Aligning India's Mangrove Restoration with Target 2 of Kunming-Montreal Global Biodiversity Framework

Introduction

Kunming-Montreal Global Biodiversity Framework is an international agreement adopted at COP15 in December of 2022. It strategizes to halt and reverse biodiversity loss by 2030 and achieve a nature positive world by 2050. This framework lists 23 targets to be attained by 2030 and four goals to be achieved by 2050, to build a world that lives in harmony with nature (Convention on Biological Diversity 2024). Although it is not legally binding, the global goals and targets in this agreement help guide action equivalent to the ambitions set by the 196 countries that signed it (WWF 2023). These nations were required to update their national biodiversity plans which describe the actions that add up to achieve the global goals of the framework, and submit them to the United Nations by November of 2024, in the COP16 held in Colombia. These plans must comply with all targets in the Global Biodiversity Framework (GBF) and importantly, be accompanied by a biodiversity financing plan that includes opportunities for private finance mobilization (Convention on Biological Diversity 2024).

In this report, we concentrate on Target 2 of the Kunming-Montreal GBF, with special focus on restoration of Mangrove ecosystems in India.

Target 2

Restore 30% of all Degraded Ecosystems

"Ensure that by 2030 at least 30% of areas of degraded terrestrial, inland water, and coastal & marine ecosystems are under effective restoration, in order to enhance biodiversity and ecosystem functions and services, ecological integrity and connectivity" (CBD 2024).

The framework recognizes and highlights that habitat degradation is one of the most debilitating effects that human activities have caused on the natural world, with it the importance of reversing those effects to build back a healthier landscape as well. The target includes terrestrial, inland water, marine, and coastal ecosystems, and stipulates that 30% of each be initiated on effective restoration by 2030.

Mangrove forests

Mangroves forests are salt-tolerant evergreen forests found in tropical and subtropical coastal areas (approx. between 320 N and 380 S), especially where the sea meets the land, in backwater creeks and river estuaries. The best mangrove forests are found where freshwater and seawater mix regularly, where annual rainfall is above 200 cm and the temperature stays above 20 0C throughout the year (Saenger et al. 1983; Ragavan et al. 2019). These hardy plants are adapted to both freshwater and highly salty water, sometimes even twice as salty as seawater.

They grow well in muddy areas with low oxygen and changing tides (Ragavan et al. 2019). Being specialized to survive in such extreme conditions, mangroves have unique roles to play in this ecotone.

Ecological importance

Their tangled roots and shallow waters create safe breeding grounds for many fish and small invertebrates (Worthington & Spalding 2019) which also supports local fisheries and sustains the marine food chain. Mangroves are also excellent at storing carbon, keeping it locked in their wood and soil for a long time which helps fight climate change. They absorb excess nutrients, reduce ocean acidification, and trap microplastics, making them important for a healthy environment (FSI 2023). Mangroves help protect coastlines from tsunamis, storms, and soil erosion. Their roots trap sediments and act as a natural barrier. This also reduces costs in loss and repair from calamities (Worthington & Spalding 2019). Mangroves are also a low-cost option, they are self-repairing, and in many places, they are even able to keep up with rising seas. Protecting and restoring mangroves is now seen as an important step for both environmental conservation and sustainable coastal management (Worthington & Spalding 2019).

Indian Mangroves

Globally, mangroves cover about 137,760 km² across 118 countries (Giri et al. 2011) where Indian mangroves represent 3.3% of global mangroves and about 56% of global mangrove species. The mangrove habitat of India is broadly divided into three types: deltaic mangroves (eastern coast mangroves), estuarine & backwater mangroves (western coast mangroves), and insular mangroves (those of the Andaman and Nicobar Islands) (Mandal & Naskar 2008).

They are found along the coastlines of nine states and four union territories on the eastern and western coast of the mainland, and on the Islands of Andaman & Nicobar and Lakshadweep (Ragavan et al. 2019). The mangrove coverage is larger and more widespread on the east coast than on the west coast because of its distinctive geomorphological setting.

