

Biodiversity at a Crossroads

India's Critical Choices



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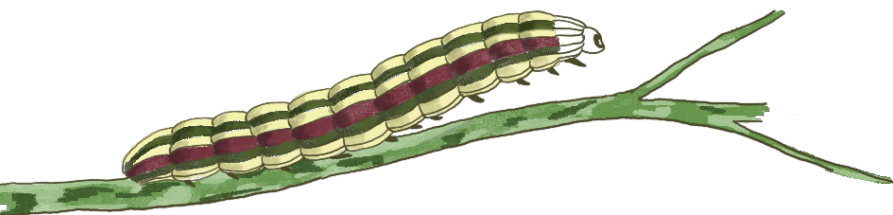


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If conservation of natural resources
goes wrong, nothing else will go right.

M.S. Swaminathan

BIODIVERSITY AT A CROSSROADS

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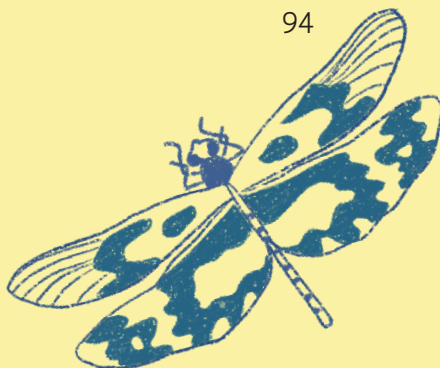
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Views expressed are those of the authors and do not necessarily reflect those of the institutions they are affiliated with.

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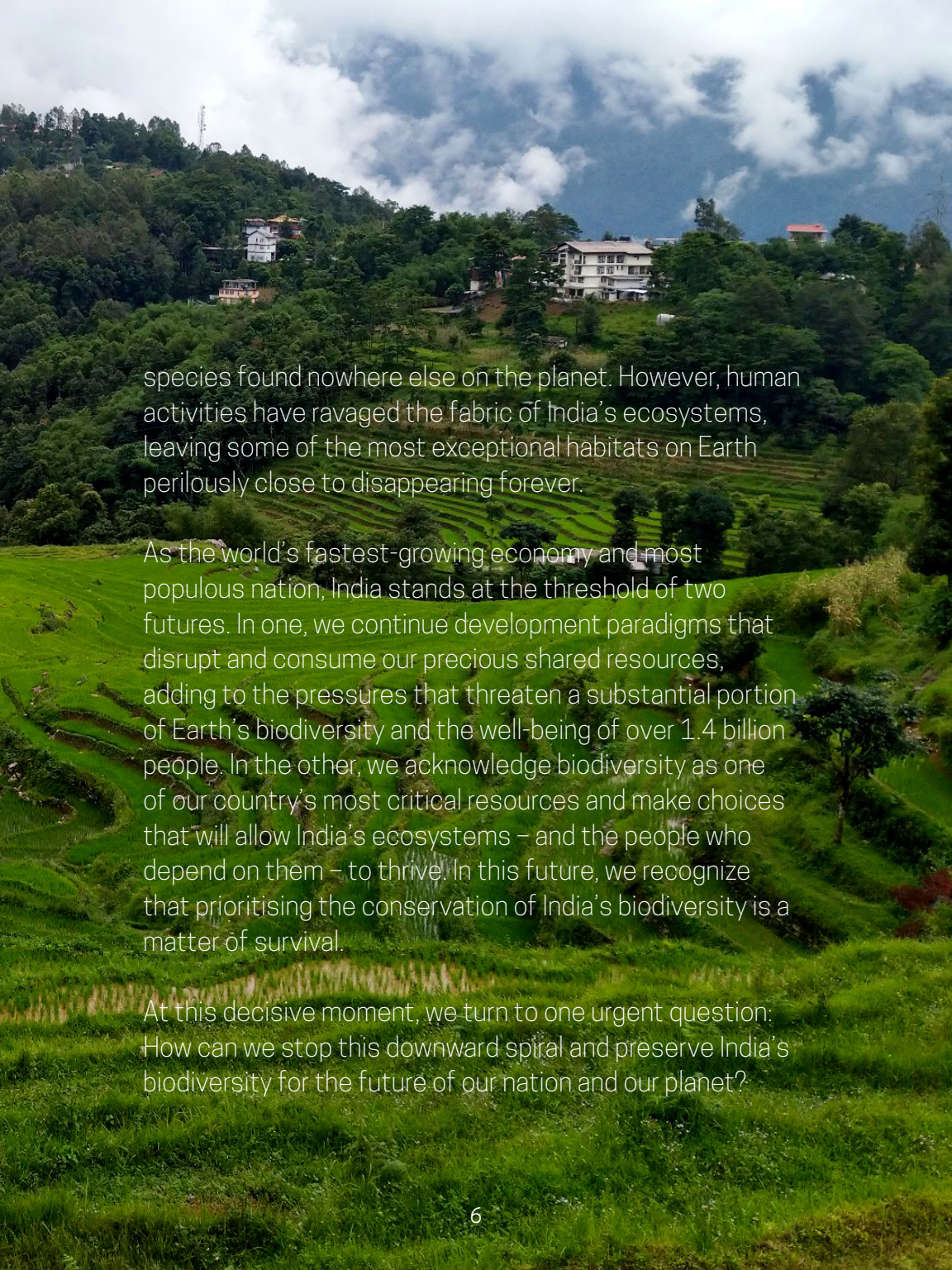


PREFACE

The book is an effort of the Biodiversity Collaborative, a group of institutions working on biodiversity science and conservation, to demonstrate and highlight the connections between conservation, sustainable use of biodiversity, and human well-being. The book is intended to draw the attention of policymakers and decision-makers as well as citizens to the choices we must make to shape the present and future of India's unique biodiversity.

Human beings have altered our environment to such an extent that the current era has been called the Anthropocene. A million living species are now threatened with extinction as a result of humanity's impacts on Earth's environment. This catastrophic loss of biodiversity risks destabilising natural ecosystems, impacting water security, livelihoods, food production, and eventually the economic and political stability of countries.

The Indian subcontinent's diverse topography and climatic regimes make it one of the most biodiverse regions in the world. With a mainland area of over 3.2 million square kilometres, India's rich ecosystems are home to many

A scenic view of a hillside with terraced rice fields, a small pond, and a few buildings under a cloudy sky. The foreground shows lush green grass and a small pond reflecting the sky. The middle ground features terraced rice fields and a few buildings. The background shows a forested hillside with a few buildings and a cloudy sky.

species found nowhere else on the planet. However, human activities have ravaged the fabric of India's ecosystems, leaving some of the most exceptional habitats on Earth perilously close to disappearing forever.

As the world's fastest-growing economy and most populous nation, India stands at the threshold of two futures. In one, we continue development paradigms that disrupt and consume our precious shared resources, adding to the pressures that threaten a substantial portion of Earth's biodiversity and the well-being of over 1.4 billion people. In the other, we acknowledge biodiversity as one of our country's most critical resources and make choices that will allow India's ecosystems – and the people who depend on them – to thrive. In this future, we recognize that prioritising the conservation of India's biodiversity is a matter of survival.

At this decisive moment, we turn to one urgent question: How can we stop this downward spiral and preserve India's biodiversity for the future of our nation and our planet?

EXECUTIVE SUMMARY

What is Biodiversity?

Biodiversity is the variety of life on Earth—from microbes to forests—and the ecological relationships that sustain human life. It underpins ecosystem services such as food, clean water, climate regulation, and cultural identity. Importantly, it also has intrinsic value, with all species holding the right to exist

Chapter 1: Biodiversity of India

India is one of 17 global “megadiverse” countries, hosting four biodiversity hotspots: Himalaya, Indo-Burma, Sundaland, and the Western Ghats.

- **Cultural heritage:** Sacred groves, rivers, and animals reflect centuries of ecological reverence. Colonial exploitation disrupted these traditions, but recent laws like the Forest Rights Act (2006) have restored some community rights.
- **Protected areas:** India has 53 Tiger Reserves, 106 National Parks, and hundreds of sanctuaries and reserves, covering ~5% of its land.
- **Community-managed biodiversity:** Sacred groves, wetlands, and grazing commons are biodiversity refuges outside formal protected areas.

- **Agrobiodiversity:** As a Vavilov Centre of crop diversity, India holds immense genetic resources vital for climate-resilient agriculture

Chapter 2: Why is Biodiversity Important?

