"BUILDING CLIMATE CHANGE RESILIENCE: COMMUNITY-DRIVEN MANGROVE RESTORATION FOR ENHANCED BLUE CARBON"

A Report By
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Photo credit:
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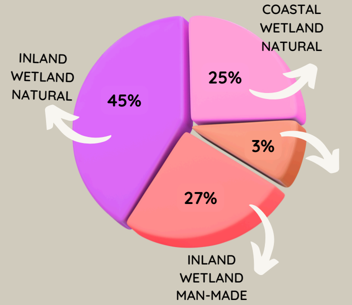
Tanjung Rhu Mangrove Tour in Langkawi

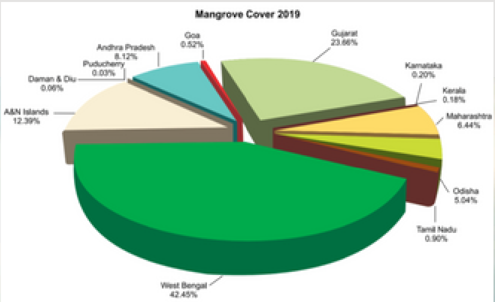
As climate change advances, our capacity for adaptation & mitigation will hinge on implementing a diverse array of strategic responses, alongside parallel efforts in ecological restoration. Conservation, the practice of protecting nature and biodiversity, has evolved alongside our growing awareness of the impact human activities have on the planet. In the 20th and 21st centuries, conservation efforts have expanded to include not only iconic species but entire ecosystems. One such ecosystem that has come to the forefront of global conservation efforts is the wetland and mangrove restoration.

Wetlands offer vital benefits to humans and wildlife, including groundwater recharge, water purification, flood protection, climate regulation, and support for biodiversity and livelihoods. By buffering communities against climate impacts, wetlands enhance resilience. Despite these essential roles, global wetland coverage declined by an estimated 64–71% in the 20th century, with inland wetlands shrinking faster (61%) than coastal ones (46%) (Davidson, 2014). This loss is widespread, with regions like Oceania and Latin America losing between 12% and 59%. In India, nearly 40% of wetlands have lost their natural state in the last 30 years. From 1970 to 2015, around 35% of inland and coastal wetlands disappeared, with recent losses occurring 3.7 times faster than in previous centuries (Ramsar Convention on Wetlands, 2018). Coastal regions, where 40% of the world's population and 12 of its largest cities are located, face particular challenges from intense human activities and the combined crises of pollution, biodiversity loss, and climate change. This has reduced ecosystem services, leaving only 15% of coastlines in a natural state (Duarte et al., 2013). Coastal wetlands stabilize shorelines, buffer storms, and support marine species, benefiting both ecosystems and economies. India's 7,516 km coastline includes diverse coastal wetlands, spanning 3,880,569 hectares across 3,497 sites, with natural coastal wetlands making up 24.27% of the country's wetlands. Mangroves are the most prominent, covering 487,100 hectares, with the Sunderbans—40% of which is in India—being the world's largest tide-dominated mangrove area.

WETLAND DISTRIBUTION IN INDIA (AREA WISE)



Source: National-wetlands-statistics, ministry of environment, forest and climate change - Govt of India



State Wise Percentage of Mangrove Cover – Source Forest Report 2019

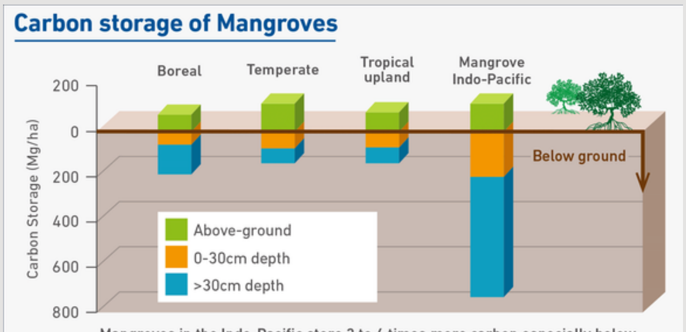
The natural coastal milieus in India, and in particular the estuary systems and fluvio-marine connections, contribute directly to producing ecological services that are useful or even indispensable to the coastal societies, perhaps even more so in the context of climate change on the agenda today. These ecological services procure identifiable benefits on every scale, including global: carbon sequestration by the mangroves, sea grass beds and coastal marshlands, the importance of which is recognized as:

Self-maintenance services: Habitat and environment upkeep, energy flow, nutrient cycles, ecosystem functions, reproduction, and nourishment.

Provisioning services: Fisheries, agriculture, firewood, gathered food products, aquaculture, building materials, medicines, genetic resources, etc.

Regulation services: Climate regulation (carbon capture), coastal protection, water purification, flood control, dune stabilization, etc.

Cultural services: Scenic landscapes, recreation, research, education, cultural heritage, and traditional practices.



