

## **STATUS OF PLANT DIVERSITY IN INDIA: CHALLENGES AND CONSERVATION EFFORTS**

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### **ABSTRACT**

India is well known for its abundant biodiversity, of which a substantial percentage is made up of plant species. A wide variety of plant species is found in the country's diverse ecosystems, which contribute significantly to the world's biodiversity. Plant diversity or the variety of plant species and ecosystems is vital to the health and sustainability of our planet and offers a multitude of ecological, economic and cultural benefits. Plants are essential to human well-being and the functioning of ecosystems, regulating climate, supporting agriculture and providing medicinal resources. As such, protecting plant diversity is essential for sustainable development and the survival of future generations. However, because of a variety of human activities and environmental variables, this biodiversity faces several problems. The aim of this paper is to examine the current status of plant diversity in India, the challenges it faces and the conservation initiatives being made to lessen these obstacles. This study offers insights into the significance of protecting plant diversity and describes practical conservation solutions by examining current research, efforts and policies.

**Keywords:** Plant diversity, biodiversity, conservation, protected areas.

### **INTRODUCTION**

*Biodiversity refers to the wide range of life forms found on our planet. Diversity in ecosystems, species and genes are all a part of it (Chandrakar, 2012). Keeping in the view of plants, Heywood and Watson (1995) defined plant diversity as "Plant diversity encompasses the variety and variability of plants, including genetic diversity, species diversity and ecosystem diversity, which are the fundamental components of biodiversity". Moreover, according to Groombridge and Jenkins (2002) "Plant diversity refers to the variability among living plants, including the diversity within species, between species and of ecosystems in which plants occur".*

India is one of the 17 mega biodiversity countries in the world (Mao *et al.* 2023). It is because such a diverse array of plant species is found in India's diverse ecosystems, which contribute significantly to the world's biodiversity. Plant diversity or the variety of plant species and ecosystems (**Table 1**), is vital to the health and sustainability of our planet and offers a multitude of ecological, economic and cultural benefits. Plants are essential to human well-being and the functioning of ecosystems, regulating climate, supporting agriculture and providing medicinal resources. As such, protecting plant diversity is essential for sustainable development and the survival of future generations.

#### **1. Present Status of Plant diversity in India:**

India constitutes about 2.4% of the Earth's terrestrial expanse, however it accounts for 7-8% of the global biodiversity, encompassing millions of plant and animal species (Bawa *et al.* 2021). The country has a remarkable variety of plant species, found in a range of habitats from tropical rainforests to alpine meadows. Because of the vast range of changes in climate, altitude, and ecological niches, India has a rich and diversified flora. According to Plant Discoveries-2022 of Botanical Survey of India (Mao *et al.* 2023)- approximately 55387 plant species have been identified and categorized in India many more are yet to be identified and described. This group, which makes up roughly 7% of all plant species worldwide, includes Angiosperms (22108), Gymnosperms (83), Pteridophytes

(1319), Bryophytes (2819), Lichens (3044), Fungi (15701), Algae (9035), and Virus/Bacteria (1278)(Fig 1). Approximately 28% of the flora in India is endemic to the Nation. According to a report of Botanical Survey of India, Kolkata under Ministry of Environment & Forest, Govt. of India (2024) - The plant diversity in India is majorly concentrated in the 4 biodiversity hotspots, namely Eastern Himalayas, Western Ghats (and Sri Lanka), Northeast India and Andaman Islands (Indo-Burma) and Nicobar Island (Sundaland) (**Table 2**), out of 34 biodiversity hotspots recognised in the world. However, numerous plant species have disappeared and habitats have deteriorated as a result of fast deforestation, habitat fragmentation, invasive species, and pollution. Many plant species are in risk of extinction if proper conservation measures are not put in place. These plants are classified as critically endangered or endangered.

Because of its varied climatic zones, geography and habitats, India is known worldwide as a hotspot for biodiversity, home to a remarkable range of plant species. India's ecosystems contain a wide variety of plant life, including indigenous and vulnerable species, from the lush tropical rainforests of the Western Ghats to the alpine meadows of the Himalayas.