Status

Mangrove coverage in India has increased significantly in the last decade. Estimates by the Forest Survey of India show a net increase of 875 km2 during 1987–2017, with a mean annual increase in mangrove coverage of 30.21 km2; the extent of the increase was 112 km2 between 2013 and 2015 and 181 km2 between 2015 and 2017 (FSI 2017).

Although there's an increase in the area, there are inadequacies in most of the mangrove restoration programs from the last two decades, due to poor species selection and lack of understanding of mangrove dynamics. This calls for better understanding of mangroves and the effectiveness of existing conservation methods, and refinement of them for better management (Ragavan et al. 2019).

Hence, the ecological health of mangroves in India remains degraded, and implicit species loss has been witnessed despite mangrove expansion in many regions (Giri et al. 2008, 2015; Hamilton & Casey 2016). The scattered information and knowledge gaps are still a drawback for conservation and management of mangroves (Maxwell 2015).

Major threats and causes for the loss of mangroves

Mangroves across the world face several serious threats, mainly from aquaculture and agricultural expansion, cutting of trees for timber, fuel & charcoal, pollution, invasive species, and the growing impacts of climate change—including hyper salinity, storm damage, changes in sediment flow, and land erosion. In addition, mangrove areas are being cleared for urban expansion and the development of coastal infrastructure such as roads and ports. These activities are especially common in regions with rapidly growing coastal populations (Worthington & Spalding 2019).

Table 1. State wise threats for mangrove (Ragavan et al. 2019)

Indian states	Threats faced by mangrove ecosystems
West Bengal	Agriculture, prawn seed collection, reduction in freshwater flow and pollution
Odisha	Natural calamities, prawn farming, encroachment, and rehabilitation
Tamil Nadu	Reduction in freshwater flow, invasion of alien species, and over-exploitation of mangroves
Andhra Pradesh	Agriculture, grazing, developmental activities, invasion of alien species, and aquaculture
Gujarat	Over-exploitation of mangroves, developmental activities, natural calamities, and coral reef degradation
Maharashtra	Urbanization and pollution
Karnataka	Agriculture, tree felling, and pollution
Kerala	Unsustainable mode of aquaculture practices, mangrove wood for fuel, industrialization & urbanization, and bio-pollution
Andaman & Nicobar Islands	Agriculture, exploitations for wood and wood products, tourism development-encroachment, and natural calamities such as cyclone, storm & tsunami.

In India, agriculture and shrimp farming are among the main causes of mangrove destruction, which in turn increases the intensity of coastal disasters. In the table below, the different types of threats at a regional level are discussed. In each state the mangroves are under threat due to the following reasons: A few signs of degradation include stunted trees or shrubs-like appearance, with broken canopy cover and patchy bare areas where dense forests once existed. The most common causes of this degradation include intensive harvesting of timber and fuelwood, reduced freshwater flow, and pollution events such as oil spills. For example, freshwater abstraction from the Indus River has greatly reduced water inflows into the Indus Delta, changing the species composition and biomass of mangroves. Other pressures such as sea level changes, cyclones, and flooding further worsen the condition of these ecosystems (Worthington & Spalding 2019).

Species composition

India is the world's third richest nation in terms of mangrove plant diversity, trailing behind Indonesia and Australia. Out of the 46 genuine mangrove species, nine hold global significance as "species of conservation importance". India also has the world's highest recorded biodiversity of global mangroves and about 56% of global mangrove species within mangrove forests with a total of 4,107 species (23% flora and 77% fauna). Bhitarkanika in the state of Odisha is popularly known as the 'Mangrove Genetic Paradise' on a global scale (FSI 2023). Floristic compositions are influenced and altered by the constant flux due to both natural forces like sedimentation, erosion, and anthropogenic forces possibly leading to changes in composition and local extinction of some species. All mangrove species are at varying degrees of threat in India, with about 52% of them having low abundance and restricted distribution (Ragavan et al. 2019).

