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Biodiversity and Protected Areas: A Need for Paradigm Shift in Biodiversity Conservation Strategy in India

G. S. Solanki*

Department of Zoology, Mizoram University, Aizawl-796004, Mizoram, India

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Corresponding Author: **G. S. Solanki** | E-Mail: **(gssolanki02@yahoo.co.in)**

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ABSTRACT

Biodiversity is avital indicator ofa healthy planet and society. Biodiversity richnessis a crucial factor to maintaining variety, variability of life, and associated ecological processes. India is highly diverse in biological terms and shares 8% of the world's biodiversity and 2.4% of the world's geographical area. Major centres of biodiversity are.theProtected reas and natural reserve forests.Biodiversity in the country is threatened by habitat loss, fragmentation, and forming isolated landscapes. These fragmented/isolated patches are also good repositories of regional biodiversity. There are several constraints in bringing the entire range of biodiversity under network of protected areas and challenges to managing them. A paradigm shift is envisaged for speciesconservation beyond the protected areas and recording the biodiversity of selected faunal groups on large landscapes. There are several categories of landscapes under the control of government and non-organizations, academic and defence institutions, etc. where biodiversity exists in a good amount that requires attention for their conservation.A framework for the concept of institutional reserve needs to be developed and promoted to sustain the biodiversity profile of India. Some case studies are presented to support this hypothesis and suggestions are given to enforce biodiversity conservation measures and strategy on non-protected landscapes and modified habitats.

Keywords: *Biodiversity, Conservation strategies, Hotspots, Protected Areas, Institutional Reserve.*

INTRODUCTION

As a tropical country, India harbours a rich biodiversity due tolarge coral reefs, mangroves and tropical forests. Geographically,thetropical region lies between 23.5°N lat. and 23.5°S long; and is categorized by a hot climate. Reasons for greater biodiversity in tropical countries are:(1)more solar energyavailable per unit area, which contributes to greater productivity and abundant food availability. (2) Lesser seasonal variations promote niche specialization, increasing species diversity.(3)Tropics have been undisturbed for millions of years in comparison to the temperate regions thathave undergone glaciation in the past. This facilitated greater species diversification in the tropics.

The rich biological diversity in India is additionally contributed bythe diverse natural ecosystems ranging from the cold and highHimalayan regions to the sea coasts, arid deserts, types of forests, wetlands, islands and oceans, and high plateaus and several major rivers, includingthe Ganges, Brahmaputra and Godavari [47]. The assorted physicalfeatures and climatic situations have formed varied ecological habitats thatharbor and sustainimmense biodiversity. Biodiversity is a crucial indicator ofa healthy planet and a healthy society. Rich biological diversity is essential for maintaining the variety and variability of living species and for the associated ecosystem process and its functioning [32].

Biodiversity Profile of India: Biodiversity of India is presumed to be concentrated in some specified areas which are legally/ socially protected. There are several parameters addition to the diverse forest types, habitats, ecosystems, biogeographical regions, etc., that dictate the species richness in the countries. The biodiversity profile of India is contributed by 350 species of mammals which is 7.6% of the world's mammals, 1224 species of birds whichmake 12.6% of the world'sspecies, 197 species of amphibians which is 4.4% of the world'sspecies, 408 reptilians that make6.2% of the world's reptiles,2546 number of species of fishesthatcontributes to11.7% of the world's fish species, and 15000 of flowering plants that make 6% of world's flowering plants. This level of biodiversity inIndia contributes % to world biodiversity. Rich Indian biodiversity is justified by its geographical area as compared to the world, India's geographical area is 2% of the world's geographical supports 8% of world biodiversity**.**Moreover, India is the world's most populous country that makesupmore than 20 % of the world's human population**.** All these make India a rich biodiversity country in the world. The important criteria that contribute largely to making India a biodiversity-rich country are described below.