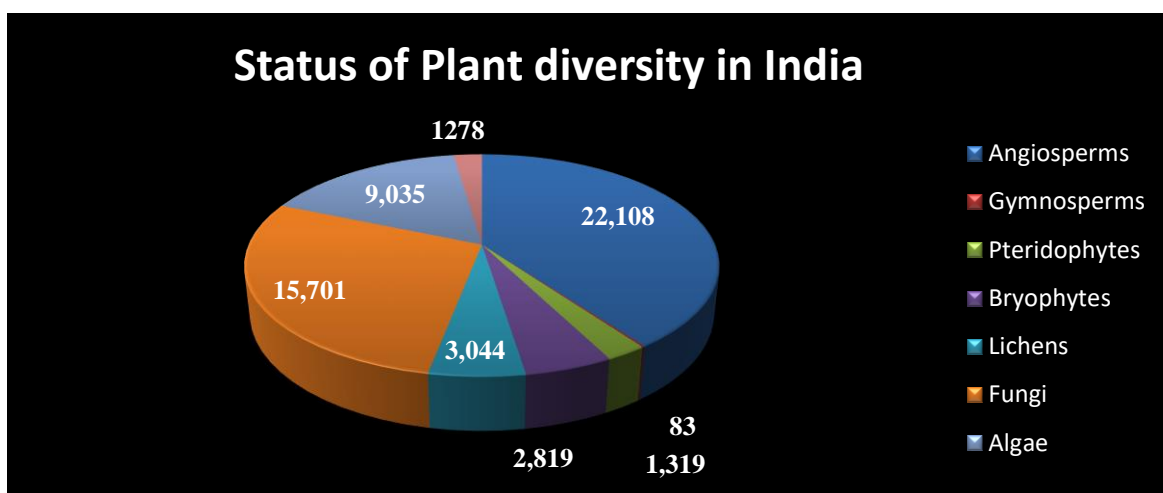


Fig 1:

Source: Mao *et al.* 2023, Arisdason, W. & Lakshminarasimhan, P. (2024) Botanical Survey of India, under Ministry of Environment & Forest, Govt. of India.

**Table 1: Different forms of Plant diversity in India:**

Form of Plant diversity	Description	Examples
Species Diversity	It denotes the diversity of various plant species within a specific area or environment.	Himalayan Rhododendrons ( <i>Rhododendron spp.</i> ), Sundarbans Mangrove Forests ( <i>Avicennia spp.</i> , <i>Rhizophora spp.</i> )
Genetic Diversity	It represents the variation within and among plant species at the genetic level. It includes differences in DNA sequences, alleles and genotypes.	Rice Varieties: Basmati rice, SonaMasuri, IR8 (Semidwarf rice), Mango Cultivars: Alphonso, Dasherri, Langra, Tea Varieties: Assam, Darjeeling, Nilgiri
Ecosystem Diversity	It includes the variety of different ecosystems and habitats in which plants develop and engage with other living things. India is home to several different types of ecosystems, such as grasslands, wetlands, forests, deserts, and coastal regions, all of which support distinct plant populations.	Western Himalayan Temperate Forests, Western Ghats Rainforests, Thar Desert Vegetation, Eastern Himalayan Broadleaf Forests, Coastal Mangrove Ecosystems

**Table 2: The Hotspots of Plant diversity in India:**

Hotspot	Description	Examples
Western Ghats	One of the eight hottest biodiversity hotspots in the world as well as a UNESCO World Heritage Site. Numerous plant species are supported by the tropical rainforests, montane forests and shola-grassland ecosystems found in the Western Ghats.	Kadamba ( <i>Neolamarekia cadamba</i> )
Eastern Himalayas	Another hotspot for biodiversity, distinguished by a wide variety of ecosystems such as subtropical forests, alpine meadows and temperate forests.	Himalayan Rhododendron ( <i>Rhododendron arboretum</i> ), Blue Poppy ( <i>Meconopsis grandis</i> ), Himalayan Yew ( <i>Taxus wallichiana</i> ), Sikkim Rhubarb ( <i>Rheum nobile</i> ), Blue Vanda ( <i>Vanda coerulea</i> ), Lady Slipper Orchids ( <i>Paphiopedilum spp.</i> )
Indo-Burma Region	This biodiversity hotspot, which includes sections of Northeast India, is among the world's most ecologically diverse regions. It encompasses a variety of habitat types, including wetlands, grasslands and tropical forests.	Wild Banana ( <i>Musa balbisiana</i> ), Pitcher Plants ( <i>Nepenthes spp.</i> ), <i>Rafflesia arnoldii</i> (World's largest flower), Khasi Pine ( <i>Pinus kesiya</i> )
Sundaland	A portion of the Andaman and Nicobar Islands, which are renowned for their exceptional plant diversity, are included in this hotspot. A variety of coral reefs, mangroves, and tropical rainforests can be found in Sundaland.	Andaman Padauk ( <i>Pterocarpus dalbergioides</i> )

