable for rhino survival.

In February 2006, for the first time in India, the Assam Forest Department and Wildlife Trust of India - International Fund for Animal Welfare (WTI-IFAW) translocated a hand-raised rhino calf to Manas. This marked the beginning of an ambitious project to reintroduce rhinos to Manas, where the species was driven to local extinction by poaching. WTI-IFAW's Rhino Rehabilitation Project aims to gradually repopulate rhinos in Manas, by relocating and rehabilitating orphaned or displaced hand-raised rhinos from Kaziranga National Park. This effort to repopulate rhinos in Manas is supported by the Bodoland Territorial Council and the Assam Forest Department.

Kaziranga National Park largely falls within the Brahmaputra River flood plains and gets inundated annually in the rainy season. The floods take a heavy toll on wildlife including rhinos. In addition to death by drowning and displacement on being washed away, increased rhino poaching has also been associated with these floods as the escaping animals are highly vulnerable when they move out of the park in search of higher ground.

The Centre for Wildlife Rehabilitation and Conservation (CWRC), situated near Kaziranga National Park has been rescuing displaced rhino calves since its inception in 2002. The project is a joint venture between the Assam Forest Department and WTI-IFAW. A resident veterinarian and animal keepers look after the rescued rhino calves and other animals at CWRC. Initially

housed in the stabilization chamber for varying periods depending on the age, the rhino calves are later transferred to a spacious outdoor enclosure within the centre.

Once the captive calves stable and old enough, they are readied for their relocation to the release site in Manas for a 'soft-release'. The rhinos are screened for diseases to prevent transmission into the wild and are radio-collared to facilitate post-release monitoring. They are then transported to Manas in trucks, usually mildly sedated to prevent panic.

In Manas, a spacious *boma* (a temporary enclosure) spanning about 33 acres has been created at Bansbari Range. The rhinos, relocated from CWRC, are released into the *boma* where they are confined till they attain sexual maturity. The *boma* ensures protection to the calves from predators, while allowing them to acclimatise to the local environment. The rhinos in the *boma*have no interactions with humans except during periodical medical assessments. After about two or three years of acclimatisation, the calves are released into the wild and are remotely monitored round-the-clock with the help of radio-transmitters.

In November 2008, three female greater one-horned rhinoceros were released in the wild from their temporary enclosure (*boma*) in Manas National Park in western Assam. (**Read Story**)

The release successfully culminated the efforts of the Assam Forest Department and Wildlife Trust of India - International Fund for Animal Welfare (WTI-IFAW) to "bring rhinos back to Manas", which began with the translocation of an individual from Kaziranga in January 2006. This was the first ever attempt to re-introduce the rhinos in Manas, which lost its 100 or so rhinos to poachers by the year 2000. Two more rhinos were translocated a year later and another in February, 2008.

WINS

Three female rhino calves, hand-raised at the CWRC and acclimatized to the wild in their*boma* in Manas, were released from their enclosure in November 2008. The calves had been radio-collared at CWRC, before their relocation to Manas. Daily monitoring allows the animal keepers to keep track of the released rhinos, who have not yet ventured far from the boma. Security in the park has also been enhanced by the authorities to protect the rhinos from poachers.

- This project was the first to reintroduce rhinos in Manas National Park. This was also the first in India to use hand-raised rhino individuals for species reintroduction programme.

- The first rhino to be relocated to Manas, *Mainao* was rescued as a few-weeks-old from Baghori Range of Kaziranga National Park during the floods in 2002. Swept away by the water, she was stuck on a forked branch of a tree stump. As the water level reduced, she faced the threat of being hung by her neck. Fortunately, she was noticed by a forest guard and was 'rescued'. She was hand-raised at CWRC for about three years before her relocation to Manas in February 2006. *Mainao* was among the three calves released into the wild in November 2008.

Indian Rhino Vision 2020

To promote the survival of Indian rhinos in India

The conservation of Indian rhinos (*Rhinoceros unicornis*) in Assam and India has been a great success in Kaziranga National Park. Through strict protection, the declining population of 10–20 rhinos in 1905 has recovered to more than 1800 individuals in 2007. However, more than 86 percent of India's rhinos live in just one national park, Kaziranga. Only few other national parks, such as Orang and Pobitora, carry valuable populations of Indian rhinos. The risk to loose rhinos to disease, poaching and other problems (e.g. habitat destruction, traffic) has grown with the increase of human populations around the national parks and the always growing demand for rhino horns.

IRV 2020 aims to increase the rhino populations in Assam to 3000 by the year 2020. These rhino populations will be built up at the seven protected areas to provide long-term viability to the rhino metapopulation in Assam. The IRV 2020 project will further improve the security of all rhinos in Assam by implementing law enforcement measures, by expanding the distribution of rhinos to reduce risks like disease, inbreeding depression and mass mortality, and by improving the security system for those protected areas where Indian rhinos already live.

The project also aims to reduce the rhino population pressures in any single habitat by ensuring a better distribution of the rhino population over suitable ranges. In addition, the project concentrates on integrating the local communities into the conservation effort. It aims to provide jobs for people living around the national parks (in conservation or tourism), to help to protect crops from being raided and to implement further educational methods.

Orang National Park (NP) is a small national park (around 72 km²), located on the northern banks of the Brahmaputra, to the west of Kaziranga NP. The rhino population currently ranges around 68 Indian rhinos. This is the third largest population of Indian Rhinos in India. Tiger and

other rare species live in this national park as well. Orang NP is directly surrounded by communities to the north, west and east. In the past, there have been insufficient infrastructure and security systems, which led to high poaching activities (between 1995 and 2000, 64 rhinos were poached). The rangers did not have the means to go on daily patrols, neither during the dry nor during the rainy season.