Biodiversity is essential for survival, livelihoods, and well-being:

- **Food & Agriculture:** Pollinators (e.g., bees pollinating 687+ crops) and predators (e.g., owls controlling rodents) safeguard yields. Soil microbes maintain fertility.
- **Ecosystem Services:** Provisioning (food, fuel), regulating (pollination, flood control), supporting (nutrient cycles), and cultural (identity, spirituality).
- **Health:** Over 6,500 plant species are used in medicine. Conserved habitats reduce risks of zoonotic diseases like Nipah and COVID-19.
- **Climate Change:** Forests, wetlands, and mangroves sequester carbon and protect against floods, droughts, and cyclone

Chapter 3: Why is Biodiversity Declining?

The drivers of biodiversity decline are interlinked and accelerating:

Underlying Drivers:

- Economic growth and overproduction demand unsustainable resource extraction.
- Development paradigms prioritize infrastructure at the expense of forests and communities.

Direct Pressures:

- Habitat loss and fragmentation (86% of forests now exist as small patches).
- Overexploitation of groundwater and fisheries.
- Pollution from pesticides, plastics (26,000 tons/day), and oil spills.
- Invasive species such as Lantana camara and African catfish.
- Climate change impacts, with Eastern Ghats projected to lose 60% of endemic species' habitats

Chapter 4: How to Curtail Biodiversity Decline?

A multi-pronged approach is essential:

- **Conservation & Development:** Transition from fossil fuel-driven growth to sustainable, renewable, and human-scale development.
- **Policy & Governance:** Expand participatory governance, integrate indigenous knowledge, and establish robust biodiversity monitoring.

- **Restoration:** India's pledge to restore 26 million hectares by 2030 should prioritize nature-based solutions (agroforestry, assisted regeneration, wetland restoration) over monoculture plantations.
- **Education & Public Engagement:** Mainstream biodiversity in schools, support citizen science, and mobilize individual action (waste reduction, reducing plastic use, local conservation)

Chapter 5: Concluding Remarks

India's biodiversity has shaped its civilization and remains its greatest natural asset. Yet the country faces stark choices:

- Ignoring biodiversity brings ecological collapse, food insecurity, and health risks.
- Conserving it offers resilience, well-being, and sustainable prosperity.

India ranked 176th out of 180 countries in the 2024 Environmental Performance Index (EPI), highlighting the urgent need to realign development with ecology. The most cost-effective response lies in conservation, restoration, and inclusive governance.

Biodiversity is our survival resource. Protecting it is not optional but essential for national and planetary well-being.

What is
biodiversity?

Biodiversity is the rich fabric of living things that, woven together, supports and sustains life on Earth. Biodiversity is the variety of life in all its forms. Biodiversity is everywhere: inside and outside our bodies as communities of microbes, in our homes and backyards, as well as in gardens, farms, forests, grasslands, deserts, rivers, lakes and oceans. Urban areas also contain significant biodiversity. We humans are integral parts of biodiversity.

Biodiversity includes every living being, from the bacterium *Mycoplasma genitalium*, just 300 nm wide, to the 400-foot-tall Sequoia tree. Biodiversity includes the innumerable variations within every species, at the level of genes and populations. And biodiversity includes every habitat that harbours living things – from the deepest oceans to the highest mountain peaks.

Biodiversity exemplifies the interconnectedness of living organisms. Biodiversity encompasses the myriad interactions between biological entities and their physical, chemical, biological, social and cultural environments. Together, these networks make up the ecosystems that form the ‘rich fabric of Life on Earth’ [1].



Biodiversity provides ecosystem services that we depend on. All human communities, and all human economies, rely directly or indirectly on ecosystems. Ecosystems provide us with food, water and shelter; protect us from natural hazards; and provide many other essential services. Biodiversity lies at the very core of human well-being, providing ‘the basic materials for a good life, freedom of choice and action, health, good social relationships, a sense of cultural identity, and a sense of security’ [2].

The genetic diversity of life forms – the outcome of billions of years of evolution – represents a vast library of potentially useful information, which has been long explored in traditional cultures and more recently become the focus of a great deal of scientific research. This information has helped humanity to develop medicines, produce food and harvest energy, among many other applications.



Biodiversity is valuable in its own right. Beyond all the known and potential benefits that biodiversity can provide to humanity, it also has intrinsic value. All forms of life have inherent worth and have the right to exist, irrespective of their known usefulness to humans.





1

Biodiversity of India

1.1 Cultural, Historical and Political Contexts

1.2 India as a Cradle of Biodiversity

1.3 Biodiversity Outside Protected Areas

1.3.1 *Sacred Biodiversity*

1.3.2 *Community Conserved Areas*

1.3.3 *Other Effective Area-Based
Conservation Measures*

1.3.4 *Vavilov Centres of Crop Diversity*

1.1 Cultural, Historical and Political Contexts

Communities in India have long maintained close relationships with biodiversity as reflected in our literature, art and cultural traditions. Many of India's hundreds of ethnic groups and spiritual-religious communities have traditionally



promoted caring for nature in various ways, contributing to biodiversity conservation. For example, Buddhism and Hinduism consider the *peepal* tree (*Ficus religiosa*) sacred. In Hinduism, animals such as the crocodile, owl, lion and elephant are venerated as mounts for gods and goddesses [3]. Indigenous communities also worship elements of biodiversity such as *Manasa*, the Snake-Goddess, and *Bon Bibi*, a guardian spirit of the forest, which protects people from the demon King Dakkhin Rai when he assumes tiger form to attack people [4].

Despite this culture of reverence for the natural world, India's colonial history has strongly influenced the current state of its biodiversity. Once British traders recognised the value of teak, the Indian Forest Act (1865) granted the East India Company authority over all forestland that was not privately owned, leading to intensive timber extraction. The subsequent National Forest Policy (1894) placed great emphasis on the expansion of commercial agriculture, which led to large-scale deforestation, increased commercialisation of forest resources and imposed restrictions on the rights of local people.

The post-Independence period brought about efforts to reverse this history of exploitation. The National Forest Policy (1952) mandated that forest cover increase to one-third of the country's geographic area, the Forest

Conservation Act (1980) consolidated the key role of the Indian Government in forest management, and the National Forest Policy (1988) aimed to reduce forest degradation by forest communities. However, although the Joint Forest Management programme (1990) encouraged forest departments to work with villagers within their blocks, local communities still had no legal authority over forest resources. It wasn't until 2006, in the Scheduled Tribes and



Other Forest Dwellers (Recognition of Forest Rights) Act, that the government formally recognised the injustices tribes and other traditional forest dwellers had suffered throughout the colonial period as well as in independent India.

Today, the lives and livelihoods of communities across India continue to be entwined with biodiversity. There remains much work to be done to preserve and restore the relationship India's people have long held with the country's natural environments.

1.2 India as a Cradle of Biodiversity

India is one of 17 global “megadiverse” countries identified by Conservation International and is home to approximately 8% of the world’s biodiversity, including an estimated 800,000 species of animals, plants and fungi. India also accounts for about 18% of the total global population of one species – Homo sapiens.

India is also at the front lines of the current biodiversity crisis. Four of the 36 regions identified as global biodiversity hotspots – namely Himalaya, Indo-Burma, Sundaland and the Western Ghats – fall mostly or partly within India’s national boundaries (Fig. 4). Biodiversity hotspots are regions that are home to at least 1500 endemic vascular plants where at least 70% of the original natural vegetation has been lost. These hotspots are essential sources of global biodiversity but also places that are considered highly vulnerable to biodiversity loss.

Biogeographic Zones in India

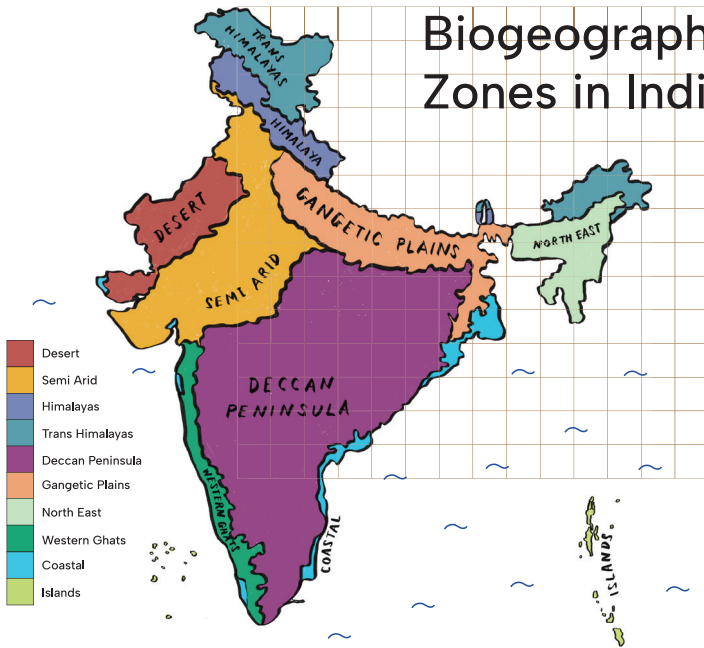


Fig.1 Biogeographic zones in India [5]