## 2. Importance of Plant diversity:

Plants are very important for the survival of human beings as well as animals. They are the foundation of ecosystem, play the role of producers and manage the climate of the Earth. Here is a review of its significance:

- 2.1. Stability of Ecosystem:** Plant diversity is the base of ecosystem, which offers vital functions like carbon sequestration, nutrient cycling and soil fertility etc. Diverse plant communities help ecosystem remain stable and productive by increasing their ability to tolerate changes in the environment.
- 2.2. Supporting Life:** In both terrestrial and aquatic environments, plants are the primary producers and the base of the food chain. For numerous living organisms, including insects, birds, animals and even microbes, they offer food, shelter and habitat.
- 2.3. Source of Medicine:** Both traditional and modern medicines rely heavily on the bioactive chemicals found in a wide variety of plant species. Indigenous people used plant-derived medicines to treat a wide range of diseases. It is necessary to preserve the diversity of plants to keep options for new medical resources available and create new medicines.
- 2.4. Genetic variation:** A large pool of genetic variation found in plants is essential for breeding initiatives, agricultural development and environmental adaptation. Wild plant relatives can be used to improve the resilience and production of cultivated crops by incorporating useful qualities including disease resistance, drought tolerance and nutritional quality. Future generations will benefit from the preservation of priceless genetic resources.

**2.5. Climate Regulation:** Plants are essential for maintaining the Earth's climate through transpiration, which affects atmospheric moisture levels and photosynthesis, which sequesters carbon dioxide. As carbon sinks, wetlands, forests and other vegetated ecosystems absorb greenhouse gases and lower atmospheric carbon concentrations, so minimizing the effects of climate change.

**2.6. Economic Benefits:** Through a variety of ecosystem services, plant diversity significantly boosts economic development. Plant diversity provides essential economic resources such as agricultural products, textiles, timber and non-timber forest products. Additionally, ecotourism initiatives focused on a variety of ecosystems draw tourists, bring in money and open up job opportunities, all of which help to sustain local economies and way of life.

**2.7. Cultural and Aesthetic Value:** Across all human communities, plants are significant from a cultural, spiritual and aesthetic viewpoint. They play a significant role in religious rites, tradition, literature and the arts, influencing cultural identities and customs. Furthermore, varied plant landscapes offer people recreational opportunities and aesthetic pleasure, strengthening bonds with the natural world and enhancing overall wellbeing.

### 3. Challenges to Plant diversity:

India's rich plant diversity is under risk, despite its richness. With the fast growth of urbanization, industrial development, agriculture growth and expanding human population resulting in degradation, fragmentation and habitat destruction of biological resources (Agnihotriet *al.* 2020). One-third to one-four of the 1.7 million species currently living on Earth are projected to go extinct in the next years (Soni, 2024). Further, the conservation efforts are hampered by a number of issues. These include insufficient finance for conservation efforts, clashing interests between the development and conservation agendas and lack of awareness, unsustainable land use practices and inadequate legal protection. The main causes of biodiversity losses are:

**3.1. Habitat Loss and Degradation:** A major obstacle to India's plant diversity is the country's expanding agricultural sector, deforestation, urbanization and infrastructure development. There are less suitable habitats available for plant species as a result of habitat fragmentation.

**3.2. Invasive Species:** The biodiversity of native plants in India is seriously threatened by the introduction and spread of invasive species. It rejects the native species for existence and availability of the resources hence degrading the quality of the environment. They compete with native species for food and habitat. *Prosopis juliflora* and *Lantana camara* are two examples of invasive species that have expanded widely and offered difficulties for ecosystem management and biodiversity protection (Table 3).

