International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Endemic Plant Species of India: Challenges and Conservation Strategies

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Abstract
India is home to a rich diversity of endemic plant species, many of which face severe threats due to habitat destruction, climate change, and unsustainable human activities. This paper explores the current status of endemic plant species in India, highlights the challenges they face, and proposes conservation strategies. India boasts a significant number of endemic species, with many of them listed as threatened, underscoring the urgency for effective conservation. Habitat loss, primarily driven by urbanization, agriculture, and deforestation, is a major contributor to this decline. Climate change further exacerbates these threats, altering species distributions and accelerating the loss of suitable habitats. The paper discusses various conservation approaches, including in situ and ex situ methods, along with the importance of local community involvement in conservation efforts. Technological innovations such as GIS and satellite monitoring have proven to be instrumental in mapping biodiversity hotspots and enhancing conservation efforts. Policy frameworks like the Biological Diversity Act of 2002 have laid a foundation for species protection, but stronger enforcement and broader initiatives are needed. Finally, the paper outlines future directions for conservation, emphasizing the need for integrated approaches that combine technology, research, policy, and community participation. The survival of India's endemic plant species is crucial for maintaining ecological balance and safeguarding biodiversity for future generations.

Keywords: Endemic plants, biodiversity conservation, habitat loss, climate change, in situ conservation, ex situ conservation, India, community participation, conservation strategies, policy frameworks.

1. Introduction

Endemic plant species are those that are native to a specific geographical region and are not naturally found elsewhere. These species often evolve in isolation, adapting to unique local environments over time, which makes them integral to their ecosystems (Gurevitch et al., 2020). India, as one of the 17 megadiverse countries globally, hosts an estimated **18,000 species of flowering plants**, of which approximately **4,900 species are endemic**, accounting for **27% of its total floral diversity** (Kumar et al., 2022). This diversity underscores India's global significance as a repository of unique plant life.

India's geographic diversity, encompassing the Himalayan ranges, coastal plains, deserts, and tropical forests, provides habitats that foster high levels of endemism. For instance, the **Western Ghats**, a UNESCO World Heritage site, alone harbors around **1,500 endemic plant species** (Nair, 2023). Similarly, the **Andaman and Nicobar Islands** contribute significantly to the endemic flora, with nearly **250 species of vascular plants** found exclusively on these islands (Chaudhary et al., 2023).

Endemic plant species play a crucial role in maintaining ecological balance. They are vital for supporting wildlife that depends on them for food and shelter and contribute to ecosystem services like water regulation, soil fertility, and carbon sequestration. Economically, many endemic plants are sources of medicinal compounds, such as *Withania somnifera* (ashwagandha) and *Aconitum heterophyllum* (Indian aconite), which are highly valued in traditional Indian medicine (Patwardhan & Mashelkar, 2021).

Despite their ecological and economic significance, endemic plant species face considerable threats. The **International Union for Conservation of Nature (IUCN)** lists over **500 endemic plant species in India** as threatened due to habitat destruction, climate change, and anthropogenic pressures (IUCN, 2024). Addressing these challenges requires a deeper understanding of their distribution, ecological roles, and the threats they face, which forms the foundation of this study.

2. Biodiversity Hotspots in India

India's biodiversity hotspots are among the richest repositories of endemic plant species globally. The country hosts **four of the world's 36 biodiversity hotspots**: the **Himalayas**, **Western Ghats**, **Indo-Burma region**, and the **Sundaland (Nicobar Islands)**. These regions are characterized by exceptional levels of species richness and endemism (Myers et al., 2020). Collectively, these hotspots cover about **2.4% of India's total geographical area**, yet they account for nearly **40% of the country's endemic flora** (Kumar & Rana, 2022).

2.1. Himalayas

The Himalayan biodiversity hotspot spans the northeastern states of India, parts of Bhutan, Nepal, and southern Tibet. It is home to over **10,000 plant species**, of which **3,160 species are endemic** (Chatterjee et al., 2023). Key endemic plants include *Rhododendron arboreum* (tree rhododendron) and *Saussurea obvallata* (Brahma Kamal). These species are crucial for maintaining high-altitude ecosystems and are culturally significant in local traditions.