Mangroves in the Indo-Pacific store 3 to 4 times more carbon especially below ground than boreal, temperate and tropical upland forests. (Donato et al., 2011)

Source: Website of the International Society for Mangrove Ecosystems

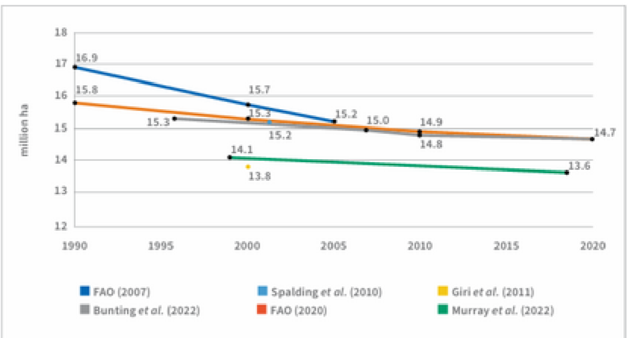
Despite these benefits, mangroves have been at risk since early colonial times. Some historical European and other "outside" observers associated mangroves with negative services, or disservices. In Florida, from the 1700s to the 1900s, mangrove destruction was widely used to control mosquito populations. Mangroves have continued to decline in more recent times in India as they are cleared for development, tourism, urban expansion, and aquaculture. Mangrove forests are globally rare and cover an area of only around 152,000 Sq.km in 123 tropical and sub-tropical nations and territories; this is less than 1% of all tropical forests worldwide, and less than 0.4% of the total global forest estate. India has 3 percent of the total mangrove cover in South Asia. The current assessment shows that mangrove cover in the India is 0.15% of the country's total geographical area." West Bengal has 42.45% of India's mangrove cover, followed by Gujarat 23.66% and A&N Islands 12.39%. Gujarat shows maximum increase of 37 sq. km in mangrove cover.

Table
Relative rates of carbon fluxes and capacity to build long-term carbon stocks for different wetland types

Wetland Type	Soil Carbon Sequestration Rate	Methane Emission Rate	Ability to act as Net GHG Sink	Long Term Carbon Stocks
Salt Marsh	High	Low	High	High
Mangrove	High	Low to High	Moderate to High	High
Freshwater Tidal Marsh	High	High	Low	Moderate
Estuarine Forest	High	Low	High	Moderate
Sea grass Bed	High	Low	High	High
Tropical Peatland	Low	Moderate to High	Moderate	Very High
Forested Freshwater Wetlands	High	Moderate	Moderate	Very High

Source: Adapted from Crooks et al. 2011. Note that there may be some overlap in the wetland types shown.

Figure 1. *Estimates of global mangrove area, 1990–2020*



Source: Compiled by the authors using the sources cited.

COMMUNITY NATURE BASED MANGROVE RESTORATION INTERVENTION

Restoration is advised when ecosystems are so degraded they can no longer self-correct or regenerate without intervention. In sites with heavy human pressures, natural recovery is often impossible without restoring physical and biological features. Mangrove restoration, for example, frequently involves directly planting propagules or transplanting saplings, whether wild or nursery-raised, to designated areas. Increasingly, researchers are recognizing the value of learning from local and indigenous communities who depend on and hold deep knowledge about mangrove ecosystems. However, no comprehensive reviews have systematically explored the role of local and indigenous knowledge (L/IK) in mangrove studies.

To address this, we conducted a systematic review specifically examining L/IK in mangrove research, focusing on studies that integrate local knowledge into data collection, planning, or understanding ecosystem functions. Our review categorizes L/IK insights (such as causes of degradation, mangrove species identification, and ecosystem services) and identifies methods used to gather and include local knowledge while ensuring ethical engagement with communities.

This review examines researchers' engagement with local and Indigenous knowledge (L/IK), identifying the specific aspects of this knowledge that have been studied and highlighting existing gaps. By outlining best practices, it advocates for deeper integration of L/IK into mangrove research, aiming to support more effective and sustainable restoration initiatives. Many mangrove restoration projects have failed when local expertise

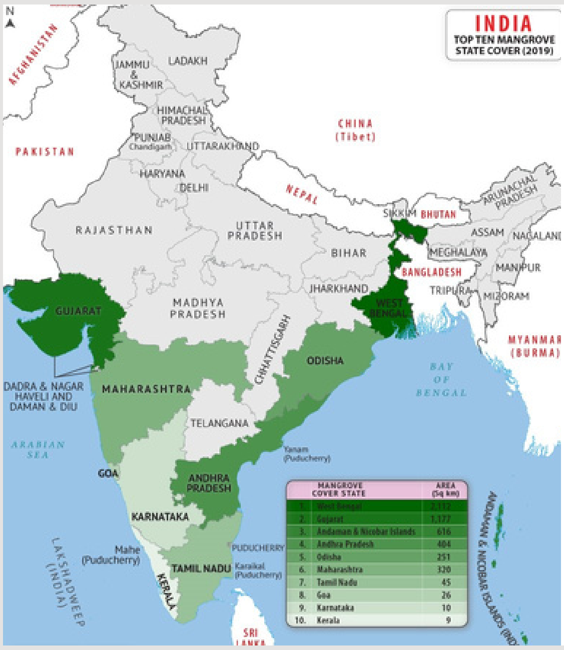
importance of integrating L/IK for meaningful and lasting restoration outcomes.

