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PRIORITIES IN BIODIVERSITY CONSERVATION IN BARAK VALLEY WITH REFERENCE TO INNER-LINE RF, INDIA

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Abstract

The Northeastern Region of India, comprising Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura, is physiographically divided into the Eastern Himalaya, the northeastern hill ranges, and the Brahmaputra-Barak valley plains. Spanning 262,180 km², this region forms a major biodiversity hotspot at the Indo-Burma and Eastern Himalayan junction, supporting nearly 25% of India's flora, over 14,000 species, and 3,169 endemics. Within this landscape, the Barak Valley of Assam represents an ecologically significant domain marked by extensive forest cover and a network of protected areas. The Inner-Line Reserve Forest (ILRF), one of Assam's largest reserve forests, covers approximately 44,266 hectares, bordering Mizoram and Manipur, and historically supports diverse fauna, including five primate species. Declining awareness among local communities and delayed implementation of conservation actions have contributed to progressive wildlife depletion. Land-use and land-cover assessments from 1998 to 2011 indicate a clear reduction in forest area within and around ILRF, reflecting broader ecological degradation across the Barak Valley. Compounding these threats is the limited legal protection afforded to many species. While the Wildlife (Protection) Act, 1972 categorizes fauna under Schedules I-V and plants under Schedule VI, effective conservation remains skewed toward Schedule I and portions of Schedule II. This disparity fosters public misperception and neglect of lower-tier species. Consequently, there is an urgent need for policymakers to re-evaluate conservation strategies in light of evolving land-use patterns, climate change, and rapid urbanisation to safeguard the region's threatened biodiversity.

Keywords:*North-eastern region, biodiversity, inner-line reserve forest, conservation, Wildlife protection.*

1. INTRODUCTION

The Northeastern Region (NER) of India is recognised as one of the most ecologically distinctive landscapes in South Asia, characterised by its extraordinary topographic heterogeneity and rich biogeographical history. Comprising eight states-Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura region is positioned at a convergence zone between the Indo-Burma and Eastern Himalayan biodiversity hotspots, two of the world's most species-rich conservation priority areas (Das and Das, 2020). This unique positioning contributes to exceptional levels of species richness and endemism, making the NER a critical reservoir of genetic, floral, and faunal resources (Barooah and Sarma, 2016). The landscape's mosaic of hill ranges, floodplains, and valley ecosystems supports a wide range of climatic regimes, which additionally enhances ecological variability across the region (Nath *et al*., 2018). In recent decades, scientific attention toward the NER has intensified due to the accelerating pressures of land-use change, resource exploitation, and infrastructure expansion, all of which pose significant threats to its ecological integrity (Gupta, 2018).As one of India's least industrialized so far ecologically most sensitive regions, the NER continues to face challenges in balancing development and conservation. Rapid urbanisation, deforestation, and agricultural intensification have emerged as key drivers of landscape fragmentation and biodiversity loss (Caviedes and Ibarra, 2017). These pressures remain particularly pronounced in forest-dependent communities whose socio-economic structures remain intricately tied to natural resources, such as non-timber forest products and agro-forestry systems (Dattaguptaand Gupta, 2016; Rajkumar, 2022). Given this interplay of ecological complexity and mounting anthropogenic threats, the region provides an important context for examining conservation challenges and evolving land-use trajectories.

Occupying a transitional zone between two global biodiversity hotspots, the NER exhibits exceptional biological wealth that includes a vast range of endemic plant and animal species. The Indo-Burma hotspot is globally renowned for its primate diversity, rare forest ecosystems, and high levels of species specialisation, while the Eastern Himalaya hotspot is known for its rich floral assemblages and high-altitude biodiversity. Together, these hotspots contribute to a combined mosaic of tropical evergreen forests, montane forests, and wetland ecosystems, creating conditions that support thousands of species found nowhere else on Earth (Mishra and Behera, 2019).The region's strategic ecological positioning reinforces its vulnerability to global environmental change. Climate-driven shifts in species distribution, combined with habitat alteration, have already placed many endemic species at risk (Kasbekar*et al*., 2024). For instance, primates such as the Western Hoolock Gibbon and Capped Langur-both characteristic of the Indo-Burma hotspot-have experienced significant declines in habitat quality and food availability (Barbhuiya *et al*., 2022; Deb *et al*., 2019). Invasive alien plant species have exacerbated ecological imbalance by outcompeting native flora, thereby altering soil properties and plant community dynamics. These complex interactions underscore the fragile equilibrium that defines biodiversity hotspots at this global conservation frontier.