Being located in a very beautiful natural setting, Orang NP has the potential to become a very attractive tourist site and to raise an income through ecotourism. However, this field has never been developed because of the proximity of the well-known Kaziranga NP. Within IRV 2020, Orang NP has received special attention as the population of rhinos live in a very good area but need strong protection. Orang NP is one of the seven national parks in Assam that help to carry a sustainable Indian rhino population in the near future and, through its location, also carries the potential to become a corridor area between Kaziranga and the northern part of Assam in the future.

The main threats for wildlife within Orange NP are currently:

- Poaching
- Shortage of manpower
- Open river fronts
- Lack of infrastructure
- Lack of community participation

In the last year, the following issues were discussed and started:

The motivation of the field staff was strengthened by improving the housing facilities, by providing basic field kits and by arranging annual medical camps for the staff and their families.

More scouts were employed and replaced those who were sick and could no longer go on duty. Each scout received a special training on foot but also along the river side and within boats for the rainy season.

More camps were build which allow for a better control. In addition the roads were cleared properly, wireless communication was optimized, a 4x4 vehicle as well as motorcycles and bicycles were purchased.

The communities were approached and several awareness campaigns raised.

Basel Zoo has assumed the sponsorship of Orang NP on a long-term base to ensure the protection of Indian rhinos and to assist in the development of Orang NP for the future.

WAZA Conservation Project 08008 is implemented by WWF India, the Government of Assam and IRF (International Rhino Foundation), with support provided by Basel Zoo; IRV 2020 is supported by IRF, USFWS, CERZA and the EAZA Rhino Campaign.

Gir Project in India

It is a rare, little-known conservation success story. Asian lions have shot up in numbers from a low 50 or fewer in the early 1900s to more than 400 today. For the last few decades, the 1,400 sq km Gir forest was known as the last refuge of a species that once ranged across north India, from the Punjab in the north, to Jharkhand in the east, to the Narmada river in the south, and as far west as northern Morocco and Greece.

In India, lions were decimated by hunters. Their frequent roars gave away their location, the plains they inhabited provided convenient access, their social habits made bagging several at a time the norm, and firearms made it all easy. In 1973, the Gir Lion Project relocated almost 600 resident Maldhari families and their livestock and banished hundreds of thousands of cattle that seasonally grazed in Gir. Easing the pressure from domestic animals allowed the vegetation to recover, and as a consequence, wild herbivores bounced back ten-fold. From living off cattle in the early days of the Project, the felines changed their diets to spotted deer, sambhar and *nilgai*. But several Maldhari families remain and livestock continue to use the forest as pasture.

Whether it is beef or venison, it makes no difference to a lion. However, the cats were chased away from cattle kills, so the owners could recoup some of their losses by selling the hide and meat. When more wild prey became available, the cats could fill their bellies, with no fear of losing their meal. And they proliferated. But they also continue to kill some livestock. That is inevitable when approximately 100,000 cattle, most belonging to people outside the reserve, continue to graze tantalizingly under the lions' noses in the forests every day. About 4% of the total livestock population is lost to these felines annually.

Lions have been living outside the forest for several decades as well, says lion expert Ravi Chellam. The conservation impetus has helped them reclaim a fraction of their past range by colonizing Girnar Wildlife Sanctuary to the northwest. The intervening 20 km is dotted by 122 villages, including Bilka, a town of 11,000 people, which apparently did not deter the lions. The

cats have padded into the sandy coast about 20 to 30 km to the south, although at least 30 villages dot the distance to the beach. They are also settling into a smattering of small riparian forests to the northeast, 9 km away. And these large cats live in the intervening farmlands. In all, more than 100 lions, including young adults, prides, and older males, share the landscape of 6 million humans outside Gir.

The surrounding farmlands were predominantly growing wheat in the 1960s and 70s, until irrigation made sugarcane cultivation possible in the 1980s. These have now given way to extensive orchards of mangoes meant for the export market, says Chellam. Tree cover with minimal human activity provides shelter and plenty of domestic animals offer sustenance. Large cats without any forests to call home will settle for much less. So clearly the challenge to conservation lies here, outside the protected Gir forests. Other predators too share this landscape; leopards dodge both, lions and people.

Lion researcher, Meena Venkataraman reasons that the cats are able to live outside the forest because of the plentiful livestock and the surprising tolerance of people. Although there are wild prey animals, like *nilgai* and boar, there are also thousands of cattle, a veritable smorgasbord on hoof.

Lions are fecund animals and, as long as Gir is well-protected, they will always be found in the surrounding landscape. Except for Girnar, the other forest areas are small; most are hardly large enough to accommodate one lion. It's likely that the cats will shelter in the woods during the day and hunt livestock in the surrounding villages at night. The only way to minimize the loss suffered by people is to help them secure their cattle, especially during the evening hours when hungry predators are on the prowl. Lack of prey will discourage the cats from settling down and getting comfortable.

Although people appreciate the Forest Department's prompt response in rescuing lions that have fallen into wells or removing ones that are particularly bothersome, they aren't impressed with the compensation scheme, which covers only a part of their cost for providing the lions' dinner, says Venkataraman.

Human residents within 5 km of the Park have lived with these felines for a long time. They have more complaints against wild herbivores eating their crops than lions taking their animals. One

might wonder why the presence of a top predator does not control crop-raiding herbivores. That's because cattle are numerous and easier to kill than alert wild animals.

These felines were already venturing far afield in the mid-1980s when a severe drought killed thousands of livestock. After an initial period of feasting, the starving lions went on a spree of attacking humans. One lion was recorded 150 km away, near Rajkot. Since then, the relationship between the cats and people has been largely amicable. Clearly we need to understand what makes these villagers so tolerant of large predators in order to ensure that this conservation ethic does not become endangered.

Any change in land use, such as mining, industrialization, and crops, or even the weather, may tilt the balance against the cats, cautions Chellam. As more rural people aspire for urban lifestyles, they may become less tolerant of lions in the landscape.

