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**Review Paper**

# Biodiversity: Values, threats and conservation strategies - a review

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ABSTRACT

**Biodiversity conservation is critical to human society's long-term development. Biodiversity is important in many ways, including improving the aesthetic value of the natural environment and contributing to our material well-being through utilitarian values like food, fodder, fuel, timber and medicine. Despite the benefits of biodiversity, today's threats to species and ecosystems are on the rise, and nearly all of them are the result of human mismanagement of biological resources. Conserving biodiversity is critical for ensuring intra and intergenerational equity. Reforestation zoological gardens, botanical gardens, national parks, biosphere reserves, germplasm banks and the adoption of breeding techniques, tissue culture techniques and social forestry are some of the existing biodiversity conservation measures. Because of the growing recognition of the value of biodiversity and the rapid rate of loss, it is critical to assess and conserve biodiversity at both the regional and global levels. India has a long conservation history and it should take the lead in developing appropriate methodologies and strategies for biodiversity assessment and conservation with increased input from the government, scientists and non-governmental organisations.**

**Keywords:** Biodiversity, biosphere reserves, conservation, exploitation, threats

Biodiversity is defined by the Convention on Biological Diversity as variation among living creatures from all sources, including terrestrial, marine and other aquatic ecosystems and ecological complexes of which they are a part (Glowka *et al.,* 1994). The majority of scientific emphasis has been focused on examining biodiversity in terms of the number of species found in a given location. A set of further terms has emerged to define the spatial limits of biodiversity: α(alpha), β(beta), and γ(gamma) diversity. Local species richness (αdiversity, the number of species at a site), regional species pool (γ diversity, the number of different species that could be at a location), and variability between localities (β diversity) are all defined by this group of terms (Thompson *et al.,* 2007). Over 400,000 plants have been identified on Earth, including 3,52,000 flowering plants, 1050 gymnosperms, 15,000 ferns and fern allies, and 33,750 mosses. Three major families, *Asteraceae, Leguminosae,* and *Orchidaceae,* account for 20% of flowering plants in angiosperms, with over 62,000 species. Because of different factors, about 25% of these are deemed endangered. Plants are used for food, medicine, shelter, fibres, and wood by an estimated 40,000–100,000 species (Ramadan, 2017).The human population began to recognise the importance of biodiversity following the adoption of the UN Convention on Biological Diversity (UNCBD) at the UN Conference on Environment and Development (UNCED) in Rio de Janeiro in June 1992, which aimed to conserve biological diversity, promote sustainable use of its components, and encourage equitable sharing of the benefits resulting from the use of genetic resources. The CBD requires signatory countries to conduct a biodiversity inventory to provide basic information about the distribution and abundance of biodiversity. India was one of the first countries to sign the CBD Treaty (Tripathi, 2015).

India is one of the world's 17 'mega diverse' countries, accounting for 7–8% of global biodiversity on just 2.4% of the world's land area and with 18% of the world's human population (MoEFCC, 2018).This estimate is based on percentages of the world's species of birds(13.7%), mammals (8.6%), reptiles (7.9%),

fishes (11.7%) and plants (~11.8%) found in India (FAO, 2013). Four of 36 global biodiversity hotspots are represented in India's landmass (MoEFCC, 2018). India is a treasure of biodiversity that is home to a wide range of plants and has been designated as one of the eight major "Vavilorian" origin and crop diversity centres. The Himalayan habitats, the Khasi and Mizo highlands of north eastern India, the Vindhya and Satpura ranges of northern peninsular India, and the Western Ghats ecosystems, which house almost 90% of the country's higher plant species, are of particular importance to traditional medicine. 2500 fishes, 150 amphibians, 450 reptiles, 1200 birds, 850 mammals, and 68,000 insects are among the faunal diversity. Although India is a mega-biodiversity hotspot, the Eastern Himalayan region and the Western Ghats are two of the world's most vulnerable 'hot spots.' "Both are paradises of precious genes but are edging towards the position of Paradise Lost". At least 10% of India's wild flora and possibly even more of its wild fauna are on the endangered species list. 80 mammalian species, 47 bird species, 15 reptile species, three amphibian species, and a huge number of moths, butterflies, and beetles are all endangered in the wild. Out of 19 species of primates, 12 are endangered (Anil *et al.,* 2014).