India's share of global biodiversity (Butler 2023)

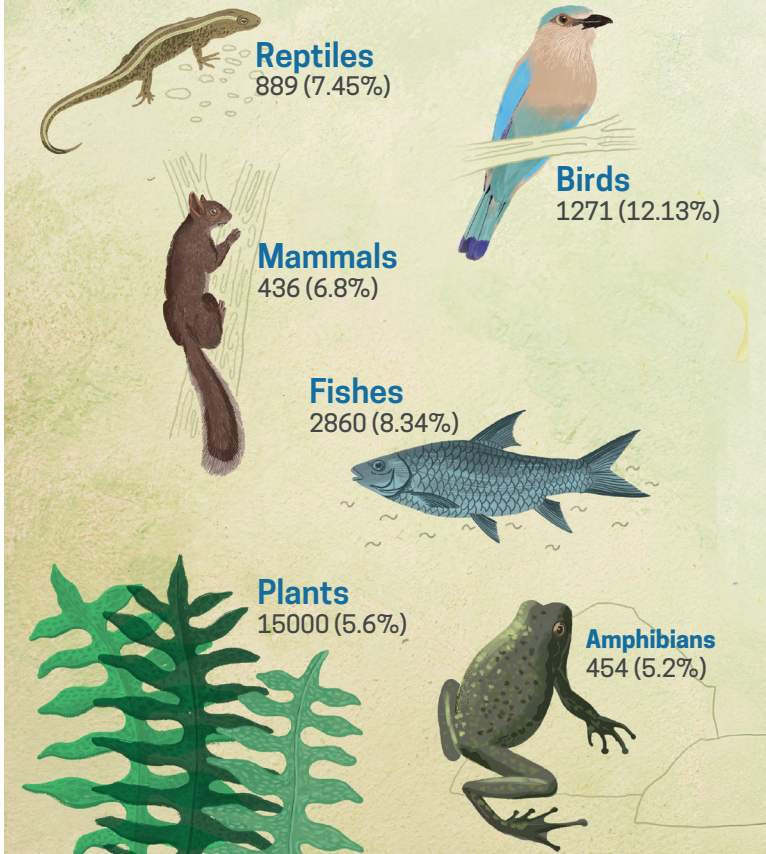


Fig.2 Species endemic to India as a share of the global biodiversity in birds, amphibians, mammals, reptiles, fish and vascular plants [6]

India's share of the global biodiversity in plants, fungi, and microorganisms



Seed-bearing Plants

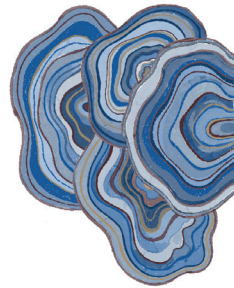
Gymnosperms
82 (7.3%)

Angiosperms
18666 (6.7%)



Non-Seed-bearing Plants

1271 (12.13%)



Others

Virus & Bacteria
986 (8.7%)

Algae
7286 (18.2%)

Fungi
14883 (15%)

Lichens
2401 (14.1%)

Fig. 3 Species endemic to India as a share of the global biodiversity in plants, fungi and microorganisms [7]

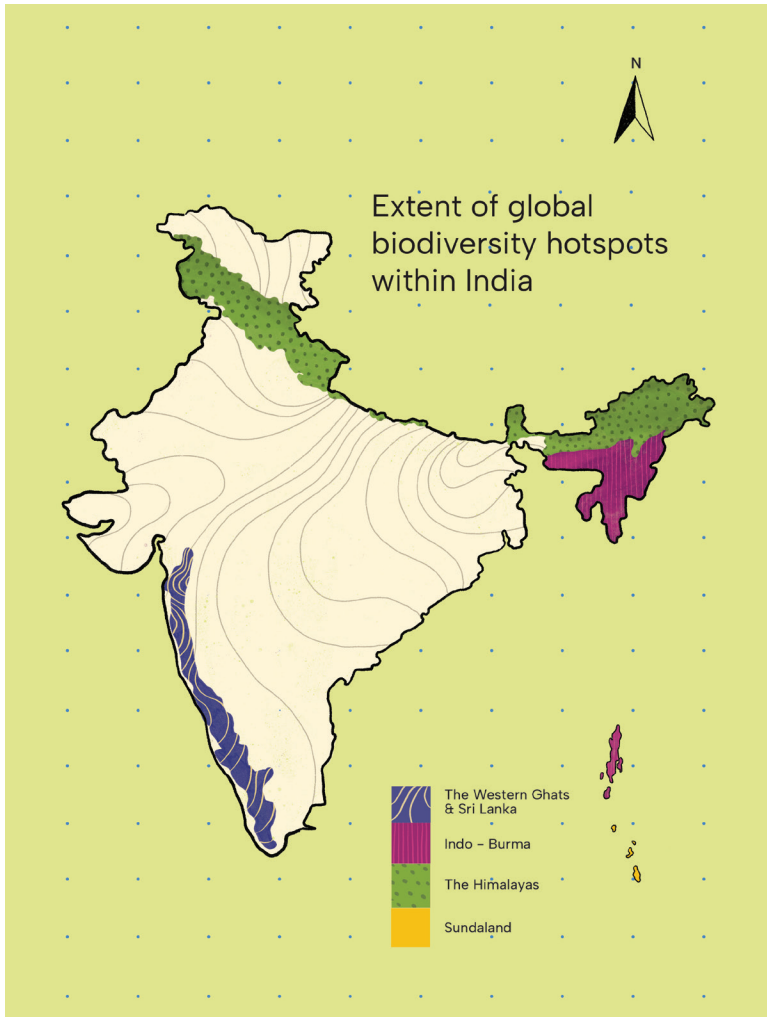


Fig. 4 Extent of global biodiversity hotspots within India [8]

Recognizing the unique value of India's biodiversity as well as the many pressures that threaten it, a range of efforts are underway to restore, protect and conserve our natural ecosystems.

As of 2022, India's formal Protected Area (PA) Network comprises 53 Tiger Reserves, 106 National Parks, 567 Wildlife Sanctuaries, 105 Conservation Reserves and 220 Community Reserves, covering areas of special floral, faunal, ecological or natural significance. This network makes up about 5% of the country's geographical area and many more PAs have been proposed.

In addition to government-managed PAs, community conserved areas, in which local communities take the lead on conservation practices for their area, are prevalent in India, broadening ecological conservation far beyond the formal PA network. These decentralized conservation efforts draw upon deep cultural traditions of stewardship of the land and local species and are a crucial part of biodiversity conservation in India.

1.3 Biodiversity Outside Protected Areas

1.3.1 Sacred Biodiversity: A classic example of community conservation



People have been protecting natural spaces for thousands of years as part of religious practices. Many spiritual and religious traditions consider natural phenomena to be manifestations of gods. Forest groves, bodies of water, mountains and glaciers have often been afforded religious significance, as have striking individual natural forms such as large old trees, rocky outcrops, cliff faces, caves or isolated hills. As a result, communities have left certain areas in an undisturbed, natural state, using them only for worship or rituals.

India is home to an estimated 100,000–150,000 such areas, which are formally called Sacred Nature Sites. Sacred forest groves are among the most common type of Sacred Nature Sites. They are found throughout the country and are among the last patches of primary forest in many areas. Scientific studies have found that sacred groves are often rich in biodiversity, providing refuge to rare species and serving as ‘ecological relics’ of ecosystems that were once prevalent in an area.

1.3.2 Community Conserved Areas: A vital – and vulnerable – resource

Communities conserve and manage ecosystems for many different purposes. Forests and grasslands may be conserved for grazing, agroforestry or protection against fire, for example, while natural and artificial wetlands may be managed for fishing, irrigation or flood protection.



Although studies on the biodiversity status of community-managed systems are limited, many have been found to have greater species richness than formal PAs. For example, in the sacred groves in the Kodagu district of Karnataka state, scientists reported populations of threatened tree species such as *Actinodaphne lawsonii*, *Hopea ponga*, *Madhuca neriifoli* and *Syzygium zeylanicum* which are absent from the PAs nearby.

Community-managed reserves are also rich in macrofungi: of about 163 species in India, 49 occur exclusively within remnant sacred groves. Over 130 species of birds endemic to the grasslands of the semi-arid peninsular grassland-savannah ecosystems have been documented in the gomala grasslands of northern Karnataka.

Wetlands throughout the country have a rich diversity of fishes, aquatic plants and birds while also being critical wintering sites for many migratory bird species.