Some Indian mangrove floral species and their IUCN threat status:

Critically Endangered: *Sonneratia griffithii*
Endangered: *Heritiera fomes*
Near Threatened: *Aegialitis rotundifolia*, *Brownlowia tersa*, *Ceriops decandra*, *Phoenix paludosa*, *Sonneratia ovata*
Least Concern: *Avicennia marina*, *Cynometra iripa*,

Excoecaria indica, *Heritiera littoralis*, *Xylocarpus granatum*
Data Deficient: *Aglaia cucullata*

Although the global threat status of some of these species may not be cause for concern, it is important to know that this status might not hold the same locally underlining the need for local assessments or evaluation of threats and stressors it is subject to on ground.

On the other hand, the mangrove provinces that India has parts of are assessed to be experiencing varying degrees of threat as well.

Southern India - Sri Lanka - CR
Western India and Pakistan- VU
Bay of Bengal and Andaman- LC
(Leal & Spalding 2024)

Protection of Mangroves in India

World over, degradation within protected areas is less than half those recorded from outside of protected areas. In India, mangroves found in protected areas represented 76,569.00 ha out of a total 403,784.62 ha. (18.96%) in 2020.

- Proportion lost outside protected areas 7.1%
- Proportion lost inside protected areas 3.6%
- Proportion of unprotected mangrove degraded 0.5%
- Proportion of protected mangrove degraded 0.1%

Although mangroves occur within protected areas, the level and the effectiveness of protection of these mangroves however are unknown. Protection should prevent some drivers of degradation, such as unsustainable timber extraction, and allow recovery. But degrading factors like upstream water abstraction or changes to sediment supplies, or coastal erosion and inundation driven by factors that occur beyond the protected area boundaries cannot be controlled by the same laws and so some degradation could continue. These challenges point to a critical fact, that protected areas alone cannot conserve mangroves (Worthington & Spalding 2019).

Past Projects

Pre-Independence and Early Post-Independence Period (1900–1979): Baseline Management Era

During British administration, mangroves in the Sundarbans and Andaman Islands were managed mainly for timber and fuelwood (Blasco 1975; Banerjee et al. 1989). These activities were resource-driven and aimed at maintaining navigability and preventing erosion rather than ecological restoration.

By the 1960s and 1970s, state forest departments in West Bengal and Odisha began small-scale experimental plantations using Rhizophora and Avicennia species. However, due to limited understanding of hydrology and the use of monocultures, survival rates were often below 40% (Kathiresan & Rajendran 2005).

1980–1999: Institutionalization through the National Mangrove Management Programme (NMMB)

India formally began mangrove restoration efforts in the 1980s with the launch of the National Mangrove Management Programme (NMMB) under the Ministry of Environment and Forests (Singh 2001). The programme covered 38 mangrove sites, including areas in Gujarat, Tamil Nadu (Pichavaram, Muthupet), and Andhra Pradesh (Godavari delta).

For example, Gujarat's mangrove cover expanded from 397 km² in 1991 to 991 km² by 1997, mainly due to large-scale Avicennia marina plantations (Singh 2001). Although there was an increase in area, biodiversity recovery remained limited. The absence of community participation, inappropriate site selection, and short-term goals contributed to these shortcomings (Selvam et al. 2010; Giri et al. 2011).

2000–2019: Community-Based and Integrated Approaches

In the early 2000s, mangrove management shifted towards hydrological restoration and local participation. The M.S. Swaminathan Research Foundation (MSSRF) implemented the Pichavaram Eco-Restoration Project (2000–2007), restoring 1,477 ha through community-led tidal channel reopening and mixed-species planting, achieving a survival rate of 75–85% (Selvam et al. 2010).

Similarly, the Mahanadi Delta Project in Odisha Integrated Coastal Zone Management (ICZM) principles (World Bank 2015). Despite strong local engagement, funding limitations hindered long-term continuation (Ghosh et al. 2015).

Under the World Bank-funded ICZM Project (2010–2019), multi-stakeholder restoration initiatives in Andhra Pradesh, Gujarat, and Odisha covered over 20,000 ha. Gujarat's community-managed afforestation, supported by private entities, resulted in an 8,300 ha increase in mangrove cover and a 31% rise in fisheries income. These projects demonstrated the value of public-private partnerships, livelihood integration, and scientific baseline mapping, though issues like fragmented monitoring and poor post-project maintenance persisted (Roy et al. 2018).