Forest cover in India currently stands at around 22% of the total area of the country and, unlike other economically developing countries, forest and tree cover has increased over the past 20 years despite growth in population and per capita incomes (Kumar *et al*., 2020). Despite having only about 2% of the world's landmass, India is home to 7.5 percent of all animal species. India is home to nearly 100,693 animal species, with insects accounting for 65,047 of them. Reptiles, amphibians, fish, birds, and mammals have fairly complete inventories. In India, there are over 5150 plant species, 20,765 insect species, 46 mammal species, 176 bird species, 214 reptile species, 138 amphibian species, and 435 fish species that are endemic (Ramakrishna and Alfred 2007; ZSI 2016). The ecosystem services emanating from India's forest biodiversity alone have been valued at 128 trillion rupees per year (Ghosh, 2015). The value is far greater when services from non-forest ecosystems – grasslands, wetlands, freshwater, estuarine, coastal and marine ecosystems are also taken into account. Beyond economic terms, biodiversity in India has been a perpetual source of cultural and spiritual enrichment, intimately linked to our physical and mental well-being (Torri and Herrmann, 2011; Anthwal *et al.,* 2010). The erosion of this biological diversity, and loss of the ecosystem services that it underpins, can thus impose a huge cost on Indian society.



**Values of Biodiversity:** Biodiversity is extremely valuable in practically every element of existence. Biodiversity can be used for a variety of purposes, including (Verma, 2016):

*Consumptive use:* in which biodiversity products, including fuels, food, medicines and fibres, are gathered and consumed directly. Humans consume a significant variety of wild flora and animals. Plants or plant extracts are used to treat around 75% of the world's population. Penicillin, for example, is an antibiotic generated from a fungus called Penicillium, while tetracycline is developed from bacteria. Quinine is a malaria treatment. Two anti-cancer medicines, vinblastin and vincristin, are derived from the bark of the Cinchona tree, derived from the Catharanthus plant, and so on. Our woodlands have been used for fuel wood for millennia. Coal, petroleum, and natural gas, all fossil fuels, are also products of fossilised biodiversity.

*Productive use:* Animal items such as musk from musk deer, silk from silkworms, wool from sheep, fur from a variety of animals, lac from lac insects, and so on are traded in the market. Furthermore, numerous sectors, including the paper and pulp industry, plywood industry, railway sleeper industry, textile industry, leather industry, and pearl industry, rely on the productive use of biodiversity values.

*Social use:* In which people's social lives, customs, religions, and psycho-spiritual components are linked, i.e. biodiversity has varying social value in different communities. Tulsi, Peepal, Mango, Lotus, and other plants are considered holy and sacred in our land. These plants' leaves, fruits, and flowers are used in worship, or the plant itself is worshipped. Tribals' social lives, music, dances, and customs are all centred on the wildlife. Many animals, such as the cow, bull, peacock, owl, and snake, play an important role in our psycho-spiritual realm and so have a specific social significance.

*Ethical value:* The concept of 'Live and Let Live' is used to define ethical worth or existence value. It means that biodiversity is valuable because our human race to exist and thrive, we must safeguard all biodiversity, i.e., "all life must be protected".

*Aesthetic value:* where eco-tourism is encouraged. People travel long distances and spend a lot of money to visit wilderness areas where they can enjoy the aesthetic value of biodiversity, so biodiversity has a high aesthetic value.

*Ecosystem service value:* where non-consumptive use of self-maintenance of the ecosystem and various ecosystems has been recognized. It refers to ecosystem services such as soil erosion prevention, flood

prevention, soil fertility maintenance, nutrient cycling, nitrogen fixation, water cycling, pollutant absorption, and reduction of the threat of global warming, among others.

*Scientific and evolutionary value:* in which each species provides scientists with information about how life evolved and will continue to evolve on Earth. Furthermore, biodiversity aids scientists in understanding how life works and the role of each species in sustaining ecosystems. Furthermore, biodiversity has numerous other benefits.