For example, annual waterbird censuses conducted between 1987-2007 reported 205 species across 3296 wetlands in India, yet only about 3% of these wetlands were located in formal PAs.

While community conserved areas are clearly important for sustaining India's rich biodiversity, most are managed as informal commons and are, therefore, vulnerable to land-use conversion. However, there have been efforts to provide stronger protections.

The 2002 Amendment of the Wild Life Protection Act formalised many community-managed systems, forming Conservation Reserves and Community Reserves that cover 0.2% of India's area today (National Wildlife Database Centre, 2023).

1.3.3 Other Effective Area-Based Conservation Measures (OECMs): A Key to Meeting National and Global Conservation Goals

Recognizing their potential for conservation, OECMs have been integrated into India's National Biodiversity Target 6 and into the post-2020 Global Biodiversity Framework (GBF).

GBF Target 3 aims to ensure that “by 2030, at least 30% of global land and sea areas, especially those crucial for biodiversity and its benefits to people, are conserved through effectively and equitably managed, ecologically representative, and well-connected systems of protected areas and other effective area-based conservation

measures, integrated into wider landscapes and seascapes.” These goals are collectively known as the “30x30 movement” [9]

The High Ambition Coalition for Nature and People, comprising more than 90 countries, is now similarly advocating for global adoption of the 30x30 movement goals. OECMs, alongside formal Protected Area systems, could be instrumental in achieving these goals [9]. OECMs are already integrated into India’s National Biodiversity Targets, and the Aravalli Biodiversity Park has been declared India’s first OECM site [10].

1.3.4 Vavilov Centres of crop diversity

Around 60% of India’s land surface, or 1,597,000 km², is occupied by agriculture. Farms – mostly small family farms – exist in almost every ecosystem in the subcontinent, and many are still cultivated mostly by hand.

Hence, agrobiodiversity is another important category of India’s biodiversity. India is one of eight global Vavilov Centres of crop plant diversity (Fig. 5).

These are regions where an unusually high diversity of wild relatives of crop plants – the natural ancestors of

domesticated crops – are found. Ancient processes of crop plant breeding in ecosystems all across India have produced a vast range of locally adapted crop varieties. Many of these have fallen into disuse in recent decades, but the genetic material underlying this varietal richness represents a critical storehouse of genetic information that will become indispensable as agroecosystems continue changing under pressure from climate change and human activity.

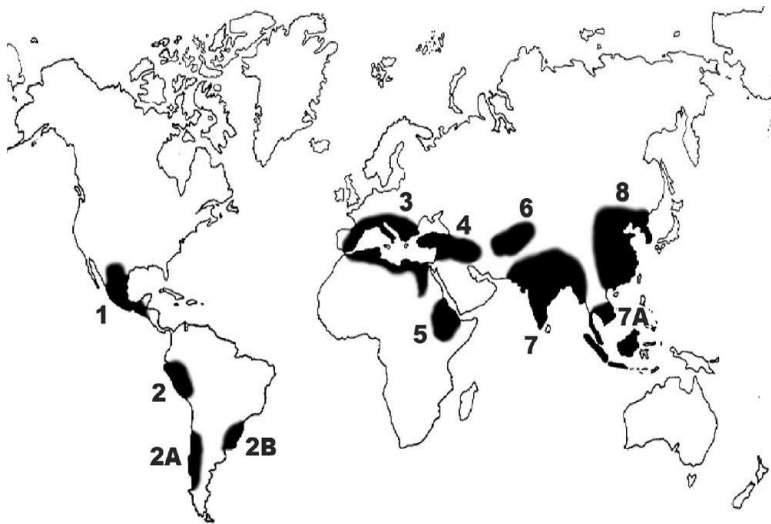


Fig. 5 The eight global Vavilov Centres of crop plant diversity, which are considered to harbour exceptional genetic variability of crop plants and their wild counterparts. South Asia (covering parts of India, Bangladesh, Myanmar) is represented by centre 7 [11].



In addition to the intrinsic value of biodiversity, thriving ecosystems provide numerous resources that are critical to our survival.



2

WHY IS BIODIVERSITY IMPORTANT?

- 2.1 Food & Agriculture
- 2.2 Ecosystem Services
- 2.3 Health
- 2.4 Climate Change

2.1 Food & Agriculture



Food crops worldwide depend on animals such as bees, beetles, flies, birds and bats for pollination and seed dispersal.

In India, estimates suggest that rock bees pollinate more than 687 plant species, including many cultivated crops.

In addition, many species of birds, amphibians, reptiles and bats consume agricultural pests, minimising crop damage and improving yields.

It is estimated that a single pair of owls can consume over 3000 rodents a year, thereby managing rodent populations that can cause significant agricultural losses.

The diverse communities of microbes that dwell within soil, another vital component of biodiversity, protect against fungal and bacterial disease, drive nutrient cycling and enhance plants' water-use efficiency, conferring economic benefits to farmers. In addition to enhancing agricultural productivity, healthy and biodiverse ecosystems provide important sources of food, income and supplies in many places. In indigenous and other communities, many people harvest wild fish and molluscs; insects and rodents; bamboo shoots; and wild fruits, tubers, and greens to help meet nutritional requirements and generate income. In the Western Ghats, the vegetation around farmlands provides leaf manure and other organic material used by betel nut cultivators as green manure.

Certain forest plants are an essential source of cattle feed in montane environments, where there is little space for livestock grazing. Trees on and around farms are additionally used as fuel, charcoal and timber for agricultural implements.

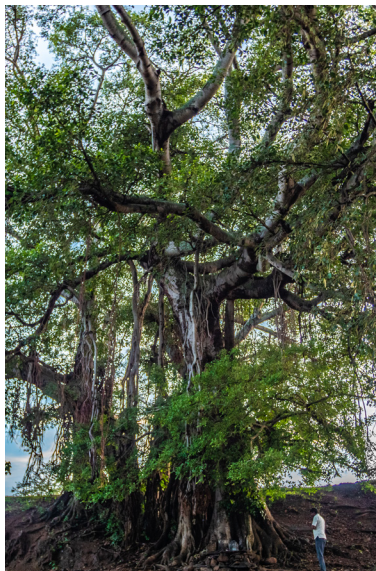
2.2 Ecosystem Services

Ecosystems provide many services that are critical to human health and well-being. These include:

- **Regulating services**, which maintain ecosystem functions (e.g., seed dispersal, pollination, water purification and climate regulation);
- **Supporting services**, which sustain ecosystem processes (e.g., photosynthesis and nutrient cycling);
- **Provisioning services**, which deliver tangible benefits (e.g., food, water and fuel); and
- **Cultural services**, which provide intangible benefits (e.g., recreation, aesthetic inspiration and spiritual uplift).

Beyond the tangible ecosystem services that can be valued materially (highlighted in Box 1), we also have complex intangible connections with biodiversity. Local biodiversity contributes to a sense of place, security and spiritual connectedness.

Popular mobilisations of environmental sentiment around rivers, such as the Ganges, or geological features like Rama Setu between Pamban and Mannar Islands underscore the deep connections between biodiversity and cultural heritage. Fostering personal connections with biodiversity and empathising with communities' beliefs related to the environment are vital but often ignored aspects of conservation.



Box 1: Quantifying the economic benefits of biodiversity



Image: Juan Carlos Fonseca Mata

The role of wild animals in pollination and seed dispersal – just two of the many tangible benefits of healthy ecosystems – offers perspective the economic importance of biodiversity.

Animal-mediated crop pollination is estimated to benefit 75% of the major crops across the world [12]. and it has been suggested that the continued loss of pollinators such as honeybees may lead to huge losses in crop production worldwide. For instance, Priess et al. [13] used land-use simulations to demonstrate that over 20 years, declining pollination services could reduce coffee yields by 18% and lead to a 14% net revenue loss in Sulawesi, Indonesia.



Animal-mediated seed dispersal can also provide major economic benefits. In Kerala and Karnataka, India, for example, bats play several key roles in the cashew industry[14]. It is estimated that cashew collectors would lose 50% of their typical cashew production in the absence of bat roosts. Moreover, bat visitations are used as an indicator of the nuts' ripeness; without this ecological signal, harvesters would incur significant labour costs for manually checking the tree canopy for ripened nuts. Auctions of bat-dispersed seeds and leases for seed collection generate significant revenues in these areas, a reflection of their economic importance.

2.3 Health



India has a rich heritage of medical traditions based on the use of native biodiversity. Local communities use over 6500 species of medicinal flora from the trans-Himalayas to the coast. In addition, many of the active components of pharmaceuticals originated in plants, animals and microorganisms, and scientists continue to study wild species in India's diverse ecosystems to discover new medicinal compounds.