2020–2025: Blue-Carbon and Climate-Resilient Approaches

The current decade aligns mangrove restoration with climate policy, blue-carbon initiatives, and Sustainable Development Goals (SDGs). The MISHTI Programme (2023–present) integrates mangrove conservation into India's Nationally Determined Contributions (NDCs), aiming to enhance shoreline protection and local livelihoods (MoEFCC 2023). The programme operates through joint efforts of government agencies, NGOs, and corporate CSR partners across Gujarat, Maharashtra, Odisha, and Tamil Nadu.

However, implementation challenges remain. For example, in Mumbai, Shaham (2025) observed that 52% of restored sites showed minimal recovery after a decade due to plastic accumulation, invasive species, and poor hydrological maintenance. Broader concerns include urban pollution, funding discontinuities, and inconsistent monitoring frameworks (Bhattacharjee et al. 2025; Mongabay India 2025).

MISHTI Programme (2023–Present)

The Mangrove Initiative for Shoreline Habitats & Tangible Incomes (MISHTI) was launched after India joined the Mangrove Alliance for Climate at COP27 (2022). It focuses on increasing mangrove cover along coastlines and saltpan lands, particularly in the Sundarbans Delta, Hooghly Estuary, and other key wetland regions.

Announced in the Union Budget 2023–24, MISHTI aims to restore approximately 540 km² of mangroves across nine States and three Union Territories over five years, promoting mangroves as vital ecosystems for carbon sequestration, coastal protection, and livelihood security.

The programme identifies four types of areas for restoration:

1. Areas submerged all day with freshwater infusion,
2. Areas with partial freshwater availability,
3. Tidal areas without freshwater infusion, and
4. Non-tidal areas without freshwater.

By 2025, about 22,560 ha of land had been brought under restoration across 13 states/UTs. Most progress occurred in Gujarat (19,220 ha), followed by Tamil Nadu (1,060 ha), Andhra Pradesh (837 ha), and Odisha (761 ha). West Bengal, despite holding the largest mangrove cover (about 2,119 km²), saw only 10 ha of new plantation.

Prime Minister Narendra Modi highlighted Gujarat's success during Mann Ki Baat, noting that mangrove plantations near Dholera now span 3,500 ha, with increased sightings of dolphins, crabs, and migratory birds. Overall, while MISHTI represents a strong national push for restoration, its success will depend on addressing site-specific challenges, sustained funding, and continued local participation.

Alignment with India's Commitments (NBSAP Goals)

India's national and state-level frameworks emphasize restoring degraded ecosystems - terrestrial, inland water, and coastal with a target of bringing 30% of degraded ecosystems under active restoration by 2030. Policies call for:

- Strengthening ecological connectivity and integrity,
- Promoting ecosystem-based and nature-based solutions,
- Supporting sustainable livelihoods to reduce dependence on natural resources, and
- Encouraging public and private sector investment in restoration and habitat improvement.

Indicators

All restoration efforts should include appropriate indicators that not only help evaluate the effectiveness of a project but also inform on ways we could alter the approach for better outcomes. It is prudent to have specific indicators at different stages of the process based on the progressive changes that finally lead to an expected outcome. Some indicators that are included in the updated National Biodiversity Strategy and Action Plans (NBSAP) 2024–2030 under Target 2 which are relevant to mangrove restoration are as follows,

- Headline indicator—2.1 Area under restoration
- Component indicators—Land degradation
- Complementary indicator—proportion of Key Biodiversity Areas in favourable condition.
- Other national indicators:
- 2.2 Trends in aquatic ecosystems
- 2.3 Trends in mangrove cover and coastal management
- 2.5 Trends in afforestation and restoration
- 2.9 Extent of restoration of degraded wetlands

The following indicators have to be quantified and recorded at the beginning and during the process of restoration to first establish a baseline and then evaluate the progress made (SWAMP). Apart from these above-mentioned general indicators, there are also some of the specific indicators that can be used in various aspects to assess progress from different components.