**Threats to biodiversity:** The depletion of biodiversity is an alarming problem all over the world. The rate of extinction has been enhanced by human intervention–habitat loss and climate change (Singh and Kushwaha, 2008). The mountains, like other ecosystems, suffer from a variety of unplanned development activities, such as road construction and degradation, which result in landslides and erosion. Mountain ecosystems in the Himalayas and Western Ghats have been identified as vulnerable and have received special attention. The grassland ecosystem is one of India's most endangered ecosystems. Grazing, fire, pollution, development projects, conversion for agriculture, and plantations are all putting a strain on this ecosystem. Other habitats, such as lakes, marshes, and river systems, are under threat from pollution, sewage, and toxic effluents. Mangroves are also threatened by reclamation for urban development, waste disposal, oil spillage, and other factors. Mining, blasting, dredging, collection of reef biota, coastal clearance for development, sewage disposal, discharge of effluents from industries and thermal power plants, chemical pollution, and oil spillage all endanger coral reef ecosystems. The Western Indian desert, which is one of the world's most densely populated deserts with more livestock, is under severe biotic pressure (Venkataraman and Sivaperuman, 2018). India, like the rest of the world, is facing threats to species and genetic diversity, and these threats are having a direct impact on the ecosystem.

Other significant facts include habitat destruction, over exploitation, flooding, droughts, and cyclones. The Indian cheetah, lesser Indian rhino, pink-headed duck, forest owlet, and Himalayan mountain quail are among the species that have gone extinct in the last century (Ramakrishna and Alfred 2007). Out of 1998 Indian plant species assessed under the International Union for Conservation of Nature (IUCN) Red List 2019-3 (excluding data-deficient species), 402 (i.e. 20%) are threatened with extinction (i.e. falling under the critically endangered, endangered or vulnerable categories.For birds, mammals and amphibians, the corresponding percentages are 8%, 24% and 40%, respectively (White *et al*., 2021; IUCN, 2020). Fig 1 shows habitat loss example of biodiversity.

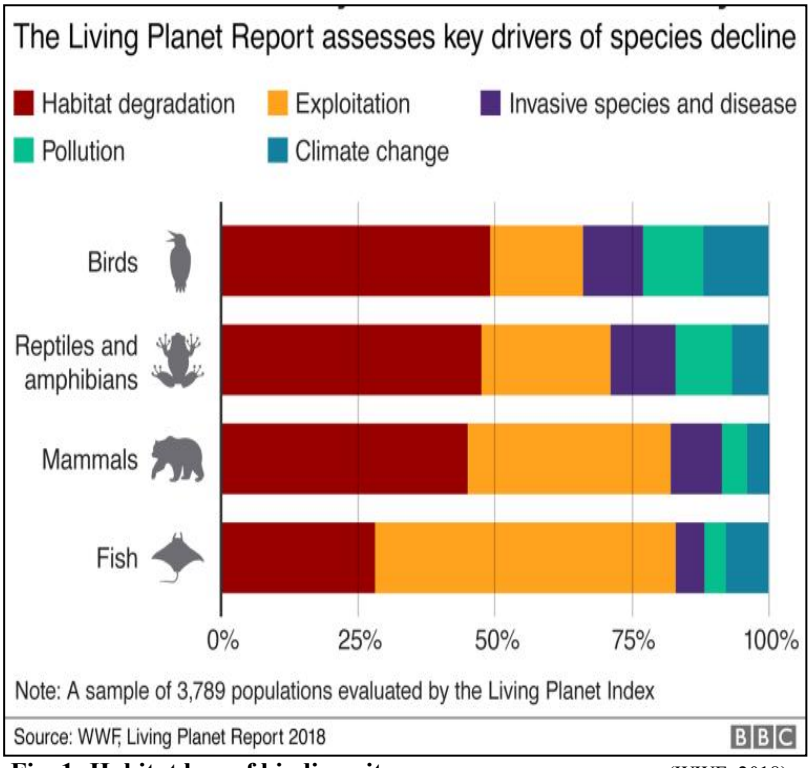


**Fig. 1: Habitat loss of biodiversity** (WWF, 2018)

Anthropogenic threats to biodiversity come in several major forms:

*Habitat alteration and destruction:* Overall, habitat alteration and destruction are the primary factors directly driving biodiversity loss around the world. Habitat destruction renders entire habitats functionally incapable of supporting the species present. When existing organisms in the habitat are displaced or destroyed, biodiversity is reduced (Ayoade *et al.,* 2009; Agarwal *et al.,* 2011). Human habitat destruction has accelerated dramatically in the latter half of the twentieth century. Natural habitats are frequently destroyed by human activity in order to harvest natural resources for industrial production and urbanisation. Clearing forest areas for agriculture, conversion of riverine habitat to lacustrine (reservoir) habitat due to the construction of hydroelectric projects on rivers, mining, logging, urban sprawl, and highway construction are

all examples of habitat destruction and fragmentation (Agarwal *et al.,* 2014). Increased greedy demand for resources has resulted into land use changes.