Luckily, these cats generally seem to avoid attacking people and stay out of trouble. Compared to other large felines, or even their African cousins, the Gir lions are remarkably at home with people. After all, they have lived close to humans for at least 200 to 300 years. Chellam recalls African colleagues being amazed by how closely he could approach his study subjects without a rifle or any other weapon to protect himself. With 100 lions living amiably among 6 million people, there is much that the rest of India and the world can learn about what makes this situation so remarkable.

Kuno Project for Lion

Asiatic Lions are facing an imminent danger of extinction, if immediate steps are not taken to stop their habitat destruction and poaching. Even today, the population of Asiatic lions in the world is limited to the Gir forests of India. As a solution of the problem of their deteriorating natural habitat, the Wildlife Institute of India conducted a research to find the place that could serve as a new home for them. After much exploration, it zeroed on the Kuno Wildlife Sanctuary as the place where the lions of Gir could be relocated.

This project was given the name of Kuno Project and was based in Madhya Pradesh. As per the conservation biologists, the introduction of lions in the Kuno Wildlife Sanctuary would lead to a distribution of their population, which is presently concentrated only in Gir. This would make the species less susceptible to poaching and at the same time, reduce the overcrowding of Gir. The Kuno Lion Project of India is intended to provide Asiatic lions with the same habitat, which they

used to rule once. Situated in the northwest of Madhya Pradesh, Kuno Wildlife Sanctuary has been selected for the project because it resembles the natural habitat of the lions to quite an extent. In the year 1981, an area of approximately 344.686 sq km in Sheopur district of Madhya Pradesh was set aside to be developed into a sanctuary. Today, this area comprises of the Kuno Wildlife Division and has an additional 900 sq km as a buffer area.

The entire area of the Kuno Wildlife Sanctuary can be divided into a number of habitats, namely riparian habitat, savanna woodland, ravenous habitat, plateau and evacuated agricultural fields. The sanctuary is serving as home to tiger, leopard, wolf, wild dog, chital, samber, chinkara, nilgai, blackbuck, four-horned antelopes, wild pig, etc. One can also see a wide range of bird species here. As a precursor to the relocation of the Asiatic lions, the sanctuary was made free of human beings. Around 24 villages were rehabilitated from the sanctuary for the purpose.

To prevent any water scarcity in the Kuno Wildlife Sanctuary, waterholes, in the form of ponds and saucers, have been created. The other efforts taken for developing the sanctuary include the education of the people belonging to the neighborhood communities, in order to make them aware of the effects of living with a mega carnivore like lion. Even after so many preparations, a number of steps are still left to be undertaken before the lions of Gir can be effectively relocated here.

Project Great Indian Bustard

With an objective of conservation of the remaining population of critically endangered Great Indian Bustard *Ardeotis nigriceps*, locally called Godawan, an ambitious conservation program namely, Project Great Indian Bustard, has was launched by Honorable Chief Minister, Ashok Gehlot on 5thof June 2013. Probably more vulnerable to extinction than even tiger, Great Indian Bustard, although it was brought under the umbrella of Wildlife (Protection) Act, 1972, it did not gain attention and remained BPL (Below Protection Line); the Project Bustard can be seen as a dawn of a new era for the conservation of neglected species like Great Indian Bustard which is also the state bird of Rajasthan.

The rapid decline in its population across its distribution has already alarmed wildlife experts, ornithologists and bird lovers across the world. The main reasons cited for its decline are habitat loss due to conversion of grasslands to other purposes, anthropogenic and related biotic disturbances during its breeding season and frequent poaching of the species as game bird.

A grassland species, Great Indian Bustard, is often considered as indicators of the health of our grasslands or pulse of grassland ecosystem which are unfortunately remained neglected and being considered as wastelands. These grasslands actually play an important role in the economy of the local communities as they support their livestock in terms of grazing. Roughly 15-20 percent of the livestock population of the world resides in India and one can imagine the dependence of them on the grasslands. So there is direct dependence of a major part of human population on these dwindling grasslands of India.

Once more than 1000 individuals few decades back, bustard population shrunk to 745 in the year 1978, 600 in 2001, 300 in 2008 and not more than 125 in the current year, 2013. Being custodian of more than 50 percent population of bustard across the world, the desert state of Rajasthan does not want to be a mere spectator of the total extermination of the species across the globe, took up the responsibility for the conservation of this species and its habitat for our future generations by becoming a first state in launching the Project Bustard, initially in the DNP Sanctuary, located in Jaisalmer district of Rajasthan.

What should be done?

Godawan can be conserved only through its protection and its habitat through following activities:

1. Intensive Patrolling by the field staff
2. Developing intelligence network in the area.
3. Making of check posts and barriers at strategic locations
4. Creation of a flying squad headed by not below the rank of a range officer.
5. Strengthening of existing Wireless Network
6. Habitat protection through creation of some inviolate areas for the bird by making some closures of appropriate size and restricting anthropogenic pressures
7. Habitat enrichment through planting grasses like *Lasiurus sindicus*(sewan grass)and providing water facilities like water *gazellers.*
8. Incentives to farmers and local people for giving information and protection of the species.
9. Involving local people in the eco-development and eco-tourism activities.
10. Generating mass awareness and sensitization among the masses.
11. Continuous monitoring of the species and habitat

Concept and Definition of Keystone Species

A keystone species is a species that plays a critical role in maintaining the structure of an ecological community and whose impact on the community is greater than would be expected based on its relative abundance or total biomass.

The concept of a keystone species was first introduced by University of Washington Professor, Robert T. Paine in 1969. Paine studied a community of organisms that inhabited the intertidal zone along Washington's Pacific coast. He found that one species, the carnivorous starfish *Pisaster ochracceus*, played a key role in maintaining the balance of all other species in the community. Paine observed that if *Pisaster ochracceus* was removed from the community, the populations of two mussel species within the community grew unchecked. Without a predator to control their numbers the mussels soon took over the community and crowded out other species, greatly reduced the community's diversity.