**Table 3: Some common Invasive plant species found in India:**

<b>Invasive Plant Species</b>	<b>Area of Origin</b>	<b>Common Places Found in India</b>
<i>Ageratina adenophora</i>	Central and South America	Northeast India, Western Ghats, Eastern Himalayas
<i>Chromolaena odorata</i>	Tropical America	Northeast India, Western Ghats, Andaman and Nicobar Islands
<i>Eichhornia crassipes</i>	South America	Lakes, rivers, water bodies across India
<i>Eucalyptus spp</i>	Australia	Haryana, Gujarat, Tamil Nadu, Andhra Pradesh, Mysore, Kerala and Nilgiri Hill
<i>Hyptis suaveolens</i>	Central and South America	Western Ghats, Eastern Ghats, Northeast India

<i>Lantana camara</i>	Central and South America	Western Ghats, Eastern Ghats, Himalayan foothills
<i>Mikania micrantha</i>	Central and South America	Northeast India, Western Ghats, Andaman and Nicobar Islands
<i>Mimosa invisa</i>	Central and South America	Andaman and Nicobar Islands, Northeast India, Western Ghats
<i>Parthenium hysterophorus</i>	Americas	Throughout India, especially in disturbed areas
<i>Prosopis juliflora</i>	Central and South America	Rajasthan, Gujarat, Maharashtra, Karnataka
Water hyacinth ( <i>Eichhornia crassipes</i> )	South America	Lakes, rivers, water bodies across India

**3.3. Threatened & Endangered Species:** Many plant species found in India are classified as critically endangered or endangered on the IUCN Red List. Some important taxa like the Indian Ghost Tree (*Davidia involucrata*), the Pitcher Plant (*Nepenthes khasiana*) and the Indian Rhododendron (*Rhododendron arboreum*) are examples of threatened plant species (**Table 4**). In order to save these species from extinction and maintain genetic diversity, conservation initiatives are essential.

**Table 4: Some of the well-known threatened plant species of India:**

Common Name	Scientific Name	Location
Assam Catkin Yew	<i>Amentotaxus assamica</i>	Assam, Northeast India
Blue Vanda	<i>Vanda coerulea</i>	Northeast India
Brahma Kamal	<i>Saussurea obvallata</i>	Himalayas, Uttarakhand
Ebony Tree	<i>Diospyros nilagirica</i>	Western Ghats
Indian Podophyllum	<i>Podophyllum hexandrum</i>	Himalayas
Kuth	<i>Saussurea costus</i>	Kashmir Himalayas
Madhucainsignis	<i>Madhuca ninsignis</i>	Western Ghats, Karnataka
Malabar Mahogany	<i>Dysoxylum malabaricum</i>	Western Ghats, Kerala
Pitcher Plant	<i>Nepenthes khasiana</i>	Meghalaya, Northeast India
Red Sandalwood	<i>Pterocarpus santalinus</i>	Eastern Ghats, Andhra Pradesh
Sandalwood	<i>Santalum album</i>	Southern India
Saracaasoca	<i>Saraca asoca</i>	Throughout India
Siroi Lily	<i>Lilium mackliniae</i>	Manipur, Northeast India
Tree Fern	<i>Cyathea nilgirensis</i>	Western Ghats
Wild Orange	<i>Citrus indica</i>	Northeast India

**3.4. Climate Change:** India's plant diversity is facing more difficulties as an outcome of climate change. Plant distribution, phenology and ecosystem functioning are impacted by evolving climatic conditions, rising temperatures, modified precipitation patterns and extreme weather events. Particularly vulnerable habitats that are sensitive to climate change, such as wetlands, coastal ecosystems and Montana forests.

**3.5. Overexploitation and Unsustainable Harvesting:** Many plant species are in danger of going extinct due to overexploitation of plant resources for fuel wood, lumber, medicinal plants and other uses. Damage to habitats and unsustainable harvesting methods endanger important plant resources and upset natural equilibrium.

**3.6. Pollution and Contamination:** India's plant diversity is under risk due to pollution from mining, industrial processes, agriculture and urbanization. Plant health, plant reproduction and

ecosystem integrity are all negatively impacted by soil contamination, chemical pesticides and pollution of the air and water. In food webs, contaminants cause bioaccumulation and biomagnification as they build up in plant tissues.

**3.7. Lack of Public Engagement and Awareness:** Policymakers, stakeholders and the general public all have a poor awareness of the value of plant diversity, which makes conservation efforts difficult. Biodiversity conservation programmes depend on public engagement, education, awareness and communication.