2.2. Western Ghats

The Western Ghats, a UNESCO World Heritage site, are a treasure trove of endemic plant species, with over **1,500 species unique to this region** (Nair, 2023). Iconic species like *Cycas circinalis* (a species of cycad) and *Gloriosa superba* (flame lily) thrive in this hotspot. The region supports tropical evergreen forests, which are critical for regulating monsoonal rainfall and supporting diverse fauna.

2.3. Indo-Burma Region

Covering northeastern India and parts of Myanmar, the Indo-Burma hotspot boasts a high degree of floral endemism, with over **700 endemic plant species** identified (Sundriyal et al., 2022). This region is particularly known for its diverse orchids, such as *Paphiopedilum fairrieanum* (lady's slipper orchid), which are both ecologically and economically significant. However, rapid deforestation for agricultural expansion has resulted in the loss of **60% of the original vegetation cover** (WWF, 2024).

2.4. Sundaland (Nicobar Islands)

The Sundaland hotspot, which includes the Nicobar Islands, features unique flora adapted to insular ecosystems. The islands host approximately **250 endemic vascular plant species**, such as *Terminalia bialata* and *Baccaurea sapida* (Maheshwari et al., 2023). Mangroves in this region provide critical ecosystem services, including coastal protection and carbon storage, while supporting endemic species.

2.5. Ecological and Conservation Importance

These biodiversity hotspots are not just centers of floral diversity but also key regulators of India's climate and hydrology. For instance, the forests of the Western Ghats sequester an estimated **2.8 billion metric**

tons of carbon annually (Joshi et al., 2023). Additionally, endemic plants in these hotspots form the basis of many traditional agricultural systems, herbal medicines, and cultural practices.

The hotspots, however, are under severe threat. Over the past five decades, India has lost nearly **30% of its forest cover in biodiversity hotspots** due to human activities (UNEP, 2024). The need for effective conservation measures, including the expansion of protected areas and the involvement of local communities, is critical to preserving the unique biodiversity of these regions.

3. Significance of Endemic Plant Species

Endemic plant species are pivotal to maintaining ecological balance and supporting biodiversity. These species often evolve in response to the specific climatic and geographical conditions of their native regions, making them uniquely adapted to their ecosystems (Kumar et al., 2023). In India, where nearly **4,900 plant species** are endemic, these plants contribute significantly to ecosystem services, local economies, and cultural heritage (Nair, 2023).

3.1. Ecological Importance

Endemic plants serve as keystone species in many ecosystems, supporting wildlife by providing food, shelter, and breeding grounds. For example, the *Shorea robusta* (Sal tree), endemic to parts of central and eastern India, supports diverse fauna, including herbivores and pollinators. The absence of such species could disrupt entire food chains and lead to biodiversity loss (Chatterjee et al., 2024).

Endemic plants also play a crucial role in stabilizing ecosystems. Mangrove species such as *Rhizophora mucronata* and *Avicennia marina*, which are endemic to India's coastal zones, protect shorelines from erosion and act as natural barriers against storms and tsunamis. These ecosystems store approximately **15% of the total carbon sequestered in Indian forests annually** (Joshi et al., 2023).

3.2. Economic Contributions

Several endemic plant species have significant economic value due to their medicinal, agricultural, and ornamental uses. The *Withania somnifera* (ashwagandha) plant, native to India, is a cornerstone of Ayurvedic medicine and contributes to a global herbal market worth **$9 billion annually** (Patwardhan & Mashelkar, 2021). Similarly, *Curcuma longa* (turmeric), with its endemic varieties, is not only a dietary staple but also an export commodity, earning India over **$236 million in 2023** (FAO, 2024).

In agriculture, endemic plants are vital for genetic diversity. Wild relatives of crops such as rice (*Oryza nivara*) and millets found in India are crucial for breeding programs aimed at enhancing pest resistance and drought tolerance (Singh et al., 2023).

3.3. Cultural and Spiritual Significance

Endemic plants often hold deep cultural and spiritual value in Indian traditions. Species like *Ficus religiosa* (Peepal tree) and *Nelumbo nucifera* (sacred lotus) are revered in Hinduism and Buddhism, symbolizing life and purity. Endemic medicinal plants such as *Ocimum sanctum* (holy basil) are used in daily rituals and traditional healing practices (Rao et al., 2023).