Keystone species, because of their proportionately large influence on species diversity and community structure, have become a popular target for conservation efforts. The reasoning is sound: protect one, key species and in doing so stabilize an entire community. But the keystone species theory remains a young theory and the underlying concepts are still being developped. For instance, the term was originally applied to a predator species (*Pisaster ochracceus*), but now the term 'keystone' has been extended to include prey species, plants, and even habitat resources.

Keystone species in ecology, a species that has a disproportionately large effect on the communities in which it occurs. Such species help to maintain local biodiversity within a community either by controlling populations of other species that would otherwise dominate the community or by providing critical resources for a wide range of species. The name *keystone species*, coined by American zoologist Robert T. Paine in 1969, was derived from the practice of using a wedge-shaped stone to support the top of an arch in a bridge or other construction. Just as other stones in the construction depend on the keystone for support, other species in a biological community depend on the presence of a keystone species to maintain the community's structure.

Examples of keystone Species

Given that there are many historical definitions of the keystone species concept, and without a consensus on its exact definition, a list of examples best illustrates the concept of keystone species.

A classic keystone species is a small predator that prevents a particular herbivorous species from eliminating dominant plant species. Since the prey numbers are low, the keystone predator numbers can be even lower and still be effective. Yet without the predators, the herbivorous prey would explode in numbers, wipe out the dominant plants, and dramatically alter the character of the ecosystem. The exact scenario changes in each example, but the central idea remains that through a chain of interactions, a non-abundant species has an out-sized impact on ecosystem functions. One example is the weevil and its suggested keystone effects on aquatic plant species diversity by prey activities on nuisance Eurasian Water milfoil.

Examples of Keystone Species

In an ecosystem, all living things rely on each other and work together to be healthy; but, some species are crucial to the way all the species interrelate. When a keystone species is removed from a habitat, the habitat is dramatically changed. All other species are affected and some may disappear from that ecosystem or even become extinct.

Keystone Species in Their Environments

Here are some examples:

- **American alligator:** Alligators use their tails to make burrows to stay warm and when they move on, these burrows fill with water which is used by other species. Alligators are also predators, keeping the numbers of other species in check.
- **Beavers:** Beavers are considered habitat engineers because they change the environment by building dams. This dam building provides still water in which many species flourish.
- **Bees:** By pollinating plants, bees contribute to their survival. The plants are shelter for insects, which are then eaten by other species, like birds.
- **Elephants:** By eating small trees, elephants preserve the grasslands, because the grasses need plenty of sun to survive. If they were not there, the savanna would convert to a forest or scrublands.
- **Grizzly bears:** As predators, bears keep down the numbers of several species, like moose and elk. They also carry and deposit seeds throughout the ecosystem. Bears that eat salmon will leave their dropping and the partially eaten remains that provide nutrients such as sulfur, nitrogen and carbon to the soil.

- **Hummingbirds:** Pollination is the reason hummingbirds are a keystone species. In places where the numbers of hummingbirds are low, other species of plants will take over the ecosystem.
- **Ivory tree coral:** 300 invertebrate species call this coral home. It is here that fish live, breed and become food for larger fish.
- **Jaguars:** Jaguars are predators, as are many keystone species. They have a very diverse diet of about 87 different species, which contributes to their importance by keeping the numbers of these species in balance.
- **Mountain Lions:** These predators cover large areas and influence many species. Their prey will alter where they eat and live because of the mountain lion. Scavengers are also affected by the mountain lions activity.
- **Red mangrove**: This tree grows along the shoreline in the tropics and its roots protect the soil from erosion. The roots also offer protection to small animals, including reef fish.
- Sea otters: Sea otters are a keystone species in the kelp forests. They eat many invertebrates, but especially sea urchins. If there are too many sea urchins, they will eat too much of the kelp and destroy it.
- **Sea stars:** Sea stars eat mussels and keep their numbers in check. Too many mussels will crowd out other species, and since mussels have no other natural predators, sea stars are invaluable for keeping the ecosystem diverse.
- **Sugar maple**: This tree is a keystone species of the hardwood forest. It brings water from lower levels in the ground that helps other plants. It is also home to many insects, birds, and small animals.
- **Tiger sharks:** These sharks will eat practically anything. This helps control populations of sea turtles and dugongs who may cause overgrazing of the sea grass in Western Australia. Since sea grass is where fish lay their eggs, overgrazing would lead to fewer fish.

Mutualism

Mutualism is a biological interaction between individuals of two different species, where both individuals derive a fitness benefit.

A hummingbird darts among the red blossoms of a plant growing at the edge of a forest glade as it inserts its bill into a flower, hovering to sip nectar, the hummingbird head brushes up against the anthers of the flower and picks up pollen. This pollen will be deposited on the stigmas of other flowers as the hummingbird goes about gathering its meal of nectar. The hummingbird disperses the plant's pollen in trade for a meal of nectar.

Example:

19. Relationships between bees and flowers,
20. Certain ants nest inside the plant's thorns. In exchange for food and shelter, ants protect trees from attack by herbivores and competition from other plants.
21. Land version of symbiosis is the relationship of the Egyptian Plover bird and the crocodile. In this relationship, the bird is well known for preying on parasites that feed on crocodiles. To that end, the crocodile openly invites the bird to hunt on its body, even going so far as to open its jaws to allow the bird enter the mouth safely to hunt the leeches from its gums. For the bird, this relationship not only is a ready source of food, but a safe one considering that few predator species would dare strike at the bird at such proximity to its host.

Belowground we encounter another partnership. The roots of the hummingbird-pollinated plant are intimately connected with fungi in an association called mycorrhizae. The hyphae of the mycorrhizal fungi extend out from the roots, increasing the capacity of the plant to harvest nutrients from the environment. In exchange for the nutrients, the plant delivers sugars and other products of photosynthesis to its fungal partner.

Meanwhile, back aboveground a deer enters the forest glade and wanders over to the plant recently visited by the hummingbird. The deer systematically grazes it to the ground, lightly chews the plant material, and then swallows it. As the plant material enters the deer's stomach, it is attacked by a variety of protozoans and bacteria. These microorganisms break down and release energy from compounds such as cellulose, which the deer's own enzymatic machinery cannot handle. In return, the protozoans and bacteria receive a steady food supply from the feeding activities of the deer as well as a warm, moist place in which to live.