*Over-exploitation of biological resources:* This occurs when individuals of a particular species are taken at a faster rate than the population's natural reproductive capacity can sustain. This can be accomplished through hunting, fishing, trade, food gathering, and so on. Overexploitation continues to be a serious threat to many species, including marine fish and invertebrates, trees, and meat-hunting animals. The grazing pressure on most of Uttarakhand's high altitude grasslands, both from migrant and local communities, is exacerbated by the extensive extraction of medicinal herbs in these areas, resulting in their overexploitation (Rawat, 1998).The majority of industrial fisheries are fully or overexploited, and destructive fishing techniques harm estuaries and wetlands. Although the true extent of exploitation is unknown, it is clear that rates of off take in tropical forests are extremely high. The trade in wild plants and animals, as well as their derivatives, is poorly documented, but it is estimated to be worth nearly $160 billion per year. It includes everything from live animals for the food and pet trade to ornamental plants and wood. Because the trade in wild animals and plants crosses national borders, regulating it necessitates international cooperation in order to protect specific species from overexploitation (Rawat and Agarwal, 2015). Fig 2 shows the species share traded in 2019.



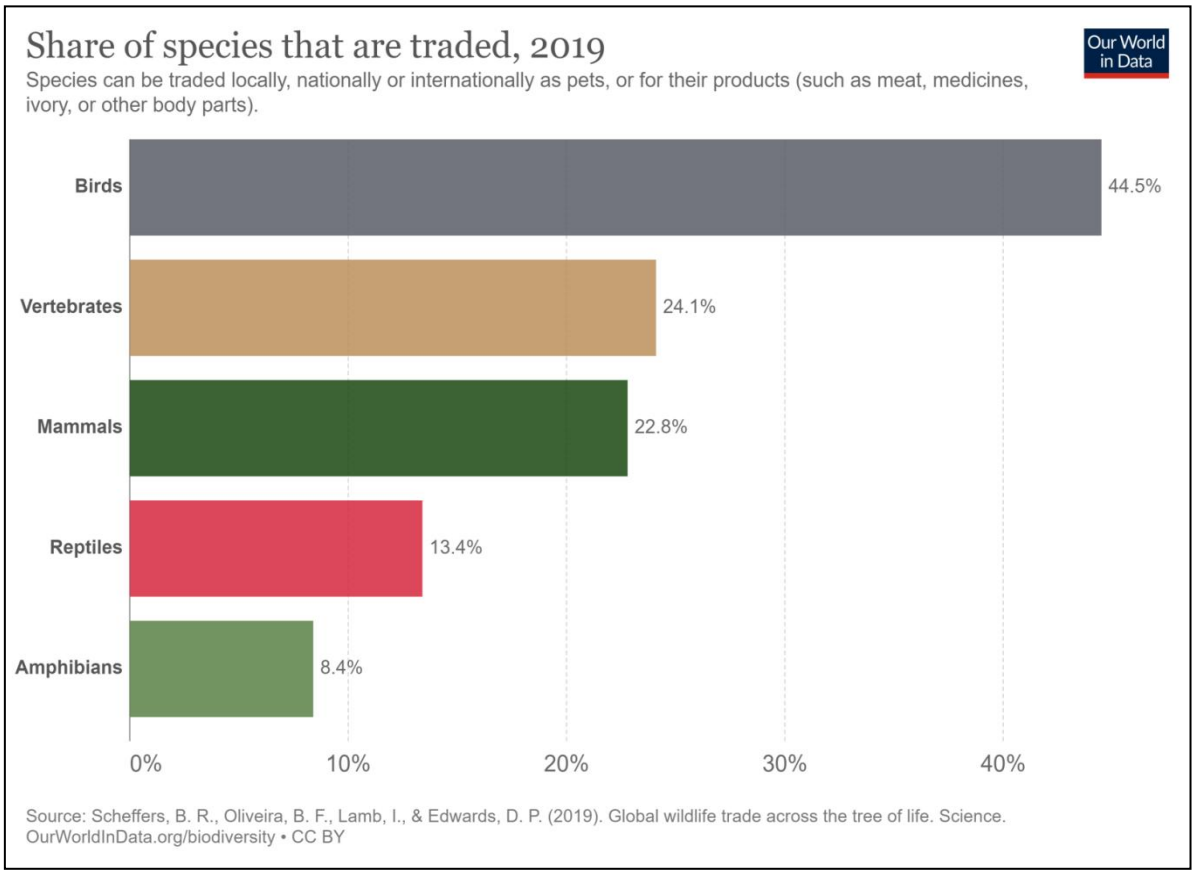


**Fig. 2: Share of species share traded in 2019** (Scheffers *et al.*, 2019)

**Pollution:** Inorganic and organic pollutants have emerged as one of the most significant contributors to biodiversity loss in terrestrial, aquatic-marine, and freshwater ecosystems over the last five decades. Another threat to biodiversity is thermal pollution. Organic pollutants in a freshwater ecosystem can cause eutrophication, hypoxia in coastal marine ecosystems, nitrous oxide emissions that contribute to global climate change, and NO air pollution in urban areas. The occurrence of such issues varies greatly across regions. Species in their natural habitats are increasingly being harmed by industrial activities and pollution caused by excessive use of agrochemicals such as DDT, oil spills, acid precipitation, and so on. Pesticides, for example, have been linked to the decline of fish-eating birds and falcons. Lead poisoning is another major cause of mortality in many species, including ducks, swans, and cranes, who ingest spent shotgun pellets that fall into lakes and marshes. The vulture was once very common in India's Gangetic plains, often seen nesting on avenue trees in large cities in the region. Prior to the 1990s, they were even considered a nuisance, particularly to aircraft because they were frequently involved in bird strikes. The vulture has experienced a 99 percent population decrease in India (Prakash, 2007) and has become rare due to poisoning

by DDT, which is used as a pesticide, and also by diclofenac, which is used as a veterinary non-steroidal anti-inflammatory drug, leaving traces