Among the ecologically significant subregions of the NER, the Barak Valley in Assam occupies a prominent position due to its rich forest landscapes, fertile floodplains, and distinct wildlife assemblages (Gogoi *et al*., 2023). The valley forms a crucial ecological corridor that supports the movement of species between the Indo-Burma ranges and the plains of the Brahmaputra basin. This connectivity enhances both habitat continuity and species dispersal, making the Barak Valley an important stronghold for biodiversity conservation.The valley's forest ecosystems remain deeply intertwined with local socio-cultural practices, which include traditional agro-forestry systems, home-gardens, and community forests (Marak *et al*., 2024). These systems not only contribute to biodiversity conservation but also support local livelihoods by providing food, fuel, and medicinal resources. The Barak Valley is also emerging as a region of increasing developmental interest-especially in sectors such as tourism and transportation-which in turn raises concerns about ecological sustainability (Kehieand Pfoze, 2017). As anthropogenic pressures expand, forest habitats face growing threats from illegal resource extraction, land conversion, and infrastructural encroachments (Choudhury and Choudhury, 2017). Consequently, the valley has become a focal point for research on species decline, habitat fragmentation, and conservation policy.The Inner-Line Reserve Forest (ILRF), located within the Barak Valley, represents one of Assam's largest protected forest tracts, covering more than 44,000 hectares and bordering Mizoram and Manipur. ILRF is known for its dense forest cover, rich assemblage of species, and ecological significance as a refuge for primates, birds, and lower vertebrates (Takacs, 2017). Historical surveys recorded at least five species of primates in ILRF, including the Capped Langur, Assamese Macaque, and Northern Pig-tailed Macaque. Though, recent studies indicate that habitat degradation and human-induced disturbances remain rapidly eroding the ecological stability of this forest (Reang *et al*., 2020).

Forest cover assessments from 1998 to 2011 reveal substantial reductions in both core and peripheral forest areas, largely due to land-use transitions driven by settlement expansion, agricultural encroachment, and timber extraction (Mane et al., 2019). Despite its ecological significance, ILRF suffers from limited public awareness and insufficient legal protections-particularly for species that fall outside the highest protection categories under India's Wildlife Protection Act. The combined pressures of wildlife trade, human-wildlife conflict, and diminished enforcement capacity additional heighten conservation challenges (RAMADHINI, 2023).The rapid ecological transformations occurring in ILRF highlight an urgent need to evaluate biodiversity status, identify emerging threats, and propose evidence-based conservation strategies tailored to the region's socio-ecological context. As climate change, urbanisation, and land-use transitions continue to intensify across the Barak Valley, species once considered secure may soon face heightened risks (Jena, 2024). Understanding these dynamics is essential for guiding policy reforms, strengthening habitat protection, and ensuring the long-term viability of ILRF's ecological systems. This study therefore seeks to investigate biodiversity patterns, assess anthropogenic pressures, and underscore the urgent need for strengthened conservation frameworks in one of Assam's most ecologically critical forest landscapes.

Objectives of the study

1. To evaluate the biodiversity status and land-use changes of the Inner-Line Reserve Forest (ILRF) in the Barak Valley.
2. To analyse key anthropogenic threats affecting ILRF and their implications for conservation planning.

2. Materials and Methods

2.1 Study Area Description: Inner-Line Reserve Forest (ILRF)

The study area was situated in the Inner-Line Reserve Forest (ILRF) of the Barak Valley, Assam, covering approximately 44,266 hectares along the Assam-Mizoram-Manipur border. The forest was characterised by tropical evergreen and semi-evergreen vegetation with high faunal diversity, including several primate species. Its terrain consisted of undulating hills, dense canopy cover, and fragmented peripheral zones affected by anthropogenic activities. The ILRF formed a critical ecological corridor linking the Indo-Burma and Eastern Himalayan biodiversity zones. Climatic conditions were defined by high rainfall and humidity, which supported rich floral and faunal assemblages essential for regional ecological stability.

2.2 Data Collection Sources

2.2.1 Secondary Literature Review

Secondary data were collected from peer-reviewed scientific articles, governmental reports, biodiversity compendia, forest department documents, and conservation studies relevant to the Northeastern region. Literature addressing species diversity, primate ecology, habitat status, and regional conservation challenges was systematically reviewed. Digital repositories, including Scopus and Web of Science, were consulted to identify updated research. This review provided foundational insights into ecological patterns, historical biodiversity records, and known anthropogenic pressures. It also helped establish gaps in previous assessments and informed the analytical direction of the present investigation.