However, India is also a hotspot for zoonotic diseases. The country's ongoing economic transformations have resulted in massive changes in land use and agriculture patterns at the same time that human populations and developments have grown extremely dense. This has led to shifts in animal distributions concurrent with increased contact between humans and wild and domestic animals, increasing the likelihood of zoonotic disease transmission.

Such patterns have been cited as a contributing factor in surges of diseases such as Nipah and COVID-19 [15]. Thus, efforts to conserve biodiversity by curtailing habitat destruction and limiting development in natural areas are considered to help safeguard against future outbreaks of pandemics.

2.4 Climate Change

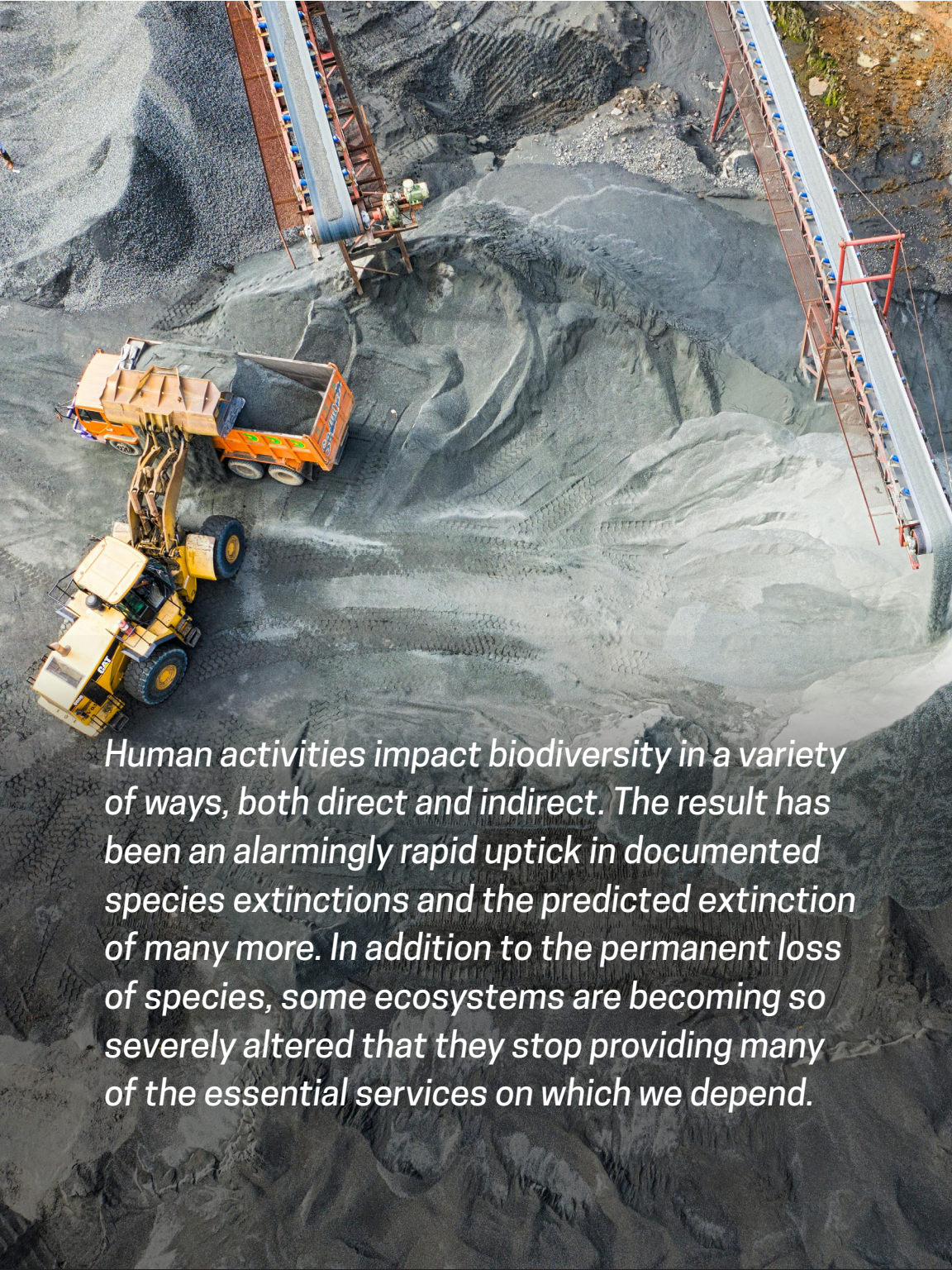
Ecosystems like forests, wetlands, rivers, estuaries and mangroves can sequester large amounts of carbon in biomass, soils and sediments. Protecting these natural carbon sinks is an essential element of policy responses to the global challenge of climate change.

Healthy ecosystems can also buffer and absorb the destructive energy of extreme weather events. For example, mangroves can shield coastal communities from storm surges, as they did during the 1999 super-cyclone in Odisha, while forest ecosystems can reduce the risk of uncontrolled runoff and flooding by keeping soils well drained.

Ecosystems also impact regional weather patterns. For instance, the humid forests of the Western Ghats pump moisture into the atmosphere and form rain clouds that increase rainfall in semi-arid parts of Southern India.

The value to society of such large-scale ecosystem services is often overlooked but could increase in coming decades as rains become erratic and droughts become more common and more severe with climate change.





Human activities impact biodiversity in a variety of ways, both direct and indirect. The result has been an alarmingly rapid uptick in documented species extinctions and the predicted extinction of many more. In addition to the permanent loss of species, some ecosystems are becoming so severely altered that they stop providing many of the essential services on which we depend.



3

WHY IS BIODIVERSITY DECLINING?

3.1 Underlying Drivers

*3.1.1 Economic growth and
overproduction*

3.1.2 Development Paradigms

3.2 Anthropogenic Pressures on Biodiversity

3.2.1 Habitat Loss and Degradation

*3.2.2 Overexploitation of biophysical
resources*

3.2.3 Chemical Pollution

3.2.4 Invasive Species

3.2.5 Climate Change

3.1 Underlying Drivers

The direct causes of biodiversity decline are well understood and often a primary focus of conservation efforts. However, at the root of these causes are complex socio-economic forces that are often overlooked. These underlying drivers are closely linked and tend to reinforce each other.

3.1.1 Economic growth and overproduction

The dominant notion of economic prosperity is based on continuous growth in producing goods and services. In pursuing such targets, our economy relies on increased production to drive consumption. Inputs such as fuels, metals, minerals, and other natural resources are thus needed in ever greater quantities to propel economic growth. Extracting these resources frequently involves damaging ecosystems, for example, to harvest biological resources directly or to dig beneath them for mining operations.

The quest for economic growth may be limitless, but the Earth's resources are not. With many extractive practices, the resource can only be taken once and it is never replenished. When extraction activities damage ecosystems, they may never fully recover. Resource extraction accounts for significant increases in habitat destruction, pollution, land diversion for mining and

industrialisation, and vulnerability to environmental disasters like floods, forest fires and heat waves.

In India and elsewhere in the populous tropics, resources are extracted not just for domestic consumption but also for global trade. Reconciling biodiversity conservation and economic development is a pervasive challenge as countries seek to improve quality of life for their people without sacrificing the land's capacity to sustain valuable ecosystem services in the future.



3.1.2 Development Paradigms



Development planning is a key component of India's policy landscape. However, the predominant development paradigm has focused on building large-scale infrastructure projects such as dams, highways and industries, often resulting in the destruction of diverse natural ecosystems and habitats. Many hectares of common lands have been converted for public and private commercial projects such as Special Economic Zones. Twenty-five thousand hectares of forests are handed over annually for "non-forestry activities", including defence projects, dams, mining, power plants, industries, and roads [16].

According to Government of India figures, 175 to 200 square kilometers of forest land was officially approved for conversion to other uses each year from 2019 to 2021 [16].

New Forest Conservation Rules may make converting forest lands to commercial uses even easier, potentially undermining the restrictions established under the Forest Rights Act of 2006.

The impacts of large-scale habitat loss and ecosystem degradation on parameters of human well-being such as nutritional security, health security and livelihoods are challenging to measure and, therefore, often unaccounted for in development planning.

Additionally, whilst these projects may improve transport connectivity and create short-term employment, the long-term impacts can be counterproductive. For example, studies show that some 50 million people have been displaced due to ill-planned developmental projects in India, creating new pressures and challenges for communities, infrastructure and the environment [16].

3.2 Anthropogenic Pressures on Biodiversity

In India, some of the most potent indirect drivers of biodiversity loss – including population growth, land-use change and economic and industrial expansion – have been gaining pace since the 1980s. These drivers exert their influence through cumulative direct impacts on ecosystems from habitat loss, overexploitation of resources, chemical pollution, invasive species, and climate change. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [17] identified these factors as the top five global threats to biodiversity.

