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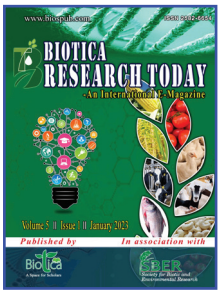

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Mangroves: Keystone of a Coastal Ecosystem

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Abstract

Globally, mangroves are one of the most productive ecosystems. They are unique with the highest record of biodiversity, gifted with the mangrove genetic bliss at Bhitarkanika, and wildlife threatened species in the Sundarbans. Mangroves are also a great source for carbon sinks and sequester the high amount of CO_2. Mangrove ecosystems are vulnerable to various anthropogenic actions such as industry, agriculture, solid waste dumping, aquaculture ponds, construction of buildings and infrastructures. This article deals with the present status of mangroves biodiversity and management strategies for restoration of particular ecosystems.

Introduction

The keystones of mangrove forest ecosystems are provided by mangrove trees; a mangrove forest would not and could not exist without mangroves. Keystone species like mangroves perform a significant ecological role by providing habitat for a variety of marine and estuarine plant and animal species. Mangroves are trees and shrubs that thrive in salty coastal environments or intertidal zones in the tropical and subtropical regions of the world (Gurjar *et al.*, 2019). Such regions are characterized by temperature range from 26 °C to 35 °C and high rainfall that are from 1000 to 3000 mm. The term "halophytes'' also refers to mangroves since they can withstand harsh environmental conditions such as high salinity levels.

According to their natural environments, they can be divided into two categories: true mangroves and mangrove associates. True mangroves are species that only thrive in intertidal zones, whereas mangrove associates can occur in either littoral or terrestrial ecosystems. Due to their anatomical, morphological and physiological adaptations, which include complex roots and salt filtering ability to deal with high salinity, frequent cyclonic storm wave action and water-logged soils, they may grow in extreme habitats. Mangroves thrive in anoxic environments because they frequently flood and have saturated soil. Mangroves are vital habitats for coastal biodiversity and also act as bio-shields against extreme weather events. Large populations, primarily rural, depend on mangrove forest for a wide variety of biomass dependent livelihoods (Kumar and Kumara, 2012).

Status of Mangrove Cover Worldwide and India

Mangroves are belongs from 9 orders, 20 families, 27 genera and around 70 species of trees. Avicennia (Avicenniaceae), Bruguiera, Laguncularia and

Lumnitzera (Combretaceae), Ceriops, Kandelia, Nypa (Palmae) and Sonneratia (Sonneratiaceae) and Rhizophora (Rhizophoraceae) are the main genera (Tomlinson, 1986). Worldwide 113 countries have mangrove forests covering an estimated 14.79 million hectares. In the world, the largest mangrove forest area is reported in Asia (5.55 million hectares) > Africa (3.24 million hectares) > North and Central America (2.57 million hectares) > South America (2.13 million hectares) > Oceania (1.30 million hectares). Four nations were said to contain more than 40% of the world's mangroves forest: Indonesia (19%) > Brazil (9%) > Nigeria (7%) > Mexico (6%).

Mangrove show conspicuous tone and texture on the satellite photographs. In this assessment, the mangrove cover has been divided into three categories: very dense (canopy density of 70% or more), moderately dense (canopy density of 40% and more but less than 70%) and open categories (canopy density of 10% and more but less than 40%). The recent report shows that mangrove cover in India is 4,992 km^2, or 0.15% of its entire geographical area. Very dense mangrove comprises 1,475 km^2 (299.55%) of the mangrove cover followed by moderately dense mangrove is 1,481 km^2 (29.67%) and open mangroves constitute an area of 2,036 km^2 (40.78%).