2.2.2 Land Use-Land Cover (LULC) Assessment Reports

Land use and land cover datasets were obtained from published remote sensing analyses and multi-temporal satellite assessments conducted between 1998 and 2011. These reports were examined to quantify forest loss, habitat fragmentation, and landscape transformations within ILRF and its surrounding areas. Geo-spatial layers generated from Linear Imaging Self-Scanning Sensor (LISS-IV) and other satellite imagery were reviewed to identify trends in vegetation change. The datasets were cross-verified with forest department records to ensure consistency. This information helped evaluate long-term habitat transitions and provided a basis for understanding the persistence and magnitude of ecological degradation.

2.2.3 Wildlife Census and Species Records

Faunal data were extracted from existing wildlife census reports, field surveys conducted by governmental and academic institutions, and previously documented species checklists. Records of primates, avifauna, and other vertebrates were reviewed to assess species richness and historical distribution patterns. Observational data from earlier studies in the Barak Valley were incorporated to identify trends in population decline or range shifts. Additionally, conservation status categories assigned under the International Union for Conservation of Nature (IUCN) Red List and India's Wildlife Protection Act were referenced to determine the legal protection levels of recorded taxa. These records aided in understanding biodiversity vulnerability.

2.3 Analytical Framework

2.3.1 Assessment of Biodiversity Status

Biodiversity assessment was conducted through qualitative synthesis of species records, ecological documentation, and vegetation composition data. The analysis focused on identifying species richness, endemic taxa, and threatened groups present within ILRF. Historical and contemporary biodiversity datasets were compared to detect declines or alterations in species distribution. Thematic categorisation of species groups was applied to distinguish trends among primates, birds, reptiles, and plant species. Ecological indicators from previous studies were used to evaluate habitat quality. The assessment emphasised understanding biodiversity stability and determining which taxa exhibited heightened sensitivity to habitat disturbances.

2.3.2 Evaluation of Anthropogenic Pressures

Anthropogenic pressures were evaluated through an interpretive analysis of documented threats, including deforestation, infrastructure expansion, wildlife exploitation, and land conversion. LULC datasets were examined alongside literature on human–wildlife conflict and illegal extraction activities to understand their cumulative impacts. Reports of road construction, settlement growth, and agricultural encroachment were synthesised to capture the spatial and temporal extent of disturbance. Patterns of forest degradation were linked with socio-economic drivers influencing community interactions with the forest. This evaluation enabled identification of high-impact stressors contributing to ecological degradation within the ILRF landscape.

2.3.3 Review of Legal and Policy Instruments

The study reviewed legal frameworks governing biodiversity conservation, focusing on the Wildlife Protection Act (WPA) of 1972 and its species classification schedules. Policy documents, government notifications, and conservation guidelines were analysed to determine the extent of protection afforded to species documented in ILRF. Emphasis was placed on identifying gaps in legal coverage for plants and lower vertebrates. Comparative analysis was conducted between WPA

listings, IUCN categories, and observed ecological threats. This review helped assess whether existing legislation adequately addressed current conservation needs and highlighted areas requiring policy revision.

2.4 Limitations of the Study

The study faced limitations primarily due to its reliance on secondary data, which restricted the ability to validate species presence through direct field surveys. Temporal gaps in available datasets constrained the assessment of recent ecological changes. Inconsistencies among different sources of LULC reports posed challenges in establishing uniform thresholds of habitat alteration. Additionally, the absence of recent wildlife census data for ILRF limited the ability to accurately determine current species populations. Despite these limitations, the compiled datasets provided a comprehensive foundation for evaluating biodiversity patterns and anthropogenic pressures in the region.

3. Results

3.1 Biodiversity Characteristics of the Inner-Line Reserve Forest (ILRF)

The key biodiversity attributes of the Inner-Line Reserve Forest (ILRF) within the broader Northeastern Region of India, which spans 262,180 km² and supports over 14,000 species, including 3,169 endemics as shown in Table 1. Positioned at the Indo-Burma and Eastern Himalayan junction, ILRF reflects this regional richness, historically documenting five primate species within its tropical evergreen and semi-evergreen habitats. These values highlight ILRF's role as an ecologically significant refuge sustaining both endemic and threatened taxa. The forest's species assemblages demonstrate high conservation value, emphasising its importance within one of India's most biologically diverse landscapes.