3.2.1 Habitat Loss and Degradation

Habitat loss is the complete conversion of parts of a landscape from one ecosystem type to another – from forest to agricultural fields, forest to open-cast coal pit, or wetland to suburban housing development, for example. Historically, the Indian subcontinent underwent a period of sweeping, large-scale habitat destruction centuries ago with the spread of settled agriculture, leaving only remnant patches of natural vegetation scattered across many landscapes that had once been contiguous natural habitats.

Today, the rate of outright conversion of natural habitats may be lower, but is difficult to estimate precisely based on available data. Nonetheless, many areas remain vulnerable to conversion due to mining, industrial and infrastructure



development. Additionally, activities such as timber logging, firewood extraction, quarrying for stone or sand, and construction of roads and pathways result in habitat disruption and fragmentation.



As a result of roads and power transmission lines, 86% of the extant forest patches in India are classified as small (median patch size $<1 \text{ km}^2$) and isolated [18]. In addition to reducing the size of habitats and severing ecological connectivity, habitat fragmentation can also lead to microclimatic changes along forest boundaries, promote the establishment of invasive species and exacerbate human-wildlife conflict [19].

3.2.2 Overexploitation of biophysical resources

Direct, intensive, and continuous extraction of terrestrial and marine resources has long-term impacts on species populations. Steep rises in extraction rates of common-pool resources such as groundwater and fisheries have raised widespread concerns about the sustainability of many modern agricultural and fishing practices.



In India, groundwater use has increased fivefold over the past 50 years, primarily for use in irrigation. Government subsidies on borewells and electricity support high-yielding varieties of rice and wheat [20]. While these subsidies aim to expand production, lower food prices, and maximise profits, they also increase demand for water, leading to declines in the groundwater table and disrupting crop yield. The mismanagement of this crucial ‘out-of-sight’ resource

threatens livelihoods, food security and wildlife [20], [21], [22].

Along India's coastlines and inland waterways, prodigious fisheries industries have led to the over-extraction of fish stocks, threatening the livelihoods of local fishing communities and altering the ecology of marine ecosystems [23].

The scale is enormous: India's inland fisheries produced approximately 11.25 million tonnes (MT) of fish and maritime fisheries produced about 3.5 MT in 2020-2021 [23].

An ineffectively regulated transition from artisanal fishing methods toward heavily mechanised approaches like deep-sea trawling has led to widespread ecological damage and the destabilisation of fish populations.



3.2.3 Chemical Pollution

Agricultural chemicals represent one of the largest sources of chemical pollution in India due to the size of the country's farming sector (See Box 2). Pesticides, herbicides and fertilizers pollute soil, freshwater and marine ecosystems, with serious implications for the health of both humans and wildlife.





Oil spills and tarball pollution are another major source of pollution, frequently affecting coastal ecosystems. In Goa, tarball deposits impact many invertebrate species and pose an economic threat to the people who depend on coastal fisheries for their livelihoods. In Maharashtra, oil spills associated with Cyclone Taukate had a substantial negative impact on the local fishing industry [24].

Swathes of tarballs deposited on beaches damaged mangroves in Mumbai, clogging vital fish breeding grounds and jeopardising the area's intertidal biodiversity [24]. Since marine and inland waterways are interconnected, much of the pollution from mass urbanisation, agriculture, and

industrial development also ultimately ends up in the oceans.

Additionally, India's solid waste management systems have not kept up with the pressures of a growing consumer economy.

The country uses at least 14 million tons of plastic annually, generating 26,000 tons of plastic waste daily – a substantial fraction being single-use plastics [25].

The Meghna-Ganges-Brahmaputra delta is one of the ten most prominent global outlets for plastic waste into the ocean. In August 2021, the Government of India passed a nationwide ban on 21 single-use plastic items (including plates, cups, cutlery, straws, packaging films and cigarette packets) [25], [26].

However, many single-use plastic products continued to be available after the ban took effect [25], [26].

Box 2: A persistent pesticide problem



Across India, organophosphorus pesticides are used extensively in cultivating rice, maize and sugarcane. These pesticides leach into groundwater systems, causing large-scale damage to aquatic and terrestrial life forms.

In humans and other mammals, residual traces of the pesticide monocrotophos (MCP) have been linked with neurobehavioral abnormalities and pulmonary failure. MCP has also been linked to suicides among farmers.

As of 2022, MCP was banned on vegetable crops in India and completely prohibited in some states (and many other countries), but it is still widely used, especially on cotton crops [27].

3.2.4 Invasive Species

People have been moving species around for millennia. Plants and animals have been intentionally relocated from their native habitats to new places for food, fuel and fibre, as well as for use as pets and game animals and in ornamental gardens.

It is estimated that about 10% of such 'alien' species worldwide become invasive, meaning their populations increase rapidly and spread widely, disrupting native ecosystems.

One such invasive alien species, *Lantana camara*, was introduced into India as an ornamental hedge plant 200 years ago. Today *lantana* has taken over several native ecosystems, forming dense thickets in forest understories, altering habitat for wildlife and suppressing native plant diversity [28].





*Lantana is estimated to occupy 40% of India's tiger habitat, and also causes problems in croplands and pastures. Another example is the African catfish, *Clarias gariepinus*. Originally brought to India for aquaculture, the fish is now widespread in natural waterways, where it preys upon and displaces native fish species and other aquatic organisms.*

In some cases, species have been introduced inadvertently but have gone on to become invasive. An example is the weed commonly known as Congress grass (*Parthenium hysterophorus*). Thought to have arrived as a hitchhiker with imported wheat, it causes severe respiratory and skin allergies in vulnerable people and is also poisonous to livestock [28].



While there is a shortage of comprehensive data on invasive species in India, researchers recently compiled a list of 220 plant species deemed invasive out of 1747 alien plants in India [29]. It is estimated that India has at least 14 species of invasive freshwater fish; 19 marine invasive species;

22 invasive insects found in agricultural systems; and 40 invasive microbes across agricultural, freshwater and brackish water systems [28].

When natural ecosystems are disrupted, even native species can become ‘invasive.’ For instance, if forest cover is substantially degraded over large areas, the soil becomes drier and can allow marginal herbaceous plants or grasses to migrate into the forest interior, where they compete successfully with forest vegetation and alter forest ecology [30].

3.2.5 Climate Change

Anthropogenic climate change threatens India's biodiversity in multiple ways. Changing temperatures can reduce or expand the ranges of species. But temperature extremes – in India, mainly at the high end – are only part of the concern.



Highly energised tropical storms, changing precipitation levels and greater variability in weather patterns must be expected over the coming decades. Without regular winter rainfall and dry-season showers, the frequency and intensity of wildfires have increased in many forest and woodland ecosystems, including the Himalayas [31].

All of these trends are expected to heighten the vulnerability of many ecosystems to biodiversity loss.

In the Eastern Ghats, for example, climate change, in combination with rapid land use change, is predicted to reduce the habitats of endemic and threatened species by about 60% and 40%, respectively [31].

The impacts of climate change are determined by both the geographical exposure to climate hazards and the capacity to adapt to changing conditions. This is true of both natural ecosystems and human communities. As climate change continues to stress ecosystems and reduce the provision of ecosystem services, the impacts are likely to disproportionately affect India's poorest and most vulnerable communities.