These are examples of mutualism, that is, interactions between individuals of different species that benefit both partners. Some species can live without their mutualistic partners and so the relationship is called facultative mutualism. Other species are so dependent upon the mutualistic

relationship that they cannot live in its absence. Such a relationship is an obligate mutualism. It is a curious fact that though observers of nature as early as Aristotle recognized such mutualisms, mutualistic interactions have received much less attention from ecologists than have either competition or exploitation. Does this lack of attention reflect the rarity of mutualism in nature? As you will see in the following pages, mutualism is virtually everywhere.

Mutualism may be common, but is it important? Does it contribute substantially to the ecological integrity of the biosphere? The answer to both these questions is yes. Without mutualism the biosphere would be entirely different. Let's remove some of the more prominent mutualisms from the biosphere and consider the consequences. An earth without mutualism would lack reef-building corals as we know them. So we can erase the Great Barrier Reef, the largest biological structure on earth, from our hypothetical world. We can also eliminate all the coral atolls that dot the tropical oceans as well as all the fringing reefs. The deep sea would have no bioluminescent fishes or invertebrates. In addition, the deep-sea oases of life associated with ocean floor hot-water vents, discovered just two decades ago (see chapter 6), would be reduced to nonmutualistic microbial species.

On land, there would be no animal-pollinated plants: no orchids, no sunflowers, and no apples. The pollinators themselves would also be gone: no bumblebees, no hummingbirds, and no monarch butterflies. Gone too would be all the herbivores that depend on animal-pollinated plants. Without plant-animal mutualisms tropical rain forests, the most diverse terrestrial biome on the planet, would be all but gone. Many wind-pollinated plants would remain. However, many of these species would also be significantly affected since approximately 90% of all plants form mycorrhizae. Those plants capable of surviving without mycorrhizal fungi would likely be restricted to the most fertile soils.

Even if wind-pollinated, non-mycorrhizal plants remained on our hypothetical world there would be no vast herds of African hoofed mammals, no horses, and no elephants, camels, or even rabbits or caterpillars. There would be few herbivores to feed on the remaining plants since herbivores and detritivores depend upon microorganisms to gain access to the energy and nutrients contained in plant tissues. The carnivores would disappear along with the herbivores. And so it would go. A biosphere without mutualism would be biologically impoverished.

The impoverishment that would follow the elimination of mumalism, however, would go deeperthan we might expect. Lynn Margulis and others (Margulis and Fester 1991) have

amassed convincing evidence that all eukaryotes, both heterotrophic and autotrophic, originated as mutualistic associations between different organisms. Eukaryotes are apparently the product of mutualistic relationships so ancient that the mutualistic partners have become cellular organelles (e.g., mitochondria and chloroplasts) whose mumalistic origins long went unrecognized. Consequently, without mutualism all the eukaryotes, from Homo sapiens to the protozoans, would be gone and the history of life on earth and biological richness would be set back about 1.4 billion years.

But back here in the present, let's accept that mutualism is an integral part of nature and review what is known of the ecology of mutualism. The first part of this brief review emphasizes experimental studies. Then, in the last part of the chapter, we examine some theoretical approaches to the study of mutualism.

Plant Mutualisms

Plants benefit from mutualistic partnerships with a wide variety of bacteria, fungi, and animals. Plants are the center of mumalistic relationships that provide benefits ranging from nitrogen fixation and nutrient absorption to pollination and seed dispersal. It is no exaggeration to say that the integrity of the terrestrial portion of the biosphere depends upon plant-centered mutualism. However, to understand the extent to which ecological integrity may depend upon these relationships we need careful observational studies and experiments. Here are some drawn from studies of mycorrhizae.

Plant Performance and Mycorrhizal Fungi: The fossil record shows that mycorrhizae arose early in the evolution of land plants, perhaps as long as 400 million years ago. Over evolutionary time, a mutualistic relationship between plants and fungi evolved in which mycorrhizal fungi provide plants with greater access to inorganic nutrients while feeding off the root exudates of plants. The two most common types of mycorrhizae are (1) arbuscular mycorrhizal fungi (AMF), in which the mycorrhizal fungus produces arbuscules, sites of exchange between plant and fungus, hyphae, fungal filaments, and vesicles, fungal energy storage organs within root cortex cells, and (2) ectomycorrhizae (ECM), in which the fungus forms a mantle around roots and a netlike structure around root cells (fig. 15.2). Mycorrhizae are especially important in increasing plant access to phosphorus and other immobile nutrients (nutrients that do not move freely through soil) such as copper and zinc, as well as to nitrogen and water.

Mycorrhizae and the Water Balance of Plants: Mycorrhizal fungi appear to improve the ability of many plants to extract soil water. Edie Allen and Michael Allen (1986) studied how mycorrhizae affect the water relations of the grass Agropyron smithii by comparing the leaf water potentials of plants with and without mycorrhizae. Agropyron with mycorrhizae maintained higher leaf water potentials than those without mycorrhizae. This means that when growing under similar conditions of soil moisture, the presence of mycorrhizae helped the grass maintain a higher water potential. Does this comparison show that mycorrhizae are directly responsible for the higher leaf water potential observed in the mycorrhizal grass? No, they do not. These higher water potentials may be an indirect effect of greater root growth resulting from the greater access to phosphorus provided by mycorrhizae.