Physico-chemical indicators

Carbon sequestration: As per Worthington & Spalding (2019) this being one of the common objectives while planting mangroves, the same can be used to evaluate mangrove restoration success as well. India shows a high likely gain from restoration in terms of tons of carbon in the upper meter of soils in restorable areas, a combination of novel carbon sequestration and avoided losses from remaining carbon still found in the soils.

- Sediment properties: Metrics like bulk-density, organic matter, total carbon, total nitrogen, and total phosphorus.
- Hydrology: Water level, pH, frequency, and duration of flooding in the site determines the salinity, nutrient availability and hence the growth of seedlings. Continued monitoring of hydrological factors like hydroperiod, availability of different sources of water can help monitor progress of the operation.

Biological indicators

- Recruitment, seedling survival, and growth rate: The growth and survival of seedlings can be monitored and recorded at regular intervals and the total percentage survival is used to evaluate the effectiveness. This rate varies with species and can be affected by the suitability of the method used.
- Species composition: Successful restoration manifests in the recolonization and persistence of biotic elements that were associated with a habitat prior to degradation along with the species composition and diversity of the mangrove flora itself. These can be specific flora and fauna that depend on a mangrove ecosystem. For example, in India there are 188 plant species and several species of fish, macroinvertebrates, birds, and reptiles documented to be associated with mangroves that often expand their range into the hinterland mangrove environments (FSI 2023). Realistically, these elements cannot be introduced but can only return in the presence of suitable conditions and resources, and hence they make an excellent natural indicator to evaluate the effectiveness of a restoration effort.
- Vegetation cover: This is more suitable for long-term evaluation or that which employs assisted natural regeneration methods of restoration. It can be quantified using GIS, remote sensing, and Landsat data. This can also be used to evaluate the area brought under effective restoration at the end of 2030 which is a direct indicator of Target 2.

Recommendations for Effective Mangrove Conservation (2025–2030)

1. Defining Clear Pathways for Implementation

To achieve the objectives of the Kunming-Montreal Global Biodiversity Framework the restoration and conservation strategies for mangroves must be clearly defined- including what needs to be done, how, when, and where, along with an upfront assessment of costs, risks, and responsibilities. Without this clarity, even well-intentioned projects risk falling apart and inefficiency.

2. Addressing Knowledge Gaps in Indian Mangroves

Indian mangroves remain underexplored in many scientific and ecological aspects. Major gaps exist in understanding forest structure, faunal & genetic diversity, soil properties, microbial communities, and ecosystem service valuation (Ragavan et al. 2019). Filling these knowledge gaps through systematic, long-term studies is essential for informed management and effective restoration.

As ecological diversity declines globally, the conservation focus has shifted from protecting individual species to safeguarding entire ecosystems. This move toward ecosystem-based management recognizes that mangrove health depends on the complex relationships between living organisms and their environment (Ragavan et al. 2019).

3. Integrating Science into National-Level Policy

At the national level, mangrove policy and planning often lack a comprehensive understanding of how different mangrove habitat's function and vary along India's coasts, both ecologically and socially. Since mangrove ecosystems are dynamic and sensitive to change, understanding these interconnections is crucial. Strengthening research on hydrology, biodiversity, and socio-economic factors will enable long-term, integrated, and ecosystem-based management frameworks that preserve mangrove biodiversity and ecological integrity (Ragavan et al. 2019).

4. Strengthening Baseline Knowledge and Floristics

The floristic diversity of India's mangroves has not been adequately studied in recent decades (Ragavan et al. 2019). Updated floristic surveys are needed to confirm correct species identification, resolve taxonomic uncertainties, and map accurate distributions along both the east and west coasts. Special attention should be given to rare and threatened species, ensuring that their populations are supported through propagation and assisted regeneration.

