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Protecting Mangrove Ecosystems

Learning from India's Coastal Regions

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Key Messages >>>

- Mangrove forests cover just 0.1 per cent of the world's land area are significant role in socio-economic and ecosystem terms and provide physical protection by serving as a natural ecological barrier against ocean currents, storms, and cyclones. India has a total mangrove cover of 4,975 sq km which amounts to 3 per cent of the global mangrove forest area and 8 per cent of Asia's mangrove forest area.
- Due to rampant human exploitation in coastal regions, unsustainable urban development, improper waste management and the accelerating impacts of climate change including rising sea-levels, altered weather patterns, and the acidification of the oceans, the health of mangrove forests have been deteriorating at an alarming rate.
- Methods for mapping and monitoring of mangroves is important and while satellite data analysis and geographical information system are the most effective methods available for monitoring 'forest cover', they cannot be used to gauge the health of the forests. Assessing the health of mangroves would require additional field surveys to complement satellite data.
- An inclusive framework for understanding, predicting, and managing interactions between climate change, human activities, and coastal ecosystems needs to be formulated. At the most basic level, efforts must be made to create awareness and educate the public regarding the vital role that mangroves play and provide community training to generate the requisite skills and knowledge to conserve and restore mangrove ecosystems.

Importance of Mangroves

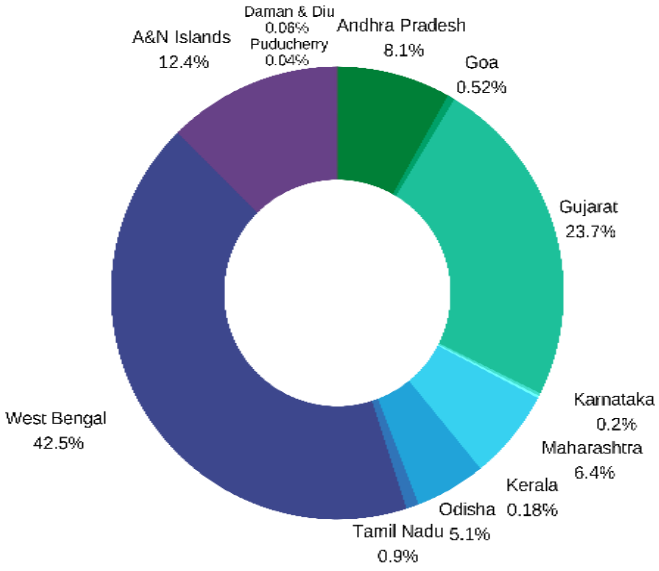
Mangroves form a unique ecosystem that exists along the coastline, on the margin between land and sea in tropical and subtropical areas.[1] Mangroves are considered to be amongst the most productive, diverse, and crucial bio-resource in the coastal environment. They have tremendous socio-economic and ecological value as they provide goods and services to human societies and coastal and marine species. For instance, they offer several vital ecosystem services such as regulating water quality, providing a breeding ground for fish species, and are a source for fuelwood, charcoal, timber, and wood chips. They have several unique features, such as aerial breathing roots and extensive supporting roots.[2] They play a significant role in stabilizing the shoreline and providing physical protection by serving as a natural ecological barrier against ocean currents, storms, and cyclones. They also help in flood-attenuation since their roots and organic matter trap sediments and act as sponges, absorbing floodwater.[3] As a result of these characteristics, they protect the most vulnerable coastal communities from the devastating impacts of climate change-induced sea-level-rise and extreme-weather events.

Mangrove forests also store large amounts of carbon — more than any other type of forest. Therefore, they play an important role in mitigating climate change. However, due to rampant human exploitation in coastal regions and the accelerating impacts of climate change including rising sea-levels, altered weather patterns, and the acidification of the oceans, the health of mangrove forests around the world is deteriorating at an alarming rate.[4]

The Case of India

Mangrove forests cover just 0.1 per cent of the world's land area and just 15 countries[1] account for more than 75 per cent of the total global mangrove forest area.[5] India has a total mangrove cover of 4,975 sq km, which is 0.15 per cent of the country's total land area but amounts to 3 per cent of the global mangrove forest area and 8 per cent of Asia's mangrove forest area.[6] Of this, about 60 per cent is located along the country's eastern coast (abutting the Bay of Bengal), 27 per cent is located along the western coast (abutting the Arabian Sea), while the remaining 13 per cent is found in the Andaman and Nicobar Islands. Coastal states are generally the most industrialized, and, in such states, the reclamation of mangrove areas to support human settlements, aquaculture, the rampant discharge of industrial effluents and toxic substances, are all major factors that lead to destruction and degradation of mangrove health and cover. Most coastal states that are vulnerable to the adverse impacts of climate change, such as Tamil Nadu, West Bengal, and the Andaman and Nicobar Islands, are the very ones that continue to experience loss of mangrove cover. As depicted in Figure 1, the mangrove-distribution among maritime states differs quite extensively.