in cattle carcasses, which when fed by vultures results in thinning of egg shells, premature hatching, and kidney failure in birds (Muralidharan *et al.,* 2008). Several South American countries have launched campaigns to prohibit the use of diclofenac in veterinary medicine. In recent years, India has seen a dramatic decrease in the population of house sparrows. It has been linked to pollution caused by electromagnetic radiation emitted by mobile phones. microwave towers; excessive pesticide use; and a gradual reduction in nesting sites due to changes in urban building design (Balmori and Hallberg, 2007).

**Introduction of Exotic / Invasive species:** This could be intentional or unintentional. Changes in an ecosystem will occur as a result of the introduction of new species. Introduced species are organisms that have emerged in areas/habitats where they were previously not native. Biological pollutants are commonly used to describe such introduced species. Hybridization, out competition, disruption of the original ecosystem, plant pathogenic influences, disease transmission, disruption of food webs, and, in some cases, extinction are some of the ecological consequences of the invasion. Species may be intentionally introduced for ornamental purposes, agriculture, hunting and spotting activities, and biotechnology for scientific research and trade.



**Global Warming and Climate Change:** This is a major concern, especially as global $CO_2$ levels rise in the atmosphere, resulting in global warming. Most species evolve within a very narrow physiological range; thus, nature maintains a range of tolerance for ecosystem stability. Changes can be gradual or abrupt, and if the upper or lower limit is exceeded, the species will become extinct. Recent climate changes, such as rising temperatures in some regions, have already had a significant impact on biodiversity and ecosystems (Rawat and Semwal, 2014). They have had an impact on species distributions, population sizes, the timing of reproduction and migration events, as well as the frequency of pest and disease outbreaks. Climate change projected by 2050 could lead to the extinction of many species living in specific geographical regions. Climate change and its consequences may become the primary direct driver of overall biodiversity loss by the end of the century. Changes in fish populations have also been linked to large-scale climate variations, such as "El Nino" which has impacted fisheries off the coasts of South America and Africa, and decadal oscillations in the Pacific, which has impacted fisheries off the west coast of North America. As climate change worsens, the negative effects on ecosystem services will outweigh the benefits in most parts of the world. According to the Intergovernmental Panel on Climate Change (IPCC), the average surface temperature will rise by 2 to 6.40 degrees Celsius by 2100 compared to pre-industrial levels. The Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005) predicts that this will have a global negative impact on biodiversity.