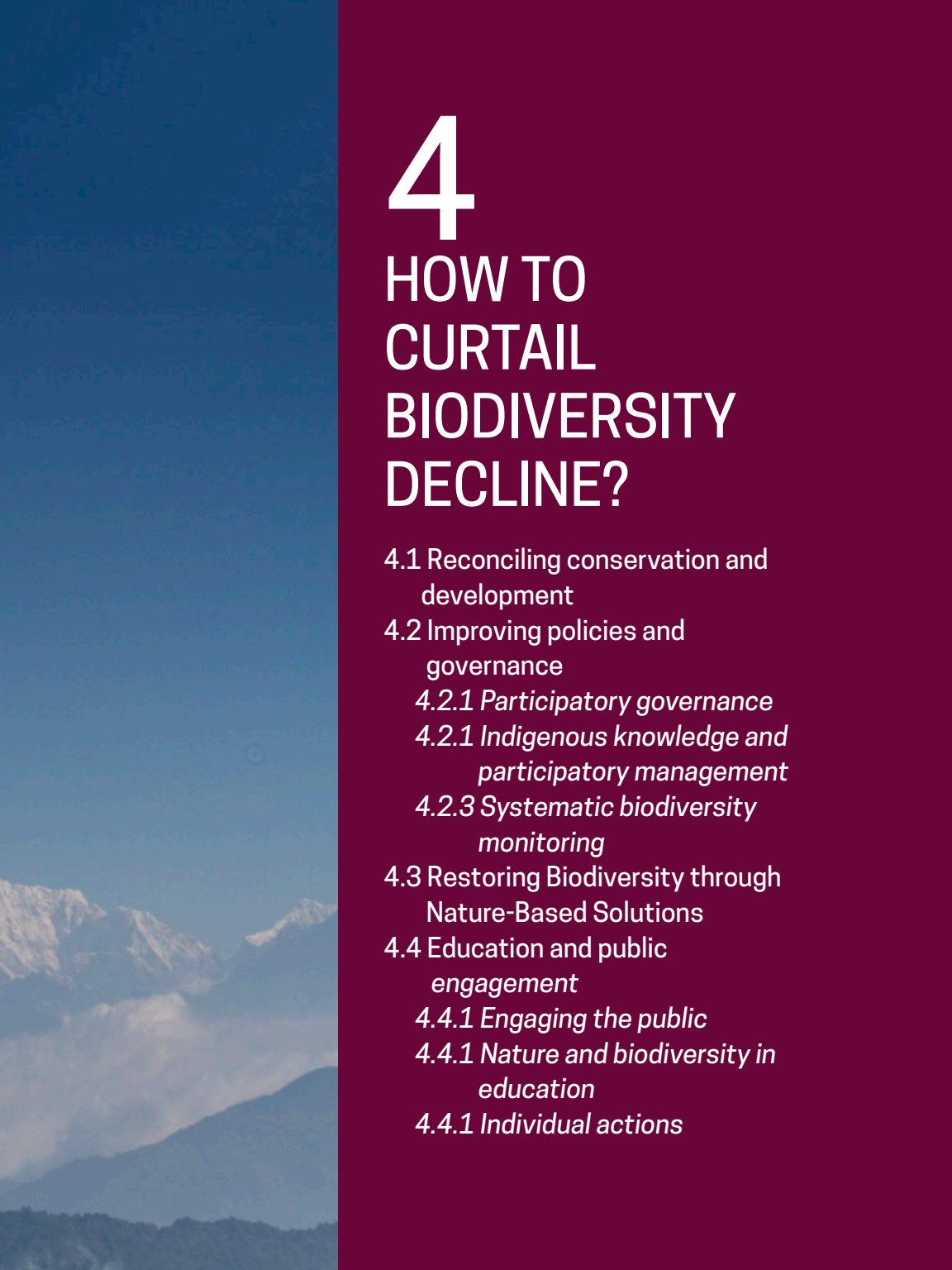
In particular, global warming-induced biodiversity decline is likely to lead to significant socio-economic losses among indigenous peoples, low-income households, and smallholder farmers [32], undermining their ability to adapt to further climate perturbations and increasing the likelihood of practices that are counterproductive to long-term climate adaptation.



Although some communities may be affected more acutely than others in the near term, ultimately all sectors of India's economy (and indeed, of the global economy) will inevitably be affected by the direct and indirect effects of changing climate conditions. In Northeast India, most districts are already seeing climate impacts in sectors of the economy that are reliant on forest, agriculture and water resources [33].

India faces critical choices in the mounting biodiversity crisis. To curtail the decline and preserve the ecosystems on which we depend, we must reconcile conservation and development goals, improve policies and governance, restore degraded ecosystems and engage the public in building a more sustainable future.





4

HOW TO CURTAIL BIODIVERSITY DECLINE?

- 4.1 Reconciling conservation and development
- 4.2 Improving policies and governance
 - 4.2.1 *Participatory governance*
 - 4.2.1 *Indigenous knowledge and participatory management*
 - 4.2.3 *Systematic biodiversity monitoring*
- 4.3 Restoring Biodiversity through Nature-Based Solutions
- 4.4 Education and public engagement
 - 4.4.1 *Engaging the public*
 - 4.4.1 *Nature and biodiversity in education*
 - 4.4.1 *Individual actions*

4.1 Reconciling conservation and development

Following a business-as-usual economic development model in India over the next few decades would lead to severe and permanent losses of our unique biodiversity and expose India's communities to increasingly complex waste management problems, ecosystem collapse, recurring weather-related crises, acute economic insecurity and intense health challenges.



The conventional modern development model is based on the pursuit of ever-more sophisticated ways to use the energy of fossil fuels to expand production and consumption. What has been overlooked in the two centuries of following this model is the waste that it creates.

Consequently, we now live in a world in which climate change (the direct outcome of unconstrained disposal of waste greenhouse gases into the atmosphere) is the global-scale symptom of our dependence on petrochemicals to drive economic growth.

This model is not the only way to support human populations. Alternative economic models and many of the technologies they require are already available. Notably, we have essentially limitless resources of renewable energy at our disposal. Although the waste management issues associated with renewable energy collection and distribution infrastructure still need consideration, these technologies are certain to have a smaller environmental footprint than the fossil fuel industry.

India can fully take its place as a global leader in nature-appropriate technologies and human-scale economic development if we can restore the awareness that economic development means improvement in economic quality and not merely growth in economic scale.

4.2 Improving policies and governance

Policies reflect the values and priorities of a government and can influence on-the-ground practices at a large scale. India's policy landscape has provided both opportunities and challenges in advancing ecological preservation and supporting the communities of people who depend on healthy, productive ecosystems.



4.2.1 Participatory governance

Local communities can and do play instrumental roles in protecting biodiversity worldwide.

In India, 27% of the human population depends on forest biodiversity for part or all of their subsistence.

As a result, many communities have a strong interest in ensuring continued access to resources and use various management approaches to sustain them.

The execution of the Joint Forest Management Programme in 1990 was the first step toward the participatory management of forest resources. Since then, laws like the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Rights) Act of 2006, known as the Forest Rights Act or FRA; the National Rural Employment Guarantee Act of 2005; and the Biological Diversity Act of 2002 have also enhanced opportunities for community-led natural resource management [34].

These laws mark significant improvements in state policy toward India's natural resource management and protection (see Box 3). Under the FRA, Community Forest Resource rights ensure communities' legal access to forests for grazing, firewood collection and other purposes, as well as their right to protect, regenerate, conserve and manage

forest resources for sustainable use. The Forest Rights Act recognises the Gram Sabha as the constitutionally mandated autonomous unit best positioned to work with state authorities to ensure the effective joint management of forest resources.

Although implementation of Community Forest Resource rights was slow at first, it is now gaining momentum, and a 2022 report of the Ministry of Tribal Affairs states that one lakh Gram Sabhas have received Community Forest Resource titles to a total of 46000 km² of forest area.



Some of these have demonstrated sustainable forest management and restoration of degraded systems. Convergent efforts by government officials working with community representatives can lead to sustainable outcomes through decentralised democratic governance.

Despite progressive policies, the implementation of community-led biodiversity-promoting laws and practices in India faces ongoing challenges related to rigid bureaucracies, under-representation of socio-economically marginalised groups, vested interests of outsiders, illegal claims and other issues. These practical hurdles must be overcome before the opportunities these acts represent for participatory governance can be fully realised.

Box 3. Key legal frameworks for community management of biodiversity resources in India



The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act of 2006, commonly known as the Forest Rights Act or FRA, is India's seminal legislation linking wildlife conservation and the traditional forest rights of indigenous communities.

It recognises forest-dwellers as “integral to the very survival and sustainability of the forest ecosystem” and incorporates provisions to secure the historically unrecognised land rights of forest-dwellers and their community rights to use, manage and protect forests and the biodiversity therein. It also provides a mechanism for explicitly reconciling the exercise of forest rights with the needs of wildlife conservation (if there is any conflict between the two) within Protected Areas through provisions for Critical Wildlife Habitats.

The Biological Diversity Act of 2002 provides a legal framework for the conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising from the use of natural resources. The Act is intended to help meet India's international obligations under the Convention on Biological Diversity, agreed upon at the United Nations Convention on Biological Diversity in 1992.

4.2.2 Indigenous knowledge and participatory management



The FRA takes a rights-based approach, meaning that the rights of forest dwellers to participate in the management and sustainable use of forests actively are presumed inherent. This approach is based on a long historical precedent, wherein multiple generations have lived in the same area and used its forest resources consistently over time. Key assumptions underpinning this approach include the accuracy and validity of local observations, interpretations and practices and the capacity of traditional institutions to manage biological diversity in the name of local communities [34].