Figure 1: Share of Mangrove Cover in Different States and UTs of India in 2019 (%)



Source: Based on India State of Forest Report 2019[7]

West Bengal has the largest mangrove forest and accounts for 42.45 per cent of the total mangroves cover, followed by Gujarat with 23.66 per cent. The mangrove forest cover of other maritime states is marginal compared to that of these two states. Daman and Diu, for instance, accounts for just 0.03 per cent (3 sq km), Puducherry 0.06 per cent (2 sq km), Goa 0.52 per cent (26 sq km), Kerala 0.20 per cent (9 sq km), Karnataka 0.205 per cent (10 sq km), and Tamil Nadu 0.09 per cent (45 sq km).

[1] Indonesia has by far the largest mangrove forest cover with 22%, followed by Brazil, Australia, Nigeria, Malaysia, Bangladesh, Papua New Guinea, Mexico, India, Cuba, Mexico, Mozambique, Myanmar, Madagascar and Philippines.

Within the states themselves, the density of mangrove forests is not uniform, as very dense mangrove comprises 1476 sq km (29.66%) of the mangrove cover and are limited to just three coastal states, namely, West Bengal (996 sq km), Andaman and Nicobar Islands (398 sq km) and Odisha (81 sq km) (see Table 1). Globally, too, mangroves are disappearing at a rate of 1 to 2 per cent per year, which is even faster than coral reefs and tropical rainforests.[8] Since the 1950s, about 50 per cent of the mangroves biome has degraded due to inadequate protection and extensive alteration of their habitat.[9] At the current rate, all the world's mangroves will be lost by the end of this century.[10] India itself has lost as much as 40 per cent of its mangroves during the last century alone.[11] India had a mangrove cover of about 6,749 sq km (the fourth largest mangrove area in the world),[12] which dropped by nearly 59.18 sq km between 1972−75 and 1980−82, as per the 2019 report of the National Remote Sensing Agency, India.[13]

Table 1: Mangrove Cover across India in 2019 (sq km)

Sr. No.	State/UT	Very Dense	Moderately Dense	Open	Total
1.	Andhra Pradesh	0	213	191	404
2.	Goa	0	20	6	26
3.	Gujarat	0	169	1008	1177
4.	Karnataka	0	2	8	10
5.	Kerala	0	5	4	9
6.	Maharashtra	0	88	232	320
7.	Odisha	81	94	76	251
8.	Tamil Nadu	1	27	17	45
9.	West Bengal	996	692	424	2112
10.	A&N Islands	398	169	49	616
11.	Daman & Diu	0	0	3	3
12.	Puducherry	0	0	2	2
Total		**1,476**	**1,479**	**2,020**	**4,975**

Source: India State of Forest Report 2019[14]

The density and diversity of mangroves are affected by temperature and moisture to a very significant degree.[15] Increasing temperature causes heat stress and increase in ocean salinity. The problem of salinity of water is exacerbated by rising sea-levels, as also by other factors such as changes in the flow of fresh water from rivers, and, the growth of human activities such as shrimp-farming and expansion of salt pans along the coast.[16] In fact, the expansion of salt pans along the coast is one of the major causes of decline of mangrove species. For instance, Gujarat is the single largest producer of salt in India and contributes 80 per cent to the total marine salt production of the country. Large portion of mangrove areas were leased to industries for the creation of salt pans. As a result, the salinity level in Gujarat's soil and water is very high and this is reducing the natural regeneration of mangrove forests. The State government of Gujarat has recorded that over 14 species of mangroves have already become extinct[17].

Despite the cases of degradation of mangroves in Gujarat, the 2019 edition of the "India State of Forest Report" (IFSR) states that the mangrove forests cover area in Gujarat (1,177 sq km) has increased "substantively"—by about 750 sq km—since 1987, which is almost a three-fold increase. There is some possibility that localized conservation efforts are at least partially responsible for this apparent reversal, but the dichotomy remains largely unaddressed. A more likely reason for the seemingly increasing trend could be ineptitude or inaccuracies in the methods used for mapping and monitoring of mangroves. Even though satellite data analysis and geographical information system are the most effective methods available for monitoring 'forest cover', they cannot be used to gauge the health of the forests. Assessing the health of mangroves would require additional field surveys to complement satellite data.