Ants and *Bullshorn Acacia:* The ants mutualistic with swollen thorn acacias are members of the genus Pseudomyrmex in the subfamily Pseudomyrmecinae. This subfamily of ants is dominated by genera and species that have evolved close relationships with living plants. Pseudomyrmex spp. are generally associated with trees and show several characteristics that Janzen suggested are associated with arboreal living. They are generally fast and agile runners, have good vision, and forage independently. To this list, the Pseudomyrmex spp. associated with swollen thorn acacias, or "acacia-ants," add aggressive behavior toward vegetation and animals contacting their home tree, larger colony size, and 24-hour activity outside of the nest. This combination of characteristics means that any herbivore attempting to forage on an acacia occupied by acacia-ants is met by a large number of fast, agile, and highly aggressive defenders and is given this reception no matter what time of the day it attempts to feed. Janzen listed six species of Pseudomyrmex with an obligate mutualistic relationship with swollen thorn acacias and refers to three additional undescribed species. His experimental work focused principally on one species, Pseudomyrmexferruginea.

Worldwide, the genus Acacia includes over 700 species. Distributed throughout the tropical and subtropical regions around the world, acacias are particularly common in drier tropical and subtropical environments. The swollen thorn acacias, which form obligate mutualisms with Pseudomyrmex spp., are restricted to the New World, where they are distributed from southern Mexico, through Central America, and into Venezuela and Columbia in northern South America. Across this region, swollen thorn acacias occur mainly in the lowlands up to 1,500 m elevation in areas with a dry season of 1 to 6 months. Swollen thorn

acacias show several characteristics related to their obligate association with ants, including enlarged thorns with a soft, easily excavated pith; year-round leaf production; enlarged foliar nectaries; and leaflet tips modified into concentrated food sources called Beltian bodies. The thorns provide living space, while the foliar nectaries provide a source of sugar and liquid. Beltian bodies are a source of oils and protein. Resident ants vigorously guard these resources against encroachment by nearly all comers, including other plants.

Long Lived Species: The lifespan of a tree depends on the tree variety and its growing conditions. Trees have some of the longest life spans in the plant kingdom, with some conifer species outliving all other varieties. Long-living tree types may stand alone or live in dense forests, such as the Redwood and Sequoias in California, or they may be used in residential landscaping as ornamental trees. Conifer trees live longer than other tree species.

Conifers: The Douglas fir tree (*Pseudotsuga menziesii*) can reach heights up to 220 feet with a width of 14 feet, living up to 1,200 years. Traditionally, the Douglas fir provided wood for telephone poles and railroad ties. The Redwood (Sequoia sempervirens) and Giant sequoia (Sequoia gigantean) trees reproduce from seeds, but the redwood has the ability to sprout from tree stumps and roots. The Giant sequoia's bark is a reddish color, whereas the bark of the redwood is a chocolate brown. Redwood trees live up to 2,200 years, while the Giant sequoia lives up to 3,000 years. The Alaska yellow Cedar (Chamaecyparis nootkatensis) grows along the Pacific Coast in the northwestern United States. They usually grow at elevations of at least 2,000 feet, making the Cascade range in Washington state a suitable place to find them. Alaska yellow cedar trees live up to 3,500 years. The bristlecone (Pinus longaeva) is one of the oldest living things on Earth, living up to 5,000 years. Scientists use bristlecone trees for tree-ring dating and in fields such as climatology, archaeology, geology, astronomy and environmental chemistry. Bristlecone trees grow well in California, Utah and Nevada, with Nevada protecting them as a declared threatened or endangered plant species.

Flowering Trees: The Magnolia tree (*Magnolia grandiflora*) is a popular evergreen tree grown in the southern parts of the U.S. They grow up to 80 feet tall with white to cream-colored blooms that span 14 inches across. Magnolia trees release a strong fragrance and drop foliage debris throughout the year. They can live up to 120 years. Dogwood trees *(Cornus florida*) reach heights up to 30 feet with white, pink or red blooms. They are used in landscaping as lawn trees,

borders and accent trees in flower gardens. Dogwoods can be propagated from seed or grafting and live up to 125 years.

Fruit Trees: Fruit trees live between 50 and 75 years depending on the cultivar and environmental exposure. The persimmon tree (*Diospyros virginiana*) has a greater life expectancy of up to 75 years and tolerates various soil types and moisture levels. Persimmons have foliage that changes to orange and red in the fall. Apple and apricot trees can live more than 60 years if appropriately cared for. Apple trees have attractive blooms with hundreds of cultivars varying in size. Red mulberry trees (Morus rubra) live more than 50 years and can grow as an ornamental tree if trained properly. Pear trees have a shorter life span. The European pear tree varieties live up to 50 years, and the Asian pear tree cultivars up to 20 years.

Other

Sugar Maple trees (*Acer saccharum*) are popular trees in the New England states. They have attractive fall foliage and provide sap for making maple syrup. Maple trees can grow more than 100 feet tall and live up to 400 years.

The Sassafras tree grows well in the eastern and southern U.S. Colonial Americans used the roots of the sassafras tree for making root beer and other beverages. Sassafras trees reach heights of 80 feet and live up to 500 years.

The Black tupelo tree (*Nyssa sylvatica*) usually grows in cool areas near wetlands and are an important food source for North American wildlife, such as ducks, turkeys, foxes and black bears. The trunks make excellent habitats for honeybees as well as other tree-dwelling animals. The average height of most black tupelo trees is 80 feet with a life span of 600 years.

This is a list of the oldest known trees, as reported in reliable sources. Definitions of what constitutes an individual tree vary. In addition, tree ages are derived from a variety of sources, including documented "tree-ring" count core samples, and from estimates. For these reasons, this article presents three lists of "oldest trees", each using varying criteria.

There are three tables of trees, which are listed by age and species. The first table includes trees for which a minimum age has been directly determined, either through counting or cross-referencing tree rings or through radiocarbon dating. Many of these trees may be even older than their listed ages, but the oldest wood in the tree has rotted away. For some old trees, so much of the center is missing that their age cannot be directly determined. Instead, estimates are made based on the tree's size and presumed growth rate. The second table includes trees with these estimated ages. The last table lists clonal colonies in which no individual tree trunks may be remarkably old but in which the organism as a whole is thought to be very old. The record-holders for individual, non-clonal trees may be the Great Basin bristlecone pine trees from California and Nevada, in the United States. Through tree-ring cross-referencing, they have been shown to be more than 5,000 years old.