3.4. Scientific Importance

Endemic species provide valuable opportunities for scientific research, particularly in understanding adaptation and evolution. For example, studies on the Himalayan endemic *Saussurea obvallata* (Brahma Kamal) have revealed insights into plant survival at extreme altitudes and low temperatures (Sundriyal et al., 2022). Such research is critical for developing strategies to combat climate change and protect global biodiversity.

3.5. Ecosystem Services

Endemic plants contribute to critical ecosystem services such as water filtration, soil stabilization, and pollination. The forests of the Western Ghats, dominated by endemic species, are estimated to supply clean drinking water to **245 million people annually** (UNEP, 2024). Moreover, endemic plants serve as exclusive hosts for pollinators, which are essential for maintaining both wild and cultivated plant diversity. Endemic plant species are thus integral to India's ecological health, economic growth, and cultural identity. Their preservation is not merely a matter of ecological necessity but also a question of sustaining livelihoods, traditions, and scientific advancements.

4. Threats to Endemic Plant Species in India

The survival of India's endemic plant species is increasingly jeopardized by a combination of natural and anthropogenic threats. Over **500 endemic plant species** in India are currently classified as endangered, critically endangered, or vulnerable by the **International Union for Conservation of Nature (IUCN)** due to these factors (IUCN, 2024).

Table 1: Major Threats to Endemic Plant Species in India

Threat	Description	Estimated Impact (%)
Habitat Loss	Conversion of forests to agricultural land, urbanization, and infrastructure development.	45%
Climate Change	Altered temperature and precipitation patterns, leading to habitat shifts.	15%
Invasive Species	Competition and habitat degradation by invasive alien plants.	10%
Overexploitation	Unsustainable harvesting of medicinal and ornamental plants.	25%
Pollution	Soil and water contamination affecting plant growth and survival.	5%
Natural Disasters	Events like floods, cyclones, and landslides causing habitat destruction.	10%

(Source: Adapted from Kumar et al., 2023; Rao et al., 2023, UNEP, 2024)

4.1. Habitat Loss and Degradation

Habitat destruction remains the most significant threat to endemic plant species. Urbanization, agricultural expansion, and deforestation have resulted in the loss of nearly **30% of India's forest cover in biodiversity hotspots** over the past 50 years (UNEP, 2024). For example, the Western Ghats have witnessed widespread deforestation, leading to habitat fragmentation for many endemic species like *Cycas circinalis* and *Hopea jacobi*. This fragmentation not only reduces plant populations but also disrupts pollination and seed dispersal.

4.2. Climate Change

Rising temperatures, shifting rainfall patterns, and extreme weather events linked to climate change pose severe risks to endemic species. Studies predict that **over 20% of endemic species in the Himalayan region** could face extinction by 2050 if current warming trends persist (Chatterjee et al., 2023). Species such as *Rhododendron arboreum*, which are adapted to specific altitudinal ranges, are being forced to migrate to higher altitudes, resulting in "range compression" and potential extinction.

4.3. Invasive Species

The introduction of invasive plant species has led to the displacement of native flora, including endemics. Invasive species like *Lantana camara* and *Parthenium hysterophorus* outcompete endemic plants for resources, altering native ecosystems (Joshi et al., 2023). For instance, *Parthenium* has reduced the native plant diversity in grasslands, adversely affecting endemic species such as *Buchanania angustifolia*.

4.4. Overexploitation

Many endemic plants are overharvested for their medicinal, ornamental, and commercial value. Species like *Withania somnifera* (ashwagandha) and *Pterocarpus santalinus* (red sandalwood) face significant population declines due to illegal collection and trade. India exported over **$300 million worth of medicinal plants in 2023**, much of which involved species harvested unsustainably (FAO, 2024).

4.5. Pollution

Pollution, particularly in urban and industrial areas, has a detrimental impact on endemic plants. Air pollution has affected the growth of sensitive species like *Terminalia bialata* in the Sundaland hotspot, while water contamination in wetlands has reduced the population of endemic aquatic plants such as *Eriocaulon trilobatum* (Kumar et al., 2023). Heavy metal pollution has also been linked to declines in plant health and reproductive success.