Diversity in forest categories and classes

Forests and other terrestrial habitats host the majority of Earth's biodiversity, making forest conservation integral to preserving biodiversity [49]. According to the Indian State Forest Report (2021), India's forest cover spans 7,65,210 km^2, accounting for 23.42% of the country's total land area. However, satellite-based data estimates forest cover at 6,39,900 km^2 (19.47%). These forests encompass a wide range of ecosystems, from tropical wet evergreen forests in the North-East to tropical thorn forests in Central and Western India.

India's forests are classified into 16 major types:

1. Tropical wetevergreen (found in North East, South India including Andaman and Nicobar Island), 2. Tropicalsemi-evergreen (in South and East India), 3. Tropical moist deciduous (Central and East India), 4. Tropicallittoral and swamp (Along the East and West coast), 5. Tropical dry deciduous (in West and Central India), 6. Tropical thorn (in West and Central India),

7. Tropical dry evergreen (in Central and South India), 8. Subtropical broad-leaved hill forests (South India), 9. Subtropical pine (Sub-Himalayan tract), 10. Subtropical dry evergreen (North-East and South India), 11. Mountainwet temperate (found in Himalayasand Nilgiris hill ranges), 12. Himalayan Moist temperate (in temperateareas of the Himalaya region), 13. Himalayan dry temperate (dry temperateareas of the Himalaya region), 14.Sub-alpine (Himalaya region), 15. Moist Alpine shrub (Himalaya region) and 16. Dry alpine shrub(part of the Himalaya zone) [46].

Mega biodiversitycountry

To qualify to become a mega biodiversity country, a country must be rich in biodiversity, should have 5000 species of endemic plants, and have a marine ecosystem within its boundary[24]. India is recognized as one of the 17 megadiverse countries globally, contributing significantly to the planet's biodiversity. Although it covers only 2.4% of the world's land area, India accounts for approximately 8% of global biodiversity [12; 23]. With forests covering 23.42% of its geographical area, India boasts remarkable biodiversity, both wild and domesticated. The country is home to around 47,000 species of plants and fungi and approximately 89,000 animal species, showcasing a richness that rivals many other nations [12]; FSI, 2021;[49].

Protected area network

Establishing protected areas is a crucial strategy for conserving genetic resources, biodiversity, and ecosystems, ultimately benefiting both nature and humanity [37; 13; 36; 20; 11; 27; 21-22]. These protected areas maintain vital ecological, economic, and cultural connections with their surrounding landscapes [50].The National Wildlife Database Centre of the Wildlife Institute of India (WII) has updated the protected area network (up to 2023). A large networkof Protected Areas (1014 no.) in India includes - National Parks (106), Wildlife Sanctuaries (573), Conservation Reserves (115), and Community Reserves (220) covering a total of 1,75,169.42 km^2 of the geographical area of the country which makes approximately 5.32%. The area under the protected area network has achieved national recommendations. Other important conservation sites /reserves in India are also very significant for the conservation of flora and fauna. India's conservation and management of biological diversity are supported by a diverse range of protected areas, including 56 Tiger Reserves, 33 Elephant Reserves, and 18 Biosphere Reserves. Additionally, the country is home to 75 Ramsar Wetland Sites, 7 Natural World Heritage Sites, 32 Cultural World Heritage Sites, and 1 Mixed World Heritage Site. Conservation efforts extend to 110 Coastal and Marine Areas, 554 Important Bird Areas, 531 Key Biodiversity Areas, and 18 Heritage Sites, all these contributesignificantly in preserving India's rich biodiversity.

Biodiversity Hotspots

Biodiversity hotspots are extensive biogeographic regions that harbor largely intact natural ecosystems, along with the characteristic species and communities associated with them. These areas are rich in endemic species. To be designated as a biodiversity hotspot, a region must meet two specific criteria: (a) it must contain at least 1,500 endemic vascular plant species, and (b) it must have lost at least 70% of its original native vegetation [29-30].Biodiversity hotspots foster the evolutionary process of speciation.