A clonal colony can survive for much longer than an individual tree. A colony of 47,000 quaking aspen trees (nicknamed "Pando"), covering 106 acres (43 ha) in the Fishlake National Forest of the United States, is considered one of the oldest and largest organisms in the world. The colony has been estimated to be 80,000 years old, although tree ring samples date individual, above-ground, trees at only an average of about 130 years. A colony of Huon pine trees covering 2.5 acres (1.0 ha) on Mount Read, Tasmania is estimated to be around 10,000 years old, as determined by DNA samples taken from pollen collected from the sediment of a nearby lake. Individual trees in this group date to no more than 4,000 years old, as determined by tree ring samples.

Types of Keystone Species?

A keystone species which can be any organism, from animals and plants to bacteria and fungi is the glue that holds a habitat together. It may not be the largest or most plentiful species in an ecological community, but if a keystone is removed, it sets off a chain of events that turns the

structure and biodiversity of its habitat into something very different. Although all of an ecosystem's many components are intricately linked, these are the living things that play a pivotal role in how their ecosystem functions.

Keystone species fall into several broad categories-

Predator: By keeping the populations and range of their prey in check, keystone predators, like wolves and sea otters, impact other predators as well as other animal and plant species farther down the food chain. Remove a keystone predator, and the population of creatures it once hunted can explode, pushing out other organisms and reducing species diversity. This domino effect is known as a trophic cascade.

Prey: Keystone prey, which include animals ranging from Antarctic krill to Canadian snowshoe hares, have a big role to play in the ecosystem. They serve as a critical food source for predator populations; moreover, they are resilient creatures, unlike some other types of prey species that are more susceptible to becoming rare or extinct within an ecosystem.

Ecosystem engineer: Instead of impacting food supply, beavers, African savanna elephants, and other ecosystem engineers create, modify, or maintain the landscape around them. They influence the prevalence and activities of other organisms and help define the overall biodiversity of their habitat.

Mutualist: Keystone mutualists are two or more species that engage in reciprocally vital interactions. The disruption of one species impacts the other and, ultimately, the ecosystem as a whole. These pairs are often pollinators, like hummingbirds, that rely on specific plants for sustenance, and plants that rely on those pollinators to reproduce.

Plants: Keystone plants, like the Sonoran Desert's saguaro cactus, are those that provide a critical source of food and/or shelter for other species.

What Effect Do Keystones Have on an Ecosystem?

Keystone species maintain the local biodiversity of an ecosystem, influencing the abundance and type of other species in a habitat. They are nearly always a critical component of the local food web. One of the defining characteristics of a keystone species is that it fills a critical ecological role that no other species can. Without its keystone species, an entire ecosystem would radically change—or cease to exist altogether. It's important to note that a species' role can change from one ecosystem to the next, and a species that is considered a keystone in one environment may not be considered the same in another.

Intact ecosystems perform many vital functions; air and water purification, turning decaying matter into nutrients, preventing erosion and flooding, and moderating climate. Some species are particularly important to the health and resilience of their ecosystems. These are called keystone species, and their absence can greatly affect the entire system. Elephants, Lions, Vultures and even termites are examples of keystone species.

As large predators, Lions are responsible (among other things) for keeping prey populations under control and removing sick, weak or genetically compromised animals from the system. Antelope and Zebra are grazers, and without Lions, or other large predators to keep numbers in check, overgrazing may occur. Without vegetation to keep the soil in place, the once lush plains could become desert.

The role of biotechnology in biodiversity conservation

At present, more than 50 000 plant species are used in phytotherapy and medicine. About 2/3 of them are harvested from nature leading to local extinction of many species or degradation of their habitats. Biotechnological methods offer possibilities not only for faster cloning and conservation of the genotype of the plants but for modification of their gene information, regulation, and expression for production of valuable substances in higher amounts or with better properties.

Biotechnology has the tremendous potential for unique, efficient, ecofriendly and economically viable options to waste treatment in situ and degradation hazardous toxic waste into relatively less harmful products.

The Department of Bio-technology has also given a major thrust to programmes of ecorestoration concerned with degraded ecosystems, mining spoil dumps, development of biosensors for detection of pollutants, treatment of industrial effluents, and use of molecular markers for characterization of biodiversity.

Biotechnological tools are being applied for conservation of endangered plant species, controlling environmental pollution restoring environmental quality, developing cleaner technologies etc. Biosensors have been developed for detection of organ-phosphate pesticides residues in water. Many projects for restoration of ecosystem particularly in coal and mining areas is in progress. Technologies for environmental monitoring based on DNA probes have been developed in the area of detection of biological toxins.

Biotechnological tools are being employed for conservation of endangered plant species of economic and medicinal importance. For this, the Red Data Book of Botanical Survey of India has been the reference point to develop research projects. Tissue culture techniques have been developed for endangered species found in southern coastal ecosystem. Germplasm of rare desert plants has been collected for conservation.

Some major achievements have been made in conservation of environment and biodiversity. Such as establishment of a Laboratory for Conservation of Endangered Animal, Hyderabad.

Various projects for ex situ conservation micro propagation and in vitro conservation of rare and endangered plants of medicinal importance, ethnobotonical plants and microbial diversity of north eastern region have been supported.

Many projects on biosystematics and conservational studies of liver worst, genetic diversity of ferns, lichens and their use as indicators of pollution have been supported. An integrated biotechnological approach for bioremediation of mine spoil dumps and degraded ecosystems has been developed by scientists at National Environmental Engineering Research institute; Nagpur and University of Delhi have been successfully demonstrated at a number of sites.