5. Monitoring and Adaptive Management

Mangrove restoration should be scientifically monitored using hydrological, biological, and sediment-based indicators. These help evaluate short, medium, and long-term restoration outcomes. Regular monitoring enables adaptive management, where interventions are adjusted based on observed results, improving the likelihood of achieving project goals.

However, inadequate monitoring and lack of adaptive management remain widespread. Many projects are treated as one-time planting events without 3–5 years of follow-up, meaning mortality is not corrected and lessons are not learned (Lovelock; Frontiers). Building long-term, data-based management into every project is critical to ensure ecological success and accountability.

6. Community-Based Conservation and Local Stewardship

Successful mangrove conservation depends on active community participation. Involving local people from the earliest planning stages through implementation and evaluation creates local ownership and ensures sustainability.

Several studies have shown the success of community-based approaches, such as those in Probolinggo (Pribadiningtyas et al. 2013), Tiwoho (Nurrani et al. 2015), Bekasi (Yuliani & Herminasari 2017), Pasawaran (Alfandi et al. 2019), and Mempawah (Roslinda et al. 2021). In India, initiatives like "Putri Gundul" in Lembur Mangrove Patikang have demonstrated that persuasive, educative, and facilitative methods can restore up to 50% of degraded mangrove areas. Nearly 94% of participants in such programs reported understanding mangrove management and silviculture, proving that knowledge and involvement go hand in hand with ecological success.

7. Promoting Mangrove Ecotourism for Livelihoods and Awareness

Mangrove ecotourism can unite conservation with community development. Properly managed, it serves as a platform for research, education, and public awareness, while generating livelihoods. In several regions, community income has increased by over 45% following the development of ecotourism, showing that conservation can directly improve local economies.

Ecotourism also helps establish integrated management systems that reduce disaster risks while promoting environmental and social resilience.

8. Adopting Ecosystem-Based Adaptation (EbA)

Mangroves enhance adaptive capacity, strengthen resilience, and reduce vulnerability to climate change. Implementing Ecosystem-based Adaptation (EbA), a nature-based solution that harnesses ecosystem services to buffer climate impacts, can help coastal communities adapt to sea-level rise, erosion, and extreme weather events. This approach aligns directly with the Kunming–Montreal targets on climate adaptation and biodiversity mainstreaming.

9. Strengthening Governance, Inclusivity, and Coordination

Despite numerous programs, mangrove management in India suffers from fragmented governance and poor coordination among government agencies, NGOs, scientists, and local communities. This leads to duplication, unclear responsibilities, and inconsistent results.

Lack of inclusivity in decision-making also limits success. When local communities are excluded, projects fail to gain long-term custodianship and local protection. Strengthening governance means fostering coordination, data sharing, and accountability across all institutions, while ensuring communities are genuine partners, not passive beneficiaries.

10. Building Meaningful Collaborations and Accountability

Mangrove conservation must become a shared mission involving researchers, government departments, civil society, and private industries. International commitments already recognize the importance of mangroves, but they must be implemented through on-ground collaboration.

Industries that damage mangrove through construction, aquaculture, or land conversion should be held accountable and required to report transparently on their impacts. Conversely, industries can also be part of the solution by supporting restoration projects and offsetting their environmental footprints. Collaboration between government, academia, and industry can bridge funding and knowledge gaps, making mangrove conservation both economically viable and ecologically sound.

Conclusion

As the Kunming–Montreal Global Biodiversity Framework sets the theme for countries to pursue shared global goals, it offers both ambition and direction. While the targets are undoubtedly challenging, they provide a collective vision and help guide nations to reimagine a sustainable future. At the very least, to stay on the right track toward ecological balance.

In the context of mangroves, these goals bring nations to restore livelihoods, strengthen coastal resilience, and advance climate action. Restoration can directly support local communities, to meet their conservation and carbon reduction commitments.

Yet, despite this promise, the practice of restoration often remains rooted in outdated or repetitive approaches, rather than being guided by the evolving science of ecological restoration or the nuanced realities of specific ecosystems. The race to appear "green" has, at times, overlooked the ecological and social consequences of poor restoration choices, including the wrong selection of species or the neglect of local context (Roy & Fleischman 2022)

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