**Biodiversity conservation:** Conservation biologists predict that the extinction rate of species will increase rapidly this century, but they believe that society can significantly reduce the future rate of biodiversity through well-planned protected area systems (Margules and Pressey, 2000; Shaffer and Stein, 2000).The 1952 national forest policy paved the way for the establishment of national parks and wildlife sanctuaries in India. The Wildlife (Protection) Act of 1972 in India recognises the critical role of protected areas (PA) in the conservation of natural resources and the preservation of biological diversity (Singh and Kushwaha, 2008).In the last century, conservation efforts have had varying degrees of success, and in the future, large-scale efforts and comprehensive strategies will become increasingly important. Due to their disproportionate consumption of natural resources, economically developed nations will increase pressures on global biodiversity. These nations should become major contributors to conservation efforts that take place outside of their borders, strategically directing funds to regions with the greatest current or future threats or the greatest potential return on investment (Tilman *et al.,* 2017). All societies protect some lands and waters from exploitation and development in order to preserve the natural and cultural values associated with those areas, but biodiversity conservation has only recently gained prominence as the primary conservation goal. The Convention on Biological Diversity (CBD) signatory nations are now focusing on developing a new post-2020 Protected area target that includes an increase in global Protected area coverage (Convention on Biological Diversity, 2020)

Conservation may be in situ or ex situ;

*In-situ conservation:* It refers to the preservation of ecosystems and natural habitats, as well as the preservation and recovery of viable populations of species in their natural habitats. Approximately 4.2 percent of India's total geographical area has been designated for extensive in-situ habitat and ecosystem

conservation. The Indian Forest Act (1927, IFA) and the Wildlife Protection Act (1972, WA) both provide legal safeguards for the establishment of India's nature reserve system. Official PAs in India currently include 104 National Parks and 551 Wildlife Sanctuaries (Gao *et al.,* 2023). In 2002, India added two new legal categories to its protected areas, Conservation Reserves on public land and Community Reserves on private land(IUCN Categories V and VI, respectively) are established primarily on the basis of approved management plans. More than 70% of the 214 such reserves established by 2019 (4,811 km²) are in just three states (122 Community Reserves are in Meghalaya and Nagaland, and 34 Conservation Reserves in Jammu & Kashmir) (Ghosh*, et al.,* 2019). This network's results have been significant in restoring viable populations of large mammals such as tigers, lions, rhinoceroses, crocodiles, and elephants. Since the extinction of the cheetah (*Acinonyx jubatus*) in the mid-20th century, no bird or mammal has been known to have been lost from India (Divyabhanusinh, 1999). Protected areas have undoubtedly played a significant role in this success (Karanth *et al.,* 2010; Walston *et al.,* 2016). After suffering a 97% population decline due to veterinary use of the drug diclofenac, the three Gyps vulture species are now mostly found inside or near National Parks (Prakash *et al.,* 2017).

*Ex-situ conservation:* It refers to the conservation of biodiversity components outside of their natural habitats, such as zoos, museums, gene banks, and botanical gardens/arboretums, which are used for threatened and endangered species to avoid extinction, also known as captive conservation.
A lot of work is being done to collect and preserve the genetic material of crops, animals, birds, and fish (Agarwal *et al.,* 2009; Agarwal 2011). Institutions such as the National Bureau of Plant Genetic Resources, the National Bureau of Fish Genetic Resources, the National Bureau of Animal Genetic Resources, and others are involved in this work. Reintroduction, captive breeding programmes, and artificial feeding have also been used as conservation measures. Another type of ex situ conservation is the reintroduction of an extinct animal or plant into its natural habitat. Ex situ conservation is important in seed banks, botanical, horticultural, and recreational gardens.

**Indian perspective in biodiversity conservation:** Protecting and promoting biodiversity has always been an important part of Indian culture and civilization. This can be seen in the thousands of sacred groves that dot the landscape. Plant and animal biodiversity is essential to Indian traditional agricultural and medical systems. The Indian Forest Act of 1927 and the Forest (Conservation) Act of 1980 govern forest management and forest land conservation, respectively. The Wildlife (Protection) Act of 1972 was enacted to protect wild animals, birds, and plants, and it primarily aims to protect, propagate, or develop wildlife or its environment through national parks, sanctuaries, and other means. Furthermore, the Act prohibits the picking and uprooting of specific plants.