Major Challenges Facing Mangroves: Climatic and Natural Factors

The mangrove forest ecosystem in general shows "exceptional morphological and physiological adaptation skills to counter the environmental and natural stress associated with their intertidal habitat".[18] However, sea-level rise is amongst the more critical of the various factors that contributes to the degradation of mangrove habitats. According to recent projections,[19] global mean sea-level could rise by an estimated 0.61-1.1 meters by the year 2100, which would place most Indian coastal cities at high risk of complete submergence or, at the very least, of experiencing frequent

inundation during high tide conditions. Changes in sea-level impact the structure, growth, and areal extent of the mangroves, while increase in temperature affects their density.[20] In an assessment conducted by Gilman et al. in 2015,[21] it has been suggested that sea-level rise will be the primary driver of future mangrove area losses in the Sunderbans. The Sunderbans area, straddling India and Bangladesh, has the world's largest mangrove ecosystem, which is recognized as the largest land-based carbon sink in South Asia. The Sunderbans mangrove forest was declared a 'reserve forest' in 1996, and a 'UNESCO World Heritage Site', in 1997,[22] because of its crucial environmental and socio-economic role. As per the latest India State of Forest survey report, Sunderbans lost 2 sq km of mangrove cover, going from 2214 sq km to 2112.11 sq km, between 2017 and 2019. This loss was primarily driven by erosion and sea-level rise in the Bay of Bengal.[23]

Besides sea-level rise, storms and tropical cyclones also have significant impacts on the coast, directly through damage caused by extreme winds, and indirectly through storm surges and high tides.[24] For instance, following the *tsunami* that occurred in the Indian Ocean in 2004, it was reported that around 62-70 per cent of the mangrove forest in the Nicobar Islands was damaged and uprooted,[25] and Pichavaram mangroves suffered 5–10 per cent damage.[26] In the case of the 1999 Orissa Super Cyclone (IMD designation BOB 06 — cyclones began to be named only from the following year), the Forest Survey of India assessed that at least 50 per cent and 40 per cent of the mangroves had been lost in two districts of Orissa, namely, Jagatsinghpur and Kendrapara, respectively, which hold a significant share of the Mahanadi mangroves.[27] Similarly, Cyclone *Amphan*, in 2020, damaged vast swaths (an area of some 1, 600 sq km) of the mangrove forest in the Indian Sunderbans that accounts nearly 40 per cent of the total area of 4,000 sq km.[28]

Although, as has been mentioned earlier, mangroves are well adapted, both morphologically and physiologically, to saline conditions, this is true only up to a finite threshold. A great degree of variation in water and soil salinity has been recorded in Indian coastal states in recent decades, with some regions experiencing significant increases. For instance, salinity in the Pichavaram mangrove of Tamil Nadu, varied between 0.6 per cent and 36.2 per cent during 2004-2005.[29] Dr V Selvam, the lead researcher who is looking into the depletion of mangrove cover in Tamil Nadu, noted in an interview in 2019 that the wetlands in Pichvaram and Muthupet have lost five species of mangrove trees over just 70 years, due to the sharp increase in salinity levels.[30] High salinity has severe and entirely adverse impacts on the species-diversity of mangroves and on even marine animal species. A notable decrease of gastropods (snails, slugs, etc.) in the Pichavaram mangroves was reported and, similarly, migratory water birds' populations were also shown to decline, due to increases in salinity.[31] Extreme saline conditions have also led to a 90 per cent reduction in freshwater flow.[32] When the supply of fresh water decreases, afforestation of mangrove in highly saline coastal wetlands becomes challenging.

Anthropogenic Factors that Impact Mangroves

Another major cause for impairment of mangrove forests in India is due to anthropogenic activities such as conversion of mangrove habitats into agricultural land or for the promotion of aquaculture, tourism, and urban development in general.[33] A majority of India's coastal communities are dependent on agriculture for their livelihood. It has been recorded that over the past 100 years, about 1,50,000 hectares[2] of mangroves have been destroyed in India and Bangladesh in order to make land available for agricultural purposes.[34] Further, Indian coastal cities are experiencing rapid urbanization and the concomitant development of urban infrastructure, whereby the majority of mangrove forest in Indian coastlines have been lost to land-reclamation and other supposedly 'developmental' projects. Mumbai city is a perfect example, as it was built on a cluster of seven islands each of which was surrounded by mangroves. In the case of the Mumbai suburban region, a total mangrove area of 36.54 sq km was lost during a period of just 11 years, from 1990 to 2001, which accounted for a 39.32 per cent decrease in the mangrove cover area.[35] Even more recently, hundreds of acres of mangroves have been cleared for the construction of the Navi Mumbai International airport. [36]