**4. Conservation Efforts:** Plant diversity conservation has gotten less attention than animal conservation, may be because plants are less popular (Corlett, 2016). India has made notable progress in conserving plant diversity in spite of obstacles. To preserve plant and animal species, the nation has built a set-up of protected areas viz National Parks, Wildlife Sanctuaries and Biosphere Reserves. Furthermore, a number of legislative initiatives offer legal foundations for the conservation of biodiversity, including the Biological Diversity Act and the Wildlife Protection Act. Plant diversity is also preserved via programs including afforestation, community-based conservation efforts and scientific study. In order to preserve plant diversity in India, conservation efforts are broad and involve a range of stakeholders, including local populations, government agencies, non-governmental organizations (NGOs), researchers and civil society. An outline of important conservation efforts is provided below:

**4.1. Network of Protected Areas:** To preserve plant diversity and protect vital habitats, India has set up a network of protected areas (Table 5). These protected areas offer vital ecosystem services and act as havens for threatened plant species. These are grouped into two broad categories- In-situ & Ex-situ Conservation. In-situ conservation refers to the conservation of ecosystems and natural habitats, ensuring that plant species thrive in their natural environments which include National Parks, Wildlife Sanctuaries and Biosphere Reserves (Table 6). Ex-situ conservation refers to the conservation of plant species outside their natural habitats. This method is employed when in-situ conservation alone is not sufficient to protect plant species that are on the verge of extinction or are difficult to conserve in their natural habitat. Ex-situ conservation includes Botanical Gardens, Seed Banks, Field Gene Banks, Cryopreservation etc (Table 7, 8 & 9). Both in-situ and ex-situ conservation strategies are critical in preserving India's rich plant diversity, ensuring that species are protected in their natural habitats and also safeguarded for future generations through scientific methods.

**Table 5: Some Protected Areas of Plant diversity in India:**

Conservation Area	City	State	Plant Species Conserved
Bandhavgarh National Park	Umariya	Madhya Pradesh	<i>Madhuca longifolia</i> , <i>Pterocarpus marsupium</i> , <i>Buchanania lanzan</i> , <i>Cassia fistula</i>
Corbett National Park	Ramnagar	Uttarakhand	<i>Salix tetrasperma</i> , <i>Taxodium distichum</i> , <i>Butea monosperma</i> , <i>Boswellia serrata</i>
Eastern Ghats	Visakhapatnam	Andhra Pradesh	<i>Syzygium cumini</i> , <i>Pterocarpus marsupium</i> , <i>Wrightia tinctoria</i> , <i>Cleistanthus collinus</i>
Gir National Park	Junagadh	Gujarat	<i>Acacia nilotica</i> , <i>Prosopis cineraria</i> , <i>Salvadora persica</i> , <i>Ziziphus mauritiana</i>

Himalayan National Parks	Dehradun	Uttarakhand	<i>Rhododendron spp.</i> , <i>Cedrus deodara</i> , <i>Taxus wallichiana</i> , <i>Saussurea obvallata</i>
Jim Corbett National Park	Nainital	Uttarakhand	<i>Shorea robusta</i> , <i>Terminalia arjuna</i> , <i>Boswellia serrata</i> , <i>Ficus religiosa</i>
Kanha National Park	Mandla	Madhya Pradesh	<i>Diospyros melanoxylon</i> , <i>Terminalia chebula</i> , <i>Anogeissus latifolia</i> , <i>Lagerstroemia parviflora</i>
Kaziranga National Park	Golaghat	Assam	<i>Elephant grass (Saccharum ravennae)</i> , <i>Giant bamboo (Dendrocalamus hamiltonii)</i> , <i>Acacia catechu</i> , <i>Arundo donax</i>
Keoladeo National Park	Bharatpur	Rajasthan	<i>Typha elephantina</i> , <i>Nymphaea nouchali</i> , <i>Phragmites karka</i> , <i>Acacia nilotica</i>
Manas National Park	Barpeta	Assam	<i>Aquilaria malaccensis</i> , <i>Shorea robusta</i> , <i>Aphanamixis polystachya</i> , <i>Dillenia indica</i>
Nagarhole National Park	Kodagu	Karnataka	<i>Tectona grandis</i> , <i>Terminalia tomentosa</i> , <i>Pterocarpus marsupium</i> , <i>Lagerstroemia microcarpa</i>
Nilgiri Biosphere Reserve	Ooty	Tamil Nadu	<i>Strobilanthes kunthianus</i> , <i>Rhopalostylis sapida</i> , <i>Vanda thwaitesii</i> , <i>Cycas spp.</i>
Pench National Park	Seoni	Madhya Pradesh	<i>Butea monosperma</i> , <i>Terminalia bellirica</i> , <i>Embllica officinalis</i> , <i>Bombax ceiba</i>
Periyar National Park	Thekkady	Kerala	<i>Diospyros ebenum</i> , <i>Cinnamomum verum</i> , <i>Artocarpus heterophyllus</i> , <i>Ficus religiosa</i>
Ranthambore National Park	SawaiMadhopur	Rajasthan	<i>Commiphora wightii</i> , <i>Terminalia arjuna</i> , <i>Anogeissus pendula</i> , <i>Berberis aristata</i>
Sariska National Park	Alwar	Rajasthan	<i>Acacia leucophloea</i> , <i>Cassia fistula</i> , <i>Prosopis cineraria</i> , <i>Anogeissus pendula</i>
Silent Valley National Park	Mannarkkad	Kerala	<i>Mesua ferrea</i> , <i>Cinnamomum verum</i> , <i>Dillenia indica</i> , <i>Elaeocarpus serratus</i>
Sundarbans National Park	Kolkata	West Bengal	<i>Avicennia marina</i> , <i>Heritiera fomes</i> , <i>Nypa fruticans</i> , <i>Rhizophora mucronata</i>
Tadoba National Park	Chandrapur	Maharashtra	<i>Boswellia serrata</i> , <i>Madhuca indica</i> , <i>Lagerstroemia parviflora</i> , <i>Butea monosperma</i>
Western Ghats	Coimbatore	Tamil Nadu	<i>Rhododendron arboreum</i> , <i>Dioscorea bulbifera</i> , <i>Vanda tessellata</i> , <i>Aerides multiflora</i>