The mangrove cover of the country has increased by 17 km^2 overall compared to the 2019 assessment. The states with the greatest increases in mangrove cover are Odisha (8 km^2) and Maharashtra (4 km^2). The main reasons for the rise in mangrove cover in Odisha include natural regeneration, planting activities on suitable terrain, such as on the sides of rivers close to estuaries and on intertidal mudflats connected to the area that are inundated by sea water. The increase in mangrove cover in Maharashtra is primarily the result of natural regeneration (Table 1). In India, the largest mangrove area is reported in West Bengal (2,114 km^2) > Gujarat (1,175 km^2) >Andaman and Nicobar Islands (616 km^2) > Andhra Pradesh (405 km^2) > Maharashtra (324 km^2) > Odisha (259 km^2) > Tamil Nadu (45 km^2) > Goa (27 km^2) > Karnataka (13 km^2) > Kerala (9 km^2) > D & NH and Daman & Diu (3 km^2) > Puducherry (2 km^2) in 2021 (Forest Survey of India, 2021).

Table 1: Mangrove covers throughout the three canopy density classifications for each state/ UT as well as a comparison to the 2019 assessment

		Mangrove Cover Assessment 2021				km^2
Sl. No.	State/ UT	Very Dense	Moderately Dense Mangrove	Open Mangrove	Total	Change with respect to ISFR 2019
1.	Andhra Pradesh	0	213	192	405	1
2.	Goa	0	21	6	27	1
3.	Gujarat	0	169	1,006	1,175	-2
4.	Karnataka	0	2	11	13	3
5.	Kerala	0	5	4	9	0
6.	Maharashtra	0	90	234	324	4
7.	Odisha	81	94	84	259	8
8.	Tamil Nadu	1	27	17	45	0
9.	West Bengal	994	692	428	2,114	2
10.	Andaman & Nicobar Islands	399	168	49	616	0
11.	D & NH and Daman & Diu	0	0	3	3	0
12.	Puducherry	0	0	2	2	0

Significance of Mangrove Forest

Mangrove forests play a crucial role in maintaining and improving ecosystem services that benefit local and regional communities as well as the global environment. Mangroves provide a variety of ecosystem services (Figure 1). Mangroves categories ecosystem services into four groups based on the Common International Classification of Ecosystem Services (CICES) as follows.

1. Provisioning Services

• **Food provisioning:** Mangroves are permanent or temporary habitats for many aquatic faunas and are also spawning and rearing grounds for many marine fishes (Gurjar *et al.*, 2019). It is estimated that up to 80% of world fish catches are directly or indirectly dependent on mangroves. The annual market value of seafood from mangroves is estimated at 7,500-1,67,500 USD km^{-2}.

• **Medicinal resources:** It is estimated that 70 different species of mangrove flora have been used traditionally as medicines to cure a variety of diseases. The traditional usage of mangrove products is expected to generate goods worth close to a quarter of the per capita gross domestic product in coastal villages in southern Thailand and parts of Indonesia, where it contributes up to half of income to the poorest households.

• **Timber and fuel wood:** All over the world, the timber of mangrove forest is used to build bridges, build rafters, houses, fences, make furniture, poles and boats.

2. Regulating Services

• **Carbon sequestering:** It is the process through which plant life absorbs carbon dioxide (CO_2) from the atmosphere and stores it as biomass. Mangroves are significant carbon sinks that store about 25.5 million tonnes of carbon annually. Additionally, they contribute more than 10% of the vital dissolved organic carbon that is transported from land to the global ocean.

• **Reducing floods:** Mangroves act as a physical buffer to prevent floods.

• **Trapping pollutants:** Mangrove roots help trap sediments and also act as filters to remove contaminants from inland waters before they reach the sea.

3. Supporting Services

• **Biodiversity:** Because they develop in the transition zone between the land and the sea, mangrove species are uniquely configured to survive in harsh and unpredictable environments. Thus, mangroves contain unique assemblage of flora and fauna that is not present in any other ecosystem.

• **Promoting accretion:** Mangroves work similarly to a living groyne to collect silt, stabilizing the land and repairing mud banks and preventing erosion. Additionally, they guard coral reefs against sedimentation.

• **Protecting the shoreline:** Depending on their ecological condition, mangroves can absorb between 70% and 90% of the energy of the waves and serve as physical barriers between the shore and the elements.

• **Enriching nutrients:** It is estimated that every time the tide recedes, it takes with it as much as 12,500 tonnes of food for marine life each annually.