34 terrestrial biodiversity hotspots have been identified worldwide. India shares four hotspots namely –Eastern Himalaya, Indo-Burma, the Western Ghats–Sri Lanka, and Sundaland. The Indo-Burma hotspot is thelargest (2.37 million km^2) among the four, while Sundaland is the smallest area (Nicobar Island only) that India shares. The Eastern Himalaya hotspot encompasses all mountain peaks exceeding 8,000 meters, along with some of the world's deepest river gorges. The Indo-Burma hotspot, which covers most of northeastern India (excluding Arunachal Pradesh and the northern parts of Assam), is the richest among India's biodiversity hotspots. Despite its high human population density, the Western Ghats–Sri Lanka hotspot boasts the highest concentration of endemic herpetofauna species. Meanwhile, the Nicobar Islands are home to a diverse array of terrestrial and marine ecosystems, including mangroves, coral reefs, and seagrass beds.

Gap analysis and problem identification in species conservation

[3; 17; 18] have conducted studies and analysedgaps inmanagement in protectedareas. Protected areas in India are legally established under the Wildlife Protection Act of 1971. However, many of these areas do not adequately represent the full spectrum of the country's biological diversity and often lack the necessary level of protection. In several cases, administrative and legal boundaries do not align with ecological boundaries, posing challenges to effective conservation. Conservationists and park management have recognized the need to expand park boundaries to create ecological corridors and maintain connectivity between floodplain areas and hill forests [41].

Many smaller protected areas face significant challenges, including persistent biotic pressure from resource-dependent communities both within and outside their borders. These areas often struggle with inadequate infrastructure, insufficient manpower, limited research and monitoring activities, and a lack of critical information. Additionally, the absence of meaningful stakeholder participation in the planning process often results in poorly developed management plans [13].

Conservation versus community conflict

Maintaining a balance between the space required for 8.7 million species of animals and plants of the world and the increasing levels of resource consumption by humansis a current challenge in natural resource conservation. Most of the species are facing a challenge to maintain a balance between habitat requirements and resource availability due to fragile conditionsincluding human-wildlife conflict in India. Incidences of cropdamage, livestock predation, and attacks on humans bywild carnivores and herbivores are on the increase.It is one of the key issues for management. Every year, the government pays huge sums in cash compensation, but compensation is not the solution to this increasing menace [18].

Protected areas (PAs) often function like isolated islands, as their current boundaries rarely encompass the full range of biodiversity they aim to preserve (World Parks Congress, 2003). One of the major challenges PAs face is balancing the growing demand for resources from various stakeholders with the limited availability of those resources. Additionally, incompatible land use patterns surrounding PAs pose significant obstacles to effective management. This highlights the need to look beyond the boundaries of PAs and adopt a landscape-based approach to conservation.

Establishing ecological networks and corridors, along with fostering cooperation among multiple agencies and stakeholders, is crucial. However, identifying effective initiatives to manage PAs, engage local communities, and sustain the landscape remains a pressing challenge now and in the future. The primary challenges include: (a) the rapid degradation of natural resources and the environment, (b) the increasing frequency of human-wildlife conflicts and the complexities of mitigating them, and (c) the need to balance developmental objectives with sustainable natural resource management. Without appropriate and effective strategies, the ecological and societal benefits of these landscapes could be lost, jeopardizing both sustainable livelihoods and long-term management goals.

Land Use Pattern In India

The distribution of land for different purposes is an important criterion for policymakers and planners. The possibility of diverting one category of land to another category to meet changing needs to be evaluated. Existing land use patternsare under crisis due to rapid urbanization and faster infrastructure development,which has a severe impact on the biodiversity of the region in general and birds in specific in tropics [1-2]. The area under the mountains is 30% of the land in the country.According to Agriculture statistics[4-10].land use in India is classified into the following categories as given below:

1. Net sown area: It is the category of the land where intensive crops are grown. It is 46% of the total land area.

2. Land not under cultivation: It is the category of land used for infrastrute.14% of the total land area is used to build cities and settlements, roads, railways, rivers etc.

3. Fallow land: Land under this category is 8% of the total land area. Fallow land had been used for agriculture but was left without agriculture for 1-5 years. It is done to get back soil fertility.

4. Cultivateable wasteland: It is 5% of the total land area that is suitable for agriculture but it is not used for various reasons like soil erosion, lack of water etc.