**Table 6: Some In-situ conservation methods of Plant diversity in India:**

In-situ Conservation Methods	Examples
<b>National Parks</b>	1. Kaziranga National Park, Assam 2. Jim Corbett National Park, Uttarakhand 3. Sundarbans National Park, West Bengal 4. Bandhavgarh National Park, Madhya Pradesh
<b>Wildlife Sanctuaries</b>	1. Periyar Wildlife Sanctuary, Kerala 2. Sariska Wildlife Sanctuary, Rajasthan 3. Manas Wildlife Sanctuary, Assam 4. Mudumalai Wildlife Sanctuary, Tamil Nadu
<b>Biosphere Reserves</b>	1. Nilgiri Biosphere Reserve, Tamil Nadu 2. Nanda Devi Biosphere Reserve, Uttarakhand 3. Gulf of Mannar Biosphere Reserve, Tamil Nadu 4. Sunderban Biosphere Reserve, West Bengal
<b>Sacred Groves</b>	1. Khasi and Jaintia Hills, Meghalaya 2. Kodagu District, Karnataka 3. Aravalli Hills, Rajasthan 4. Western Ghats, Maharashtra and Kerala
<b>Reserve Forests</b>	1. Simlipal Reserve Forest, Odisha 2. Gir Reserve Forest, Gujarat 3. Dandeli Reserve Forest, Karnataka 4. Seshachalam Reserve Forest, Andhra Pradesh

**Table 7: Some Ex-situ conservation methods of Plant diversity in India:**

Ex-situ Conservation Methods	Examples	Description
<b>Botanical Gardens</b>	1. Lloyd Botanic Garden, Darjeeling 2. Indian Botanic Garden, Howrah 3. Lalbagh Botanical Garden, Bangalore 4. Acharya Jagadish Chandra Bose Indian Botanic Garden, Kolkata	Large gardens for conservation and education that are home to a wide range of plant species, including rare and endangered ones.
<b>Seed Banks</b>	1. National Bureau of Plant Genetic Resources (NBPGR), New Delhi 2. ICRISAT Gene Bank, Hyderabad 3. MSSRF Community Seed Bank, Chennai 4. Forest Research Institute (FRI) Seed Bank, Dehradun	Establishments that retain seeds of different plant species for the purpose of maintaining genetic diversity and utilizing them in future breeding and restoration events.
<b>Field Gene Banks</b>	1. Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow 2. Rubber Research Institute of India, Kottayam 3. National Research Centre for Agroforestry, Jhansi	Preserves live plant collections in fields in order to protect the genetic resources of economically significant plants as well as those of their wild relatives.
<b>Cryopreservation</b>	1. National Bureau of Plant Genetic Resources (NBPGR), New Delhi 2. Institute of Himalayan Bioresource Technology (IHBT), Palampur	Preserves plant germplasm-seeds, embryos, and tissues by employing extremely low temperatures (-196°C)