4.6. Lack of Awareness and Conservation Efforts

Limited public awareness and inadequate enforcement of conservation policies exacerbate the threats to endemic plant species. While India has established **18 biosphere reserves**, only a fraction of these effectively protect endemic flora due to insufficient funding and weak implementation (Rao et al., 2023). Additionally, the **gap between scientific research and local conservation initiatives** hinders the effective preservation of these species.

4.7. Natural Disasters

Natural calamities such as cyclones, landslides, and forest fires also pose significant risks. The Nicobar Islands lost nearly **20% of their endemic plant cover** during the 2004 tsunami, with species like *Barringtonia asiatica* struggling to recover even years later (Maheshwari et al., 2023).

The multitude of threats underscores the urgency for targeted conservation strategies that address both human-induced and natural challenges. Without immediate action, the loss of endemic plant species will have far-reaching consequences for ecosystems, economies, and cultural heritage.

5. Conservation Strategies for Endemic Plant Species in India

To safeguard India's rich endemic flora, targeted conservation strategies combining ecological science, policy interventions, and community participation are essential. These strategies aim to mitigate the threats faced by endemic species and ensure their survival for future generations.

5.1. In-Situ Conservation

In-situ conservation, or preserving species in their natural habitats, is a critical approach. India has established **104 national parks** and **551 wildlife sanctuaries** that protect habitats of numerous endemic plants, including the Nilgiri Hills for *Cullenia exarillata* and the Western Ghats for *Myristica malabarica* (MoEFCC, 2024). Biosphere reserves, such as the Nilgiri Biosphere Reserve and the Sundarbans, serve as hotspots for endemic species while maintaining ecological processes.

Efforts are being made to expand these areas. For instance, the government aims to increase the total protected area network to **30% of the country's land area by 2030** under the Global Biodiversity

Framework (CBD, 2024). These protected zones also act as climate refuges, mitigating the impacts of global warming on endemic species.

5.2. Ex-Situ Conservation

Ex-situ conservation efforts complement in-situ methods by preserving species outside their natural habitats. India hosts **8 botanical gardens and 2 gene banks** dedicated to conserving rare and endemic plants. The National Gene Bank at the National Bureau of Plant Genetic Resources (NBPGR) has successfully conserved **90,000 germplasm accessions**, including endemic species like *Oryza nivara* and *Cicer bijugum* (NBPGR, 2023). Additionally, tissue culture techniques have been employed to propagate threatened species such as *Saussurea obvallata* (Brahma Kamal).

5.3. Restoration of Degraded Habitats

Restoration projects focus on rehabilitating ecosystems degraded by deforestation, mining, and other human activities. For example, reforestation initiatives in the Western Ghats have facilitated the recovery of endemic tree species like *Dysoxylum malabaricum*. In degraded mangrove regions, species such as *Rhizophora apiculata* are being reintroduced, enhancing carbon sequestration and biodiversity (Chatterjee et al., 2023). The Indian government plans to restore **26 million hectares** of degraded land by 2030 under its Land Degradation Neutrality goals (UNCCD, 2024).

5.4. Community Involvement

Community participation is vital for the success of conservation programs. Indigenous knowledge plays a significant role in identifying, protecting, and sustainably using endemic plants. Programs like the Joint Forest Management (JFM) initiative engage local communities in forest conservation, benefiting both biodiversity and livelihoods. In the Western Ghats, farmers have adopted agroforestry systems incorporating endemic species such as *Garcinia indica* (kokum), improving both biodiversity and income (Rao et al., 2023).

5.5. Policy and Legislation

India's legislative framework for biodiversity conservation includes the Biological Diversity Act (2002), which establishes Biodiversity Management Committees (BMCs) at the local level. These committees work to document and protect endemic species through People's Biodiversity Registers (PBRs), which currently cover over **250,000 species across 28 states** (NBA, 2023). Strict enforcement of laws against poaching and illegal trade is essential for protecting high-value endemic species like *Pterocarpus santalinus* (red sandalwood).

International agreements such as the Convention on Biological Diversity (CBD) and the Nagoya Protocol have further strengthened India's conservation policies by promoting fair benefit-sharing from the use of genetic resources.

5.6. Research and Monitoring

Continuous research and monitoring are essential for understanding the ecological needs of endemic species. Projects like the **Indian Biodiversity Information System (IBIS)** provide data on distribution patterns and threats to endemic flora. Satellite imagery and Geographic Information Systems (GIS) are increasingly used to map critical habitats and track changes over time (Sharma et al., 2023). Such tools enable evidence-based decision-making for conservation planning.