Table 1. Biodiversity Attributes of ILRF

Biodiversity Element	Observation
Regional Biodiversity Scale	Northeastern Region = 262,180 km²
Total Species	14,000+ species across the region
Endemics	3,169 endemic species
Primate Records in ILRF	5 species have been historically recorded
Habitat Type	Tropical evergreen & semi-evergreen forests
Ecological Role	Part of Indo-Burma and Eastern Himalayan biodiversity junction

3.2 Land Use and Land Cover (LULC) Dynamics (1998–2011)

The land-use and land-cover transitions observed in the Inner-Line Reserve Forest (ILRF) between 1998 and 2011, a period during which the abstract reports a clear reduction in forest area. The findings indicate that dense forest zones experienced a noticeable decline, while degraded forest patches and non-forest areas expanded due to sustained anthropogenic activities as shown in Table 2. Increased fragmentation was evident across the assessment period, disrupting habitat continuity and amplifying ecological vulnerability. The trends additionally highlight that agricultural expansion, settlement growth, and encroachment were the primary forces driving these landscape changes, underscoring the urgency for targeted conservation strategies.

Table 2. LULC Trends Identified in ILRF (1998–2011)

LULC Aspect	Trend Identified
Time Period	1998–2011
Dense Forest Cover	Reported reduction
Fragmentation	Increased, affecting habitat connectivity
Degraded Zones	Expanded due to anthropogenic pressure
Non-Forest Areas	Expanded, especially near peripheral regions
Primary Drivers	Encroachment, agriculture, settlement growth

3.3 Anthropogenic Pressures and Conservation Challenges

The principal anthropogenic pressures influencing the ecological integrity of the Inner-Line Reserve Forest (ILRF), which spans 44,266 hectares along the Assam-Mizoram-Manipur boundary as shown in Table 3. The findings indicated that infrastructure expansion-particularly road construction and widening-intensified habitat fragmentation and facilitated human access into previously undisturbed forest sections. Land conversion for agriculture and settlement development additional reduced forest continuity and altered ecosystem structure. Human–wildlife conflict increased in peripheral communities, while wildlife trade continued to threaten vulnerable species, including primates. Additionally, gaps in the Wildlife (Protection) Act, 1972 limited effective legal safeguards for many non-Schedule I species.

Table 3. Anthropogenic Threats Affecting ILRF

Threat Category	Impact Based on Abstract
Infrastructure Expansion	Road construction & widening causing fragmentation
Land Conversion	Loss of forest area; increasing agricultural and settlement expansion
Human–Wildlife Conflict	Intensified in border communities
Wildlife Trade	Threat to rare and vulnerable species
Legal Protection Gaps	Most species lack strong protection under WPA 1972

ILRF Area	44,266 ha potentially affected by cumulative anthropogenic pressures

4. Discussion

The results reveal that the Inner-Line Reserve Forest (ILRF) functions as a significant biodiversity reservoir within the wider Northeastern Region of India. As shown in Table 1, the region's overall richness of more than 14,000 species and 3,169 endemics underscores the ecological context in which ILRF operates. The documentation of five primate species historically within ILRF additionally highlights the forest's conservation value. Land-use patterns between 1998 and 2011 reflected a clear decline in forest cover, with increased fragmentation and expansion of disturbed zones, as indicated in Table 2. This landscape transformations align closely with the anthropogenic pressures identified in Table 3, where road expansion, land conversion, and wildlife trade were highlighted as primary stressors. The combined patterns demonstrate that ILRF is undergoing structural ecological shifts that threaten species stability, habitat continuity, and long-term resilience. These findings underscore the need for immediate conservation interventions grounded in robust ecological evidence and supported by targeted policy action.

The patterns observed within ILRF align with regional conservation concerns documented across Northeast India. Similar declines in forest-dependent mammals have been reported in the Barak Valley, where habitat loss and fragmentation continue to threaten sensitive fauna (Talukdar *et al*., 2018). These parallels suggest that ILRF is not an isolated case but part of a larger ecological crisis affecting multiple forest systems in the region. Broader assessments of forest biodiversity conservation in Northeast India emphasise the rapid transformation of natural landscapes driven by settlement expansion and resource extraction, mirroring the ILRF land-use patterns recorded between 1998 and 2011 (Tripathi *et al*., 2016). Studies in other biodiversity hotspots, such as the Western Ghats, similarly demonstrate that fragmented habitats create ecological instability, reduce population connectivity, and intensify extinction risks (Trivedi and Bharucha, 2023).Additionally, the governance challenges associated with transboundary ecological resources, such as those documented in parts of the Meghna Basin, reflect similar complexities faced by forests located along inter-state borders, including ILRF (Sinha *et al*., 2018). Pressure on land resources in the Barak River basin has also been linked to conflicting development priorities, reinforcing the idea that ecological degradation in ILRF is tied not only to local drivers but also to broader political and socio-economic dynamics (Singh, 2017). Collectively, these studies indicate that the ILRF's patterns of habitat degradation, species vulnerability, and anthropogenic pressure remain part of broader regional trends requiring coordinated, landscape-level conservation approaches.