4. Cultural Services

• **Aesthetic value:** In recent years, visitors to mangroves have increased, as they learn to appreciate the uniqueness and value of mangrove ecosystems.

• **Mangroves sustain traditional fishing practices:** Mangroves are responsible for sustaining traditional fisheries in South Asia, including brush pile fisheries (traditional fishing methods in Bangladesh and Sri Lanka).

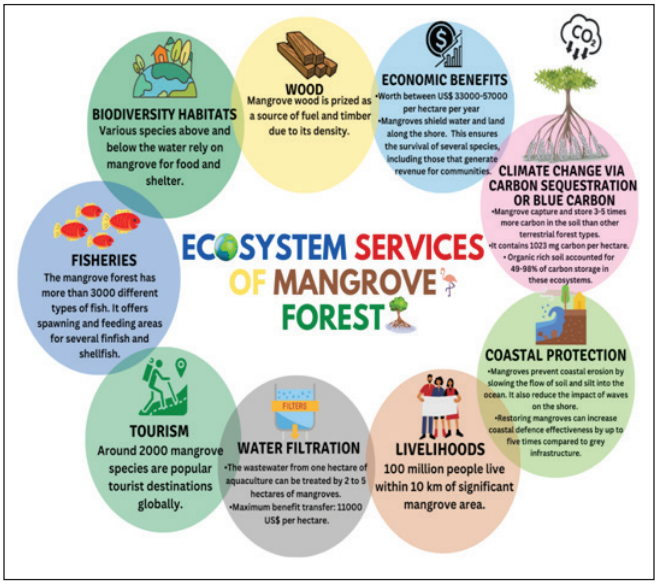

Figure 1: Ecosystem services provided by mangroves forest

Threats to Mangroves

The Indian Ocean has the largest tract of mangroves in the world and the Indo-Malayan region is the world hub for mangrove diversity, this region has also had the highest rate of mangrove loss over the past ten years. Today mangroves cover less than half of their original area and half of the surviving habitats have faced degradation. Deforestation of mangroves occurs at a rate of 2-8% annually throughout the world. There are numerous threats to mangroves, as below as well as seen in Figure 2.

Natural Causes

Powerful storms, cyclones and hurricanes may also severely damage mangrove habitats. Flooding, winds and waves might be damaging enough to completely clear mangrove islands. Other natural threats to mangrove forests include barnacle infestation, crustacean damage, insect pests such as wood borers and caterpillars and drying out of mangrove trees.

Land-Use Change

Acres of mangrove forest are steadily decreasing as a result of urbanization, infrastructure expansion and agricultural land conversion. Mangroves are cleared, dredged and diked as a result of coastal development for tourist facilities, shrimp farming, aquaculture and salt farms.

Destruction of Coral Reefs

The initial line of barrier against powerful waves and currents is provided by coral reefs. The mangroves grow in fine sediment that is washed away when they are destroyed by the high waves and currents that reach the coast. Additionally, this may prevent seedlings from germinating and wash away nutrients necessary for mangrove ecosystems.

Figure 2: Threats to mangrove forest

Impacts of Crude Oil on Mangroves

Significant amount of crude oil is discharged into coastal environments and these mangroves are highly responsive to contamination by oil and industrial waste. Mangroves are susceptible to oil deposits as marine tar residues, which alter soil chemistry and permeability and causes death as well as other sub-lethal effects.

Weak Legislation's and Enforcement

The enforcement of forest laws in India appears to be lacking and numerous legal instruments including the Forest Act of 1927's penalties are ineffectual. The Coastal Regulation Zone (CRZ) could also not be strictly enforced because it is simply a notification.

Conservation of Mangrove Forest

A total of 84 species of flora have been recognized in the mangrove forest of Indian Sundarbans of which 34 are true mangroves. However, multiple studies have assessed the patterns of biomass production in this forest for timber production and other economic operations. The Sundarbans mangrove forest is the biggest single tract of mangrove forest in the world.