[2] One hectare [abbreviation: 'ha'] is equal to 2.47 acres or 10,000 square metres

In 2019, Maharashtra's Transport Minister blandly stated that around 32,044 mangroves would be cleared for the Mumbai-Ahmedabad bullet train project.[37] Achal Khare, Managing Director of the National High-Speed Rail Corporation Limited (NHSRCL), claimed that *"if 32,044 mangroves are cut, then around 1,60,000 new mangroves will be planted, and the entire financial expense will be borne by NHSRCL".*[38] However, even as the Maharashtra government promises to replant mangroves to substitute those that were cleared, there is no land available within the city to replant the mangroves, as was pointed out by Debi Goenka, the executive trustee of a Mumbai-based non-profit organization, the 'Conservation Action Trust'. Goenka pointed out that even if mangrove restoration did, by some miracle, take place, most of the planted saplings would not survive. Presently, Mumbai city has only 2 sq km of mangrove forests in all. This is a huge loss for this megapolis, if only because mangroves are highly efficient natural defenses against sea-level-rise and cyclonic storms, both of which have already begun to ravage the city.

The seemingly ceaseless development of ports and harbors is also contributing to mangrove degradation. For instance, the port of Mundra, in Gujarat, has been roundly condemned globally for severely degrading Indus delta mangroves. Likewise, Paradip Port in Odisha has also been reported to have built over dense patches of Mahanadi delta mangroves.[39] Pollution is yet another big challenge for the mangrove ecosystem, especially in megacities such as Mumbai and Kolkata. Large amounts of solid waste and effluents from various sources are being callously dumped into the mangrove ecosystems. Oil spills, when they happen in coastal waters, severely impact mangrove ecosystems. If all this were not enough, the construction of dams on rivers also leads to reduced flow of freshwater, which adversely affects the growth of mangroves.

Implications of Loss of Mangroves

The acceleration of unsustainable human activities, coupled with the adverse impacts of climate change, are threatening the mangrove ecosystem, placing the lives and livelihoods of millions of coastal residents at high levels of risk. Any further loss of mangrove forests would leave coastal communities without a vital line of defence against extreme-weather events that are becoming more frequent and more intense. Numerous studies have shown that mangroves play a critical role in protecting coastal communities from the impact of large storms. For instance, when Cyclone *Bulbul* hit Odisha and West Bengal on 9 Nov 2019, it was reported that the wind speed of Cyclone *Bulbul* was reduced by 20 km an hour because of the Sunderbans mangrove forest. This saved the rest of southern West Bengal from the disastrous storm, which might otherwise have proven to be cataclysmic for Kolkata and its environs.[40] On the other hand, the catastrophic impact of the unprecedented flooding in Mumbai, in 2005, was exacerbated by the lack of mangroves along the 18 km long *Mithi* river. These mangroves had earlier been cleared for construction purposes. Consequently, Mumbai was left without any natural buffer against flood surges.

More often than not, biodiversity and the functioning of marine ecosystems are closely interlinked. A loss of biodiversity loss could limit the functioning of ecosystems, which subsequently reduces their capacity to provide goods and services to coastal communities. Roughly 560 million people live along India's coastline and the vast majority of them are dependent on marine and coastal ecosystems, even if they and their elected representatives seem largely oblivious of this fact.

Mangroves serve as a critical breeding ground and nursery habitat for a wide range of marine organisms, including shrimps and fishes. Importantly, commercial marine fish species such as cuttlefish, squid, lobster, shrimp, and certain types of finfish, contribute enormously to India's seafood exports.[41] India ranks second, globally, in fish-production; the fisheries sector employs 145 million people and contributes 1.07 per cent to the GDP, as per a recent estimate of the National Fisheries Development Board.[42] If conserved, mangroves have the potential to significantly enhance the productivity of fisheries. On the other hand, a continuing loss of mangrove forests, will significantly and adversely impact the health and quantity of fisheries and hence the economic productivity of coastal communities.