	3. ICAR-National Dairy Research Institute, Karnal 4. Regional Centre for Biotechnology, Faridabad	that cannot be preserved by normal means.
<b>In Vitro Conservation</b>	1. Tissue Culture and Cryopreservation Unit, NBPGR 2. ICAR-Indian Agricultural Research Institute (IARI), New Delhi 3. Kerala Forest Research Institute, Peechi	Uses tissue culture methods to cultivate and preserve plant tissues for conservation and propagation in a sterile, controlled environment.
<b>Arboreta</b>	1. Indian Council of Forestry Research and Education (ICFRE) Arboretum, Dehradun 2. Lalbagh Botanical Garden, Bangalore 3. Aravalli Biodiversity Park, Delhi 4. Tropical Botanic Garden and Research Institute (TBGRI), Thiruvananthapuram	Collections of specific trees and plants that are kept up for scientific study, education and conservation.
<b>DNA Banks</b>	1. Centre for Cellular and Molecular Biology (CCMB), Hyderabad 2. Rajiv Gandhi Centre for Biotechnology (RGCB), Thiruvananthapuram 3. National Institute of Plant Genome Research (NIPGR), New Delhi	Preserves genetic material- such as DNA samples from different plant species for breeding, genetic research and conservation.

**Table 8: Botanical Gardens/Ex-situ conservatories under the control of Botanical Survey of India:**

S.No.	Name of Botanical Garden/Ex-situ conservatories	Total No. of Species conserved (approx.)	Area (Acres)
1	Acharya Jagdish Chandra Bose Indian Botanical Garden, Howrah (West Bengal)	1400	273
2	Botanical Garden of Indian Republic (BGIR), Noida (Uttar Pradesh)	900	163.79
3	Barapani Experimental Garden, Barapani & National Orchidarium, Shilong (Meghalaya)	750	25
4	Experimental Botanical Garden, Andaman & Nicobar Island, Dhanikari	250	70
5	Experimental Botanical Garden, Arunachal Regional Centre, Sankie view	200	110
6	Experimental Botanical Garden & National Orchidarium, Yercaud, (Tamil Nadu) under Southern Regional Centre, Coimbatore (A.P.)	1200	40
7	Experimental Botanical Garden, Western Regional Centre, Mundhwa, Pune (Maharashtra)	500	38
8	Experimental Botanical Garden, Sikkim & Himalayan Regional Centre, Gangtok	200	
9	Experimental Botanical Garden, Northen Regional Centre, Pauri	750	35
10	Experimental Botanical Garden, Northen Regional Centre, Khirsu		18
11	Experimental Botanical Garden, Northen Regional Centre, Dehradun (Uttarakhand)	350	5
12	Experimental Botanical Garden, Arid Zone Regional Centre, Dehradun	185	12
13	Experimental Botanical Garden, Central Circle, Allahabad (Uttar Pradesh)	600	7

Source: Botanical Survey of India (BSI), 2020.

**Table 9: Plant species conserved in some famous Herbarium of India:**

Name of Herbarium	No. of Plant Specimen conserved
The Central National Herbarium, Howrah	2,000,000 (2 million) specimens
Forest Research Institute, Dehradun	350,000 specimens
The National Botanic Gardens, Lucknow	260,000 specimens
Blatter Herbarium, St. Xavier's college, Fort Bombay	200,000 specimens

Source: Botanical Survey of India (BSI), 2020.

**4.2. Policy and Legal Frameworks:** The conservation of biodiversity, the preservation of habitats and the sustainable management of resources are all made possible by laws like the Biological Diversity Act, the Forest Conservation Act and the Wildlife Protection Act (**Table 10**). The Biological Diversity Act, 2002 (BDA) provides an umbrella legal framework to affirm our commitments for conservation and sustainable use of biodiversity in India (Meenakumari & Rana, 2017). These regulations, which attempt to stop the loss of biodiversity and advance sustainable development, control activities including hunting, logging, habitat damage and the trade in endangered species.