In order for mangroves to be managed effectively, critical frameworks or enabling conditions must be built. An effective co-management regime will enable coastal communities to contribute to the successful conservation of the mangrove environment, which is crucial for the survival of coastal populations (Figure 3). In the Sundarbans, this system has been used. The co-management strategy establishes specific roles and responsibilities for many stakeholders, including coastal communities, in mangrove conservation. The framework makes sure coastal communities are primarily involved in and permitted to participate in decision-making processes related to mangrove conservation.

A strict legislative framework supporting and incorporating mangrove management strategies into a broader planning and policy framework is also essential. Other than traditional de facto rights, local communities and institutions do not hold any legal title to the property; local populations are regularly uprooted by centralized decisions that result in the development, reclamation and removal of mangrove habitats. It is possible to stop bit by bit loss and degradation by establishing framework policies and laws at the national level.

The Convention on Wetlands, also known as the Ramsar Convention, was signed in 1971 in Ramsar, Iran and is the most comprehensive treaty for the protection of mangroves worldwide. This is an intergovernmental agreement that establishes the framework for both domestic and global cooperation in the conservation and wise use of wetlands and their resources.

Figure 3: Proposed co-management model for mangrove conservation (Onyena and Sam, 2020)

Restoration of Mangrove Forest

Mangrove restoration is a nature-based solution advocated to conserve/ protect biodiversity and in climate change adaptation and mitigation programs. However, most restoration programs rarely integrate ecological components and its social aspects are often neglected. The general effectiveness of restoration on ecological qualities and the success or failure of management efforts are unclear due to the variety of restoration objectives and methodologies used.

A significant ecosystem recovery should be the goal of ecological restoration when compared to a suitable reference model that takes into account community structure, physical conditions and species composition. Three methods of mangrove restoration have frequently been reported: direct planting (either monogeneric or multi-species planting), integration of coastal engineering methods and hydrological rehabilitation (Table 2) (Gerona-Daga and Salmo, 2022).

Table 2: Mangrove restoration techniques

Sl. No.	Restoration techniques	Description
1.	Direct planting	Monogeneric planting- primarily used species were *Rhizophora apiculata* and *R. stylosa*; multi-species planting
2.	Integration of coastal engineering methods	Deployed hard (several types of breakwaters and sea dykes) and soft-engineering methods (T-groins/fences made up of bamboo, Melaleuca entrapping microsites before to planting or to encourage natural recruitment)
3.	Hydrological rehabilitation	Before planting, physical alterations made to the site's hydrological conditions such as surface elevation, tidal inundation, *etc.*) or to promote natural regeneration

(Source: Gerona-Daga and Salmo, 2022)

Conclusion

Mangroves are keystone species which play a crucial role in the ecosystems and they are a part of, ensuring the survival of other species. Their ecology would change significantly or potentially vanish without them. Mangroves, also referred to as the "kidneys of the coast," are magnificent filters that preserve the water clarity needed for offshore corals and near-shore sea-grasses.

References

Forest Survey of India, 2021. India State of Forest Report, 2021. Ministry of Environment, Forest and Climate Change, Government of India, p. 854.

Gerona-Daga, M.E.B., Salmo III, S.G., 2022. A systematic review of mangrove restoration studies in Southeast Asia: Challenges and opportunities for the United Nation's Decade on Ecosystem Restoration. *Frontiers in Marine Science* 9, 987737. DOI: 10.3389/fmars.2022.987737.

Gurjar, U.R., Takar, S., Bunkar, K., Pathak, V., Singh, J., 2019. Present status on distribution, biodiversity and management of Indian mangroves. *Research Biotica* 1(1), 16-22.

Kumar, K.M.V., Kumara, V., 2012. Diversity of true mangroves and their associates in the Kundapura region, Udupi district, Karnataka, Southwest coast of India. *Current Botany* 3(2), 3-9.

Onyena, A.P., Sam, K., 2020. A review of the threat of oil exploitation to mangrove ecosystem: Insights from Niger Delta, Nigeria. *Global Ecology and Conservation* 22, e00961. DOI: https://doi.org/10.1016/j.gecco.2020.e00961.