At times, indigenous knowledge and knowledge generated through systematic scientific methods can appear to be in conflict. Scientific studies may provide precise measurements, but they are often expensive and time-consuming and can overlook factors that influence real-world outcomes. Conversely, indigenous knowledge and management practices may be deeply grounded in real-world experience but lack precision, misinterpret certain cause-and-effect connections or fail to account for large-scale or external forces impacting local trends. There is also no guarantee that traditional institutions will be fully democratic or that the interests of underprivileged groups within communities will be adequately represented in deliberations. Unfortunately, it is difficult to generalise these matters, and they must be addressed on a case-by-case basis.

In general, incorporating scientific and indigenous knowledge systems into resource management practices – while recognising their limitations – can promote sustainable forest resource management and biodiversity conservation [35]. For example, in Biligiri Rangaswamy Temple Tiger Reserve, forest product monitoring has expanded to include the documentation of land use history, local natural resource use practices and cultural ecology, enabling a holistic understanding of land transformation in the sanctuary [36].

4.2.3 Systematic biodiversity monitoring

Adequate monitoring systems are critical for supporting sustainable human interactions with natural systems.

In India, as elsewhere, environmental management interventions are often pursued on a project basis, with funding that lasts for a few years with little or no follow-up. Ideally, monitoring systems should be set up to produce periodic data over time to reflect the progress of any systematic changes set in motion by the original interventions. However, monitoring environmental health and socio-ecological trends is a complex undertaking.





Systematic monitoring programmes represent one area that can greatly benefit from productive collaboration between scientists and indigenous or local communities. Especially in developing countries like India, changes in the human-ecological interface are felt most immediately by the communities that rely directly on natural resources for their livelihoods. Hence, these communities have a vested interest in collecting information about the ecosystems they interact with and are often the first to observe significant ecological changes.

Scientific collaborators can aid these community-based efforts and gain insights into the broader context by providing systematic frameworks for recording and interpreting this information.

4.3 Restoring Biodiversity through Nature-based solutions

Restoring degraded ecosystems can benefit biodiversity and human well-being by enhancing ecosystem services. The global community has recognised the urgent need for ecological restoration and rehabilitation, as exemplified in the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

As part of its United Nations Land Degradation Neutrality commitment, India set a target of restoring 26 million hectares of degraded land by 2030. To meet this goal, the Government of India has spent upwards of \$25 billion on restoration-based programmes in the past decade and allocated \$6 billion for compensatory afforestation (tree-planting programmes) to state governments.

While fostering healthy ecosystems is vital for preserving biodiversity, the benefits of large-scale restoration projects are far from straightforward when afforestation is the primary intervention and carbon sequestration is the primary goal. Many such projects have consisted of large single-species plantations of fast-growing trees, sometimes even alien species, which have often had disappointingly low survival rates. Assessments show that such projects are not

only a drain on public finances and philanthropic investments but also relatively ineffective for biodiversity conservation. Open non-forested natural habitats, which support a variety of endemic and endangered species and agro-pastoralist communities, are often misclassified as “wastelands” and are vulnerable to large-scale afforestation programmes and renewable energy projects that can wind up further degrading ecosystems.



Nature-based restoration intervention options including agroforestry, reforestation, assisted natural regeneration and conservation can be suitable for different local contexts. Restoration programmes, informed by scientific evidence, can simultaneously enhance biodiversity and directly benefit rural livelihoods – especially among women and marginalised social groups – by generating local jobs, increasing nutritional security, improving groundwater recharge and supporting other ecosystem services. Restoration efforts that focus only on biophysical variables may overlook social, economic and cultural factors that determine how land and natural resources are used at the local scale and what species and restoration approaches may fit best in that context. Identifying the drivers of degradation is therefore a critical first step to ensuring socio-ecologically sound restoration interventions.

Greater local community involvement in designing and implementing restoration projects reduces the risks to local biodiversity and livelihoods that emerge from reckless plantations and other interventions that are ill-suited to the local context. Community-centric efforts can also help to improve soil health; manage invasive species; and enhance climate adaptation through restoration measures for coastal mangroves and dune vegetation, road verges and stream banks in hilly areas, windbreaks and soil stabilisation in agricultural landscapes and green spaces in urban areas.

4.4 Education and public engagement

Preserving biodiversity requires action, but spurring action first requires awareness. It is critical for decision makers across many sectors, as well as the public more broadly, to understand the threats posed by biodiversity loss and the steps necessary to curtail it.



4.4.1 Engaging the public

Mainstreaming biodiversity into India's public consciousness and discourse requires outreach and communication to the public and to decision-makers in government, industry, the judiciary, the media and other professions. There is a role for everyone in this process. Local communities can incorporate traditional knowledge and expertise into the awareness of the value of biodiversity. Governing bodies can

embrace biodiversity and take a more inclusive approach to planning for economic development and environmental protection. Further, businesses with corporate responsibility can promote biodiversity as an asset to their products rather than seeing environmental protections as merely a burden.

Citizen science also provides many opportunities for the general public to be directly involved in biodiversity monitoring and ecological restoration. It is essential to involve all community members, including historically marginalised communities and those in geographically neglected areas, in such projects and to address bias and inclusion challenges that may emerge from social, linguistic and disability issues.

Given the immense potential to contribute to biodiversity monitoring at different scales, there is a need to integrate biodiversity information, including through large-scale data repositories and analytics, with appropriate technical design and stakeholder networking to empower communities to actively participate in and benefit from conservation efforts.

4.4.2 Nature and biodiversity in education

The values that children are exposed to early on often stay with them for the rest of their lives. India's young people must learn about nature and biodiversity both in school and

in their everyday lives. Age-appropriate themes and methods can stimulate children's innate 'biophilia' [37], leaving them with a lasting love for and understanding of the natural world. Experiential, hands-on and activity-based approaches focusing on curiosity and wonder are appropriate for younger children. Older children can use their analytical and problem-solving skills to diagnose critical biodiversity and conservation issues.

At a higher level, resources are urgently needed to provide internships, fellowships and scholarships to students and professionals interested in biodiversity-related topics, particularly those in biodiversity-rich rural landscapes. Further support must be leveraged for equipment and resources for field studies, databases, analytical tools, online and offline nationwide curricula, course development and international networking to foster communities of learning and exchange.

Finally, it is important to facilitate connections with job opportunities to spread biodiversity knowledge through public and private sectors. In a megadiverse and rapidly developing country like India, there are vast untapped opportunities for professionals to study and manage the interface between human activities and natural systems.

4.4.3 Individual actions

Individual actions can have a meaningful impact on biodiversity. Careful waste management, minimising the use of plastics, avoiding toxic chemicals in the household and farm and participating in local neighbourhood clean-ups can all have immediate positive effects. Yet the more prominent problems lie with the development paradigm that government administrations favour. Therefore, gathering with neighbours, community members, and like-minded peers is critical to convincing agencies and businesses to take better care of the natural systems we depend on.









5

CONCLUDING REMARKS

For centuries, India's biodiversity has sustained peoples, cultures and traditions that have shaped our nation's identity [38], [39]. The loss of this biodiversity imposes a considerable cost on both natural ecosystems and on Indian society.

India ranked 176th out of 180 countries in the 2024 Environmental Performance Index [40].

While this index has been criticised [41], India's overall track record under the current development paradigm is clearly at odds with the country's unique ecosystems and the well-being of Indian citizens [42].

Ignoring the environment may often appear cheaper in the short run, but it is likely to bring far higher social and financial costs in the long run. Conservation and restoration of biodiversity is perhaps the most cost-effective and least hazardous way to mitigate the impacts of land degradation and climate-induced environmental disasters [43].

We hope this booklet will be a timely reminder that biodiversity is India's greatest asset and help to inspire research-guided policies that prioritise the preservation and sustainable use of our irreplaceable natural resources.

India's updated National Biodiversity Strategy and Action Plan (NBSAP) was launched in 2024 at the Kunming-Montreal Global Biodiversity Framework's COP16. The NBSAP sets 23 national targets for biodiversity protection, addressing threats to biodiversity, meeting people's needs through the sustainable use of biodiversity, and mainstreaming conservation solutions. India's NBSAP calls for a "bottom-up" implementation approach: local Biodiversity Management Committees act on the ground and report to State Biodiversity Boards, which are guided by the National Biodiversity Authority (NBA), the biodiversity advisory agency for the MoEFCC and 22 other agencies. Implementation of this plan is critical to the future of India's biodiversity.

India has also joined the High Ambition Coalition for Nature and People, a group of over 100 countries calling for "30x30", a global effort to protect 30% of global land and ocean by 2030. Approximately 28% of India's land area is considered under some form of protection through different legal frameworks and the remainder is hoped to be added through Other Effective area-based Conservation Measures (OECMs) [44]. Consistent implementation of these goals will be vital—and will require strategic, inclusive, and equitable conservation approaches. [45]





6

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