<u>Encouraging community participation</u>

Restoring mangroves is a powerful nature-based solution to address societal issues, like the financial consequences of climate change, poverty, and jobs creation. The

> A growing body of literature shows that there is considerable interest in learning from the people who live in, rely on, and hold extensive knowledge about mangroves.

was ignored, demonstrating that community involvement is often essential to sustainable resource management. For conservation and rehabilitation of mangrove ecosystems, community participation is vital in the planning, execution, and monitoring stages, fostering a sense of accountability for the program's long-term success. Equally important is raising public awareness about mangrove conservation, with educational programs helping to build environmental stewardship. Sustainable mangrove management, especially in areas requiring restoration, benefits from the commitment of local residents. When communities are motivated by both environmental and personal gains, restoration efforts are more likely to succeed. With ongoing community



Mangroves capture and store more CO2 relative to their area than forests on land. This ability to store carbon has drawn attention to mangroves as a powerful tool to fight climate change.

engagement and proper care, mangrove biodiversity can be preserved, while organized local groups, often supported by government initiatives, can sustainably manage and utilize mangrove regions along coastlines. The environment and mangrove diversity are successfully preserved by this community involvement. Important issues that must be considered in bringing in and addressing community interests are such as:

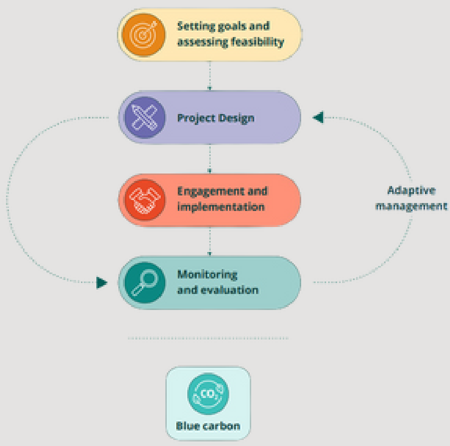
i. Community perceptions and understanding on the comparative benefits of conversion to other uses versus maintenance of intact mangrove forest ecosystems;

ii. Legal recognition of the mangrove resources in terms of rights to access and use; and

ii. Land use governance defined by the institutional, economic, socio-cultural and property rights dynamics.

Additionally, mangrove ecosystems help frontline communities adapt and build resilience to a changing climate by protecting against extreme weather events and sea level rise, and supporting sustainable livelihoods such as fisheries.

Implementation of mangrove restoration projects requires adaptive approaches (learning by doing) to be effective. This includes the use of multiple scenarios on future socio-economic and physical changes (e.g. land use and/or climate change). Each potential restoration site requires field investigation to identify areas of stressed, dead or lost mangroves, and to determine whether the site requires management to support recovery or it is



Several project stages, often overlapping rather than strictly linear. Monitoring and evaluating progress helps adapt and refine project design and implementation as needed.

capable to recover by itself over time.

Countries with coastal wetlands can include commitments to protect and restore mangroves in their Nationally Determined Contributions (NDCs) under the Paris Agreement, recognizing their mitigation and adaptation benefits. Coastal and marine Nature-based Solutions (NbS), such as conserving and restoring mangroves, seagrasses, and tidal salt marshes, are crucial for achieving the Paris Agreement goals. The current "Ambition Cycle" offers an opportunity to enhance mangrove conservation efforts and strengthen commitments through national and international processes. Including mangroves in NDCs highlights national policy priorities, encouraging global support and action for their protection and restoration.

Engaging national-level stakeholders can be one of the most complex aspects of a restoration project, as it often depends onthe political climate and the shifts indecisions and leadership after elections. Incountries where much of the land suitable for restoration is state-owned, changes in national priorities can affect land availability for these projects. For instance, before an election, the government may focus on achieving climate targets, while after an election, the new administration may prioritize economic growth, creating either alignment or conflict in priorities. Establishing institutional partnerships between national agencies and other stakeholders can provide financial sustainability and scalability for mangrove restoration programs. Government involvement can enhance goal evaluation, facilitate outcome dissemination, secure funding renewals, and support the development of future projects. By restoring mangrove ecosystems, these projects not only enhances coastal resilience but also promotes biodiversity, provides habitat for marine life, and supports sustainable fisheries management.


Sundarbans mangrove forest, (140,000 ha)

Red mangroves (Rhizophora mangle), identified by their stilt-like roots, and the black (Avicennia germinans) and white mangroves (Laguncularia racemosa) thrive in tidal waters, where freshwater from the Everglades (Florida, USA) mixes with saltwater.
Photo credit: Arun Kashyap

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