India was an early signatory to the United Nations Convention on Biological Diversity (CBD). Even before CBD, India had legal provisions dealing with aspects of biodiversity. India has passed and notified the Biological Diversity Act, 2002.According to the provisions of the Biological Diversity Act of 2002, a National Biodiversity Authority was established on October 1, 2003, in Chennai, to facilitate the implementation of the Act. In accordance with the Act's provisions, states established State Biodiversity Boards, and at the local level, Biodiversity Management Committees were established. For two years, India presided over the Group of Like-Minded Mega Diverse Countries (LMMCs) (March, 2004 to March, 2006). Following the Cabinet's approval of the National Environment Policy (NEP) in 2006, the National Biodiversity Action Plan (NBAP) was approved in November 2008 to supplement the natural resource base and its sustainable utilisation (Rawat and Agarwal, 2015).

Due to non-accomplishment of CBD goals by signatories, the Strategic Plan for Biodiversity 2011-2020, a ten-year framework for action with Aichi Targets, was adopted in 2010 at its tenth Conference of Parties (COP10), with time-bound goals to be achieved by 2020. (Dhami, 2021).Despite population pressure on land, India’s geographical area under protected areas is 1,71,921 sq.km. Under 981 protected areas including 104 National Parks, 566 Wildlife Sanctuaries, 97 Conservation Reserves, and 214 Community Reserves. This accounts for only 5.03% of India's geographical area (Wildlife Institute of India 2021).

For the first time in India, the Ministry of Environment and Forest (MoEF) assessed the availability of funds for biodiversity conservation in 2010-11. The total funding for 2010-11 for biodiversity conservation was estimated at Rs.11,077.13 crores (USD 1.46 billion8). This included funding from the Government of India for core (direct and immediate biodiversity impact of MoEF programs/schemes), net non-core (i.e., net of MoEF schemes that are directly relevant to biodiversity) 9 and net peripheral funding flows (from biodiversity relevant 29 schemes of Ministries other than MoEF) (MoEF, 2012).

India has a strong network of R&D institutions supported by Central Government Ministries/Departments (e.g., MOEF, DST, ICAR, CSIR, and ICFRE), Statements, Universities, State Agricultural Universities, and NGOs (e.g., FRLHT, KFRI, MSSRF, TERI, and WEF. India). These institutions have conducted research and conservation activities such as inventorying RET species and

assessing their status, conservation biology of RET species, mapping RET species distribution, in-situ and ex-situ conservation programmes such as micro propagation techniques, gene banks, reintroduction programmes, conservation educative agrotechnology, genetic diversity assessment, characterising the level of passport data preparation, and bioprospecting ( Pushpangadan *et al.,* 2018). India has special programmes in place to protect high-profile endangered species such as tigers and elephants. The project tiger was initiated in 1973 with 9 tiger reserves in 9 different states with core areas of 9374 km² and has since increased to 50 tiger reserves spread across 18 different states with core areas of 40,145 km² and buffer areas of 32,604 km² as on June 2018 (Nayak *et al.,* 2020).

## CONCLUSION

Biodiversity stands as a cornerstone in our understanding of the intricate web of life on Earth. The discourse surrounding biodiversity underscores the urgency of preserving and sustainably managing our natural resources. As we navigate the myriad challenges and opportunities presented by biodiversity, it becomes evident that sustainable development and responsible resource utilization are paramount. The concepts of biodiversity loss and conservation are pivotal in guiding our efforts towards preserving the richness of life on our planet. Addressing biodiversity management necessitates collaborative action from a diverse array of stakeholders, including governmental bodies, private enterprises, non-governmental organizations and grassroots volunteers. Such collaboration is essential for implementing effective strategies that safeguard biodiversity for future generations. Furthermore, the establishment of robust national and international frameworks, supported by legislation and enforcement mechanisms, serves as a crucial foundation for promoting and upholding biodiversity conservation efforts. By fostering a shared commitment to biodiversity preservation, we can strive towards a future where the Earth's natural heritage thrives, and the benefits of biodiversity are enjoyed by all.



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