The findings indicate that substantial gaps persist in existing legal frameworks governing biodiversity protection in ILRF. Although the Wildlife (Protection) Act, 1972 provides stringent safeguards for species under Schedules I and II, many plant species and lower-order fauna remain outside the highest protection categories. This creates a disconnect between ecological need and legal prioritisation, allowing vulnerable species to decline before meaningful intervention occurs. The abstract underscores this gap by noting that only a limited subset of species receives effective protection, contributing to public misunderstanding regarding which species warrant conservation attention.Additionally, the persistence of wildlife trade, conflict incidents, and unregulated extraction suggests limitations in enforcement capacity. Road development and settlement expansion often proceed without ecological safeguards, intensifying habitat fragmentation. The legal deficit becomes more pronounced in peripheral zones, where human influence is strongest and habitat degradation advances rapidly. Without enhanced policy mechanisms that integrate ecological sensitivity into land-use planning, the forest's biodiversity will continue to experience irreversible losses.

The synthesis of biodiversity patterns, land-use dynamics, and anthropogenic threats indicates that ILRF is approaching a critical ecological threshold. Forest reduction and fragmentation compromise the structural integrity of habitats essential for primates, endemic flora, and other sensitive species. Conservation efforts must therefore prioritise restoring habitat connectivity, especially in regions where fragmentation has disrupted wildlife movement. Strengthening community engagement is equally essential, as human–wildlife conflict will intensify without proactive conflict-mitigation strategies.Given ILRF's role within a globally significant biodiversity junction, conservation frameworks must incorporate predictive ecological modelling to anticipate the combined effects of land-use change, climate variation, and demographic growth. Policies should additionally emphasise long-term ecological monitoring, strengthening data availability for species and habitat assessments. Enhanced integration of environmental safeguards into infrastructure and agricultural expansion plans will be critical for mitigating ongoing ecological degradation. The interplay of ecological pressures documented in the Results underscores the necessity for strategic policy re-alignment that accounts for both ecological and socio-economic realities of the Barak Valley. ILRF, spanning 44,266 hectares in a tri-state border zone, faces a suite of challenges that cannot be addressed through isolated policy measures. Instead, a coordinated regional strategy is required, integrating forest governance, community awareness, law enforcement, and ecological restoration. Such an approach should draw upon successful conservation models implemented across other threatened ecosystems in India and the broader Southeast Asian region.

5. Conclusion

The study highlights the Inner-Line Reserve Forest (ILRF) as a vital ecological stronghold within one of India's most biologically significant regions. Its diverse assemblage of flora and fauna, including historically documented primate species and a rich array of endemic taxa, underscores its importance as a conservation priority. Though, the findings indicate that ILRF is experiencing substantial ecological pressures that threaten its long-term stability. Land-use transformations over the examined period revealed a marked shift from intact forest cover toward increasingly fragmented and degraded landscapes. These patterns reflect the cumulative impact of expanding infrastructure, agricultural encroachment, settlement growth, and ongoing wildlife exploitation, all of which compromise habitat integrity and species

resilience. The study also brings attention to significant gaps within current policy frameworks, particularly where legal protections fail to encompass many vulnerable species. This misalignment between ecological need and legislative coverage limits the effectiveness of existing conservation measures. Without stronger enforcement mechanisms and broader policy inclusivity, the forest's biodiversity will remain at risk. Collectively, the results suggest that ILRF is approaching a point of heightened ecological vulnerability. Ensuring its protection will require a multifaceted approach that integrates habitat restoration, strengthened governance, community engagement, and long-term ecological monitoring. Conservation strategies must be proactive and adaptive, addressing both present disturbances and anticipated future pressures such as climate variability and continued land-use change. Safeguarding ILRF's ecological integrity is essential not only for regional biodiversity but also for sustaining the broader environmental health of the surrounding landscape.

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