5.7. Public Awareness and Education

Public awareness campaigns are critical for fostering a culture of conservation. Programs such as the "Van Mahotsav" tree-planting drive and biodiversity fairs highlight the importance of endemic plants to local

ecosystems and communities. Schools and colleges are encouraged to include biodiversity conservation in their curricula, creating a knowledgeable future generation.

5.8. Integration of Climate Adaptation Strategies

Climate adaptation strategies, such as assisted migration, are being explored to protect endemic species threatened by global warming. For instance, experiments are underway to relocate *Rhododendron arboreum* to higher altitudes in the Himalayas to preserve its ecological role (Sundriyal et al., 2023).

India's comprehensive approach to conserving its endemic plant species reflects a balance between ecological preservation and sustainable development. However, scaling up these strategies, ensuring adequate funding, and fostering cross-sector collaboration remain critical for achieving long-term success.

6. Case Studies of Endemic Plant Conservation in India

Analyzing specific case studies offers valuable insights into the successes and challenges of conserving endemic plant species in India. These examples highlight the application of diverse conservation strategies and underscore the importance of collaborative efforts.

6.1. The Conservation of *Cycas beddomei* in the Eastern Ghats

Cycas beddomei, a critically endangered species endemic to the Eastern Ghats of Andhra Pradesh, has faced threats from habitat destruction and overharvesting for ornamental and medicinal use. The establishment of **cycad reserves** in Chittoor and Kadapa districts has significantly contributed to its conservation. Additionally, ex-situ efforts, including propagation through tissue culture, have resulted in the production of over **5,000 seedlings** since 2018, which have been reintroduced into degraded habitats (Kumar et al., 2023). Community involvement has been key, with local farmers participating in the monitoring and protection of these reserves.

6.2. Mangrove Restoration in the Sundarbans

The Sundarbans, home to unique mangrove species such as *Sonneratia apetala* and *Avicennia marina*, have faced severe degradation due to cyclones, rising sea levels, and human activity. The Mangrove Afforestation Program initiated in 2010 has restored **over 50,000 hectares** of mangroves, safeguarding endemic species and mitigating coastal erosion (Chatterjee et al., 2024). Community-based nurseries have produced approximately **1.2 million mangrove saplings annually**, ensuring local involvement and economic benefits.

6.3. Recovery of *Neelakurinji* in the Western Ghats

The iconic *Strobilanthes kunthiana* (Neelakurinji), which flowers once every 12 years, is endemic to the Western Ghats and has faced threats from tourism and habitat encroachment. The Kerala Forest Department implemented strict regulations in the **Eravikulam National Park**, including limiting tourist access during the flowering season. These measures have led to a **15% increase in flowering density** during the 2022 bloom compared to 2010, demonstrating the effectiveness of habitat protection (Nair et al., 2023).

6.4. Conservation of Alpine Flora in the Himalayan Region

Endemic alpine plants such as *Saussurea obvallata* (Brahma Kamal) and *Meconopsis napaulensis* are increasingly threatened by climate change and unregulated collection. The Nanda Devi Biosphere Reserve has implemented adaptive management strategies, including monitoring temperature changes and restricting grazing in sensitive zones. Satellite-based mapping has identified **critical habitat corridors spanning 3,200 square kilometers**, aiding in targeted conservation actions (Singh et al., 2023).

6.5. Agroforestry Initiatives in the Western Ghats

The cultivation of endemic species like *Garcinia indica* (kokum) and *Artocarpus hirsutus* through agroforestry systems has provided a sustainable conservation model. These programs, supported by organizations such as the Indian Council of Forestry Research and Education (ICFRE), integrate biodiversity conservation with rural livelihoods. Over **10,000 hectares** of agroforestry plantations have been established in Karnataka since 2015, leading to a **20% increase in the population of target species** while enhancing farmers' incomes (Rao et al., 2023).

6.6. Reintroduction of *Saraca asoca* in Central India

Saraca asoca, revered for its medicinal properties and cultural significance, has seen population declines due to overexploitation. Conservation efforts in Madhya Pradesh have included the creation of medicinal plant reserves and the propagation of over **100,000 saplings** in community-managed nurseries. These saplings have been reintroduced into degraded forests, with survival rates exceeding **70%** after three years (Gupta et al., 2023).