The role of mangrove forest ecosystems, particularly in the tropics, in mitigating climate change through carbon sequestration can hardly be overstated, given that these ecosystems constitute one of the largest carbon sinks.[43] Conversely, when these mangroves are cut down, they release significant quantities of stored carbon, accelerating global warming. India is currently the eighth-

largest carbon emitter in the world in terms of total amount of annual CO_2 emissions and is likely to become the second-largest carbon emitter by 2050. Therefore, mangroves are more critical now than ever to counteract the rise in carbon emissions from human activities and mitigate global climate change.

Way Forward: Conservation of Mangroves

There has been some success in restoration of mangrove forests in India, but it is nowhere near enough, given the rate of loss of mangroves during the last few decades. A far more inclusive framework for understanding, predicting, and managing interactions between climate change, human activities, and coastal ecosystems needs to be formulated. At the most basic level, efforts must be made to create awareness and educate the public regarding the vital role that mangroves play and provide community training to generate the requisite skills and knowledge to conserve and restore mangrove ecosystems.

In recent years, some policies and conservation efforts from government, NGOs, and local communities in India, have played an important role in sustaining and restoring mangrove forests. For instance, a community-based restoration programme was carried out by local communities in the Krishna district of Andhra Pradesh, where the community innovated new techniques for cultivation and plantation of mangroves, created a village-level Forest Conservation Council, and planted 6000 mangrove saplings in the district.[44] In Gujarat, the mangrove conservation strategy involves large-scale plantation, development of new mangrove habitats at suitable areas, and, capacity-building of managers and staff. Different approaches, strategies, and methods must be studied and promoted, and the success stories shared.

Conservation of mangroves can be enhanced by devising well-balanced coastal land-use plans, such as maintaining sustainable limits in logging and other harvesting activities. Mangroves also hold religious, cultural, and sentimental value to the local communities, which is another reason to protect and preserve them. The inland mangrove forests in Shravan Kavadia, Kachchh, are considered sacred and the locals in that area strictly regulate any exploitation of the forests as such activities are believed to be inauspicious. Similarly, the Kagekanu forest patch, which is dominated by species such as *Rhizophora mucronata*, *Avicennia officinalis* and *Kandelia candel*, off the coast of Karwar in Karnataka, is one of the examples of traditional conservation through sacred groves.[45] In a way, the resource-dependent community of Karwar protects its forest from destruction as they associate nature with sacred deities. Therefore, traditional conservation strategies and inclusion of local and resource-dependent communities should be given priority in policy making.

Participation of the local community in the conservation and prevention of illegal clearing and encroachment of mangrove areas is crucial. There are a few cases where resource-dependent communities have fought against illegal activities. For instance, Sahjeevan, an NGO based in Kachchh initiated a photo story campaign to raise funds for the Camel Breeders Association of Kutch (*Kuth Ucherak Maldhari Sangathan* (KUUMS)) to "Save the Mangroves of Kandla from Salt Making Industries". It was stated that in February 2018, "Hitachi machines and tractors illegally cleared more than 4 sq km of pristine mangrove forest for salt industries".[46] Camel breeders and camels are dependent on the mangroves for their livelihood. The Camel Breeder association members saw the threat and protested against the destruction; and have started the process to revive the mangroves that were destroyed for ostensibly 'developmental' purposes. In such a situation, local authorities and other concerned stakeholders need to support the community and provide it with necessary resources, be these monetary or legal assistance. Therefore, existing forest rules must be strictly enforced to prevent unlawful entry/encroachment and indiscriminate exploitation.

In the face of rapid urbanization of coastal cities, urban development policies should vigorously address the issue of livelihoods of slum dwellers and urban poverty in India. As Seema Adgaonkar, who until recently was one of the four Range Forest Officers at the Mumbai Mangrove Conservation Unit, and has been guarding the city's vital coastal ecosystem has said, *"It's very difficult to demolish illegal structures and slums encroaching mangrove areas. There are social and political pressures from all sides on us."* [47] Ensuring urban poor with shelter and access to basic urban infrastructure and services would address some of the problems of

urban poor in the encroachment of the mangrove ecosystem.

While conservation of mangroves in the context of anthropogenic activities and pollution is discussed at least occasionally, even if not frequently enough, there is little discussion on protection of mangroves from climate change. As has already been explained, the health, growth, survival, and productivity of mangroves are largely influenced by the rise in salinity in soil. Extreme climate change is a looming danger for the entire mangrove ecosystem. Since degradation of mangrove ecosystem is caused by a wide range of factors, which cannot be treated in isolation, it is necessary to adopt an integrated management approach by taking into consideration all the factors such as sea-level rise, extreme weather, and human exploitation, and involve all the stakeholders to protect and conserve mangroves.

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About the Author

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