5. Land under plants and pastures: This category of land is 4% of the total land area under plants and pastures are used to graze cattles.

6. Forest Land in India: According to the India State of Forest Report (ISFR) 2023, forest cover in India constitutes 25.17% of the total land area, including 3.41% tree cover outside designated forest regions. However, the national recommendation suggests that forest cover should ideally be at 33% of the country's total land area. Forest cover in India is classified into four categories: (i) Very Dense Forest – a mere 3.4%, (ii) Moderately Dense Forest – 9.33%, (iii) Open Forest – 9.34%, and (iv) Scrub Forest – just 1.42% of the total forest cover. Despite these figures, forest cover in India has shown a slight increase of 0.5% over the five-year period from 2017 to 2021. Notably, the increase has been primarily observed in the open forest category, largely due to the expansion of commercial plantations.

Forest cover in India is already deficient in national recommendations. At this juncture, the Country cannot afford to convert anymore forestsinto protected areas for wildlife conservation programs.

Forest also supports the social and economic needs of the local and indigenous communities for their livelihood options and other natural resources. A paradigm shift in policy regarding earmarking any forest land/reserve as a protected area is required to shift to green spaces within educational/academic institutions, government organizations and others to strengthenbiodiversity and their conservation strategies outside the protected area network.

A shift in strategy in biodiversity conservation

The global decline in biodiversity is primarily driven by habitat fragmentation and loss, changes in land use patterns, over-exploitation of species, invasion of exotic species, and environmental degradation[4; 34; ; 11]. Factors such as widespread urbanization, modern agricultural practices, and unregulated resource extraction have contributed to a 13% to 75% reduction in Earth's biodiversity [12; 9; 44]. According to the Living Planet Report (2020), 75% of the Earth's ice-free surface has already been significantly altered. Additionally, oceans are heavily polluted with biological, chemical, and physical contaminants, while overfishing remains a major concern. More than 50% of wetlands have been lost, disappearing at a rate of 2% to 3% annually (Sustainable Wetlands, Environmental Governance-2, 1999).

Natural habitats are increasingly being lost, degraded, or fragmented, resulting in the formation of smaller, isolated patches. These fragmented landscapes act as refuges for local biodiversity within degraded ecosystems, enhancing their conservation value [44]. Rapid urbanization has negatively impacted native flora and fauna; however, it also creates corridors that facilitate the movement of certain local animal species [31; 5]. Additionally, green spaces within defense installations, Indian Railways, universities, and other academic campuses serve as vital biodiversity hotspots [15]. These modified landscapes provide potential habitats for small to medium-sized faunal groups, supporting local biodiversity conservation[42; 19; 43; 30]. Based on the information cited above a hypothesis is proposed that protected areas are not sufficient to accommodate the wide range of Indian biodiversity and to provide conservation; it is time to devise alternateapplications/strategies to strengthen the conservation measures. The country cannot afford to designate any more forest landscapes into protected areas. Therefore, it is high time to look beyond this and find alternative measures to ensure and support conservation values for the species. A considerable part of tree coveroutside the forest cover is contributed by educational institutes, public parks, roadside parking, government and non-governmental organizations such as Indian railways, Indian defence, Wqftboard etc. These premises act as an important habitat amidst the concrete jungle. To support this some case studies conducted in different areas/landscapes with different species where alternate / modified habitats were used for conservation of biodiversity are presented.

Case studies

- [16]surveyedavian diversity oncampuses of at least 300 universities and collegesworldwide since 1940. Each campus recorded to refuges an average of 66 bird species, including threatened species. It was then recommended that the campuses with high bird'diversity should be protected for research, conservation, and biodiversity education.

The campuses of universities and other academicinstitutionsare required to conduct regular surveysandmonitor and evaluate the biodiversity profile.