**Table 10: Outline of different policies and acts for the conservation of Plant diversity in India:**

Policy/Act	Year	Description
Wildlife Protection Act	1972	Protects wildlife, birds, and plants and their habitats. Controls hunting and trading.
Forest Conservation Act	1980	Regulates diversion of forest land for non-forest purposes. Aims to conserve forests and biodiversity.
National Forest Policy	1988	Emphasizes conservation, regeneration, and sustainable management of forests for ecological stability.
National Biodiversity Action Plan (NBAP)	2002	Aims to conserve biodiversity, identify threats, and prioritize conservation actions.
Biological Diversity Act	2002	Aims to conserve biological diversity, promote sustainable use of biological resources, and equitable benefit-sharing.
National Wildlife Action Plan	2002	Provides a framework for wildlife conservation, habitat management, and species recovery programs.
National Policy for Farmers	2007	Promotes conservation of traditional crop varieties and encourages sustainable agricultural practices.
National Agroforestry Policy	2014	Encourages agroforestry practices to enhance productivity, conserve biodiversity, and improve rural livelihoods.
National Bamboo Mission	2018	Promotes cultivation of bamboo for sustainable resource management, biodiversity conservation, and livelihoods.
National Afforestation Programme	Ongoing	Aims to increase forest cover, restore degraded lands, and promote biodiversity conservation through afforestation.

**4.3. Species-specific Conservation:** Through ex-situ conservation target endangered and threatened plant species. Plans for species-specific conservation provide top priority to safeguarding flagship species and keystone plant taxa, which are essential to the resilience and smooth operation of ecosystems.

- 4.4. Forest Conservation:** The main goals of forest conservation are to combat illicit logging and deforestation, restore degraded forest ecosystems and promote sustainable forest management. Agroforestry, community-based forest management, afforestation and reforestation are a few of the initiatives that help preserve Plant diversity, improve carbon sequestration and sustain livelihoods.
- 4.5. Indigenous Knowledge & Community-based Conservation:** It means involving local people in conservation efforts. The effectiveness of biodiversity conservation programmes in India depends on the engagement and participation of the community in conservation initiatives. It lies in the fact that indigenous groups have invaluable traditional knowledge about many plant species and their applications, which can help guide conservation efforts. Community-based conservation strategies give local people the capacity to preserve traditional knowledge, manage natural resources responsibly and preserve biodiversity.
- 4.6. Research and Monitoring:** For successful conservation programmes, scientific study, monitoring and recording of plant species are crucial. To evaluate plant diversity, Research Institutes, Universities and Botanical Gardens carry out surveys, taxonomic investigations and ecological research.
- 4.7. Public awareness and Education:** Public awareness and education initiatives serve to increase the general public, policymakers' and stakeholders' understanding of the significance of plant diversity, conservation challenges and sustainable practices. Campaigns, workshops, seminars and environmental education initiatives all support biodiversity conservation and responsible behaviour in the general public.
- 4.8. Sustainable Land Use Practices:** Sustainable land use strategies like agroforestry, organic farming, sustainable forestry, and habitat restoration reduce plant diversity threats. Integrated landscape management coordinates development and conservation.
- 4.9. International Collaboration:** India shares information, skills, resources and exchange knowledge on biodiversity conservation projects with International Organizations, Research Institutes and Agencies. Cooperation is made easier by international agreements like the Convention on Biological Diversity (CBD), Ramsar Convention on Wetlands and Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

## CONCLUSION

In conclusion, plant diversity is vital to the continuation of life on earth, the maintenance of ecosystem services and the development of human culture and well-being. India's rich plant diversity is under risk, despite its richness. Further, the conservation efforts are loaded by a number of issues including insufficient finance for conservation efforts, clashing interests between the development and conservation agendas and lack of awareness, unsustainable land use practices and inadequate legal protection. But, India has made notable progress in conserving plant diversity in spite of obstacles. The nation has built a set-up of protected areas along with a number of legislative initiatives for the conservation of biodiversity, including the Biological Diversity Act and the Wildlife Protection Act. Plant diversity is also preserved via programmes including afforestation, community-based conservation efforts and including a range of stakeholders such as local populations, government agencies, NGOs, researchers and civil society. India can protect its unique biological legacy for future generations by acknowledging the significance of plant diversity, addressing the root causes of biodiversity loss and putting strong conservation measures, research, innovation, education, raising public awareness and by integrating traditional knowledge with modern science and educating the public about biodiversity conservation.

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