Biotechnology and biodiversity

Biotechnology is generally considered to be "any technique that uses living organisms to make or modify a product, to improve plants or animals, or to develop microorganisms for specific uses". Modern biotechnologies offer vast potential for improving the quality and increasing the productivity of agriculture, forestry and fisheries. Genes from plants, animals and microorganisms that flourish in the forests, fields and seas of the developing world are the strategic raw materials for the commercial development of new pharmaceutical, agricultural and industrial products. Whereas genetic wealth, especially in tropical areas such as rainforests, was once a relatively inaccessible trust fund, it is fast becoming a highly valuable currency.

Introduction of modern biotechnologies in the developing world is frequently compared to the Green Revolution. While the Green Revolution involved introducing new varieties of primarily wheat and rice in selected areas, biotechnology has the potential to affect all crops and tree species, as well as fish and livestock, in any corner of the globe. The Green Revolution was introduced to the Third World largely by international institutions, but the "Gene Revolution" is primarily in the hands of the private sector, with transnational corporations being the leading players. With few exceptions, scientific and technical capacity in the biosciences is centred in the industrialized world. As a consequence, biotechnology research, by and large, does not focus on the needs or interests of poor farmers in marginal areas of the world. Emerging biotechnologies have considerable potential to enhance food and agricultural production in the developing world, but they could also add to existing inequities by displacing traditional agricultural products, accelerating genetic erosion and introducing new environmental hazards.

Molecular biology is the most powerful tool of biotechnology. In the area known generally as genetic engineering, scientists can transfer genes between unrelated species endowing such "transgenic" plants, animals and microorganisms with properties that they could probably never have acquired in nature. As yet, only a handful of genetically engineered products are available commercially, but hundreds are in the pipeline.

Genetic engineers can design crop varieties containing natural insecticidal genes, fish with human growth hormones, and faster growing trees. It must be stressed, however, that genetic engineering consists essentially of mixing and matching genes from different species. It cannot create genetic material, replace lost material or eliminate the need to conserve living resources.

Molecular biology is important in characterizing and conserving biodiversity. For example, molecular markers can help establish the extent of diversity within a species and to identify genes of interest to breeders. Such techniques can also help establish priorities for conservation.

Biotechnology to protect biodiversity

Biotechnology already assists the conservation of plant and animal genetic resources through:

- new methods for collecting and storing genes (as seed and tissue culture);
- detection and elimination of diseases in gene bank collections;
- identification of useful genes;
- improved techniques for long-term storage;
- safer and more efficient distribution of germplasm to users.

Tissue culture is just one example. The technique, which involves growing small pieces of plant tissue or individual cells in culture, provides a fast and efficient way of taking numerous cuttings from a single plant. In many cases, entire plants can be regenerated from a single cell because each cell contains all the necessary genetic information. After selecting a disease-free cutting, for example, scientists can mass-produce copies that are genetically identical. This is the basis of plant cloning, or micro propagation of plants.

In gene banks, tissue culture is now used routinely to preserve the genetic information of plants which have seeds that do not store well, are sterile or have poor germination rates. Plant cells maintained on a growth medium in a test-tube replace seeds or plants. Plants stored in this way include sweet potatoes, bananas and plantains, apples, cocoa and many tropical fruits.

Biodiversity: obstacle or…

Biotechnology contributes to conservation and the sustainable use of biodiversity, but several areas exist where modern biotechnology may hinder development or create serious hardship for rural communities.

Substitution. The economies of developing countries are threatened by biotechnology research that promises to eliminate or displace traditional export commodities, often a primary source of foreign exchange. Current research, for example, focuses on substitutes for tropical oils and fats —ranging from cocoa butter to castor oil. Biosynthesis in the laboratory of high-value ingredients such as vanilla, pyrethrum and rubber could ultimately transfer production out of farmers' fields and into industrial bioreactors. Without ample opportunity to plan and diversify, developing country farmers and their botanical exports may suffer massive displacement, wreaking havoc on already weak economies.

A new wave of genetic erosion?

Biotechnology may threaten the genetic diversity on which it depends. In the absence of conservation, commercial biotechnology may unleash a new era of genetic erosion. A commercial venture in Chile, for example, can propagate up to 10 million eucalyptus seedlings, all identical clones, in automated nurseries. Similarly, commercial semen and embryo transfer services for domestic animals raise concern about the displacement of traditional livestock breeds. Cloning could accelerate replacement or dilution of indigenous stock by imported breeds, leading to a loss of genetic diversity.

Biosafety. A related concern involves the ecological risks of introducing genetically engineered plants into centres of diversity. Transgenic varieties, a good number of them resistant to herbicides, have been produced in more than 40 crop plants. Gene flow to weeds from resistant

plants could have far-reaching consequences. The resulting herbicide-tolerant weed could be difficult to control, harming future crop production as well as the surrounding ecosystem. Will biotechnology firms seeking to penetrate markets in developing countries take into account the risks posed in regions where wild and weedy relatives of major food and industrial crops are found? Will the developing countries have the capacity to monitor and assess the risks?

Opportunity for development?

Biotechnologists could develop new varieties and breeds adapted to low-input agriculture or harsh conditions, or improve processing. Biotechnology may help create markets by developing new industrial, medicinal and aromatic crops. Given their richness in biodiversity, several developing countries that have the capabilities, such as Brazil, China and India, could produce new high-value products based on local flora. The congenial agro-ecological settings and availability of relatively cheap labour should be conducive to large-scale production of new high-value crops, enabling such countries to maintain their comparative advantage in these commodities.

The use of biotechnology to develop biofertilizers and to detect and control pests and pathogens will be particularly helpful to poor farmers. Such technologies could also bring trading advantages by removing non-tariff barriers arising from the presence of pesticide residues or pest infestation in food commodities that otherwise have an export, and therefore income-generating, potential.

The fundamental question posed by biotechnology remains: Who will control the new technologies and benefit from them? FAO is trying to strengthen national capacities to exploit biotechnology for sustainable, low-input agriculture, and to encourage biotechnology research on products/commodities that are important to developing nations. It is also fostering the best uses of biotechnologies to identify and conserve genetic resources. Finally, FAO is developing a Code of Conduct that covers the issues raised above.

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