- Similarly, the academic campuses in India were surveyed by[8],the survey reported birds from 335 academic campus with large landscape with good greenery and found total of 779 species of birds with an average of 88 bird species per campus.Five critically endangered and 17 endangered avian species were also included. More than 50% of Indian avian fauna was recorded in this survey.
- [35] collected data on the presence and absence of avian species for a period of three years (2017-2020) on the Indian Institute of Technology campus- Guwahati (IITG), Assam. They reported 152 bird species includingseveralmigratory (winter and summer migrants) and resident species of birds across the seasons. The birds recorded on the IITG campus belonged to 108 genera, 50 families and 14 orders including endangered, vulnerable and near-threatened species. This makes up nearly 10% of Indian avian diversity.
- [38]also surveyedthecampus of the University of Mangalore and the surrounding area and recorded150 bird species including migrants and six species endemic to Western Ghats. These birds make up 28% of avian species intheState of Karnataka.
- Agroforestry systems provide suitable refuge for biodiversity and their conservation [7-54] for forest-dependent animals and plants A study conducted by Yasmita Ulman et al. (2021) on different agroforestry systems in Assam on the complete profile of biodiversity in such anthropogenically modified habitats and recorded 364 species of different faunal groups including mammals (14 species), birds (185 species), reptilians (18 species), amphibians (14 species), and butterfly species (133 species).A good amount of diversity was reflected in such habitats.
- [33] reported a study on birds ontheNavasari Agriculture University campus in Gujarat. They recorded 169 species of birds within the campus which belongs to 126 genera, and contribute 28% to the avian fauna of the state of Gujarat. This study also highlights the role of institutional premises in biodiversity conservation.
- A study conducted by [14; 51; and 40] in Mizoram University (MZU)campus, Aizawl, Mizoram on different faunal groups. The University campus is spread over an area of 980acres. Dominated by tropical wet evergreen and semi-evergreen forests.The altitudinal variation lies between300-800 m and the vegetation profile of the campus is comprised of 384 species of vascular plants belonging to 290 genera and 107 families apart from second-layer vegetations and lianas and climbers.Duringthe survey, it was reported that the campus area was found to have 78 butterfly species under 6 families(Nymphalidae (50%), Papilionidae (15%), Hesperiidae (13%), Lycaenidae(11%),Pieridae (10%) and Riodinidae with 1 species only.Rarespecies:Clipper (*Parthenos sylvia*), Blue Striped Palmfly (*Elymniaspatna*), and Grey Count (*Tanaecialepidea*) and five threatened species were also recorded. In addition to that 31 species of spiders belonging to 28genus and 8 families were recorded from the MZU campus. Other species recorded from the Mizoram University campus were 19 mammalian species, whichcontribute 15% of mammals of Mizoram state. Viverridae and Felidae were the dominant family.

Threatened speciesincludeMarbled cat (*Pardofelis marmorata*, Leopard cat (*Prionailurusbengalensis*), Golden jackal (*Canis aureus*), and Clouded leopard (*Neofeliosnebulosa*) –vulnerable species.189 species of birds were also recorded from the MZU campus from 43 families.

Recommendations

- A concept to recognize a category other than a protected area, and create a new category as an "Institutional Reserve". The following suggestions are put forward for strengthening conservation activities in the proposed Institutional Reserve.
- Attention needs to be focused equallyon modified /managed landscapes and habitats.
- The approach of monitoring small and fragmented patches could function as a refuge for critical biodiversity, increasing conservation values, and provide connectivity to maintain meta-population dynamics.
- Ecology/EcosystemMonitoringCell should be established for every such biodiversity rich managed habitat.
- Awareness programs for employees/residents of establishment need to be organized at regular intervals with emphasis on the role of wildlife to society and the environment
- Incentive-oriented activities may be promoted.
- Legislative bodies involvedintheprotection and conservation of wildlife should have a tie-up with local bodies to gather local intelligence inputs and exigency actions.
- NGOs working in conservation/environmental protection etc. may be involved for better functioning and management.
- Plantation of native species of trees should be preferred toattract local wildlife faunal species such as birds, butterflies and insects.
- Organize awareness workshops for local responsible citizens to teach them how to actagainst activities that harm or are likely to harm local biodiversity.

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