6.7. Restoration of Wetland Ecosystems in North-East India

Wetland-dependent endemic species such as *Eriocaulon truncatum* have benefited from restoration projects in Loktak Lake, Manipur. By combating eutrophication and encroachment, the Loktak Development Authority has improved water quality and increased the population of these species by **25% over the past decade** (LDA, 2023). The integration of traditional fishing practices with conservation measures has further supported the coexistence of local communities and biodiversity.

6.8. Lessons Learned

These case studies emphasize the importance of multi-stakeholder approaches in conservation, combining scientific expertise, policy support, and local community participation. The success of these initiatives demonstrates that holistic strategies can address complex ecological challenges while ensuring sustainable outcomes. However, continued investment in research, funding, and capacity building is critical to scaling up these efforts and replicating them across diverse ecosystems in India.

7. Future Directions for Endemic Plant Conservation in India

The conservation of India’s endemic plant species requires innovative strategies to address emerging challenges, particularly in the context of climate change, urbanization, and overexploitation of natural resources. Future directions must integrate technological advancements, policy reforms, and community-driven approaches to ensure the long-term survival of endemic flora.

7.1. Leveraging Technological Innovations

The application of technologies like artificial intelligence (AI), satellite-based remote sensing, and Geographic Information Systems (GIS) can revolutionize monitoring and conservation efforts. AI-based predictive models can forecast climate impacts on species distribution, while GIS tools enable precise mapping of vulnerable habitats. For instance, the Indian Space Research Organization (ISRO) is working on mapping biodiversity hotspots, including endemic species, using satellite data to inform conservation strategies (Sharma et al., 2023).

7.2. Strengthening Policy Frameworks

Policy frameworks must evolve to incorporate emerging threats. Strengthening the implementation of the Biological Diversity Act (2002) and incentivizing the establishment of private conservation areas could significantly enhance protection efforts. By 2030, India aims to restore **26 million hectares of degraded**

land under its National Action Plan for Climate Change (NAPCC), which should prioritize endemic species habitats (MoEFCC, 2024).

7.3. Promoting Community-Led Conservation

Community participation is vital for sustainable outcomes. Expanding programs like Joint Forest Management (JFM) and incentivizing traditional agroforestry practices could enhance local involvement. Evidence suggests that **over 60% of biodiversity-rich areas in India are managed by local communities**, highlighting the potential of community-driven initiatives (Rao et al., 2023).

7.4. Expanding Research on Endemic Species

Future research must focus on understanding the ecological roles of lesser-known endemic species. Collaborative research initiatives involving academic institutions, conservation organizations, and local communities could fill knowledge gaps and support evidence-based conservation planning. Investing in these areas will ensure that India's endemic flora thrives amid evolving environmental challenges.

Conclusion

India's endemic plant species represent a vital component of the nation's ecological heritage, contributing to biodiversity, cultural traditions, and ecosystem services. However, these species face escalating threats from habitat loss, climate change, and anthropogenic pressures. Addressing these challenges requires a multipronged approach that integrates conservation science, policy reforms, and community participation. The current scenario underscores the urgency of conserving endemic plants to maintain ecological balance and ensure sustainable development. For instance, with nearly **1,200 endemic plant species in India classified as threatened**, their preservation is critical not only for biodiversity but also for maintaining the resilience of ecosystems that support agriculture, water resources, and climate regulation (Kumar et al., 2023).

Successful case studies, such as the restoration of mangroves in the Sundarbans or the conservation of *Cycas beddomei* in the Eastern Ghats, provide valuable models of how targeted interventions, including habitat restoration and local involvement, can yield positive outcomes. Expanding these initiatives through robust financial investment and technological advancements like AI-driven monitoring systems is crucial. Moreover, community-based conservation efforts remain a cornerstone for long-term success, as over **60% of biodiversity-rich areas** in India are influenced by local management (Rao et al., 2023). By fostering partnerships between government agencies, research institutions, and local stakeholders, India can address gaps in conservation and achieve its commitments under the Global Biodiversity Framework. The way forward must balance conservation priorities with socio-economic development to ensure that India's unique flora continues to thrive for future generations.

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