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Mangrove conservation in India: Future perspectives

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Abstract
Mangroves are ecologically important for carbon sequestration and storehouses of biodiversity. In India, about 40% of mangroves are lost in the past due to natural and anthropogenic disturbances. This article discusses the present status of mangrove forests, conservation and management strategies being followed successfully in India, and recommends the future directions for mangrove restoration.

Keywords: Fauna, Threats, Restoration, Initiatives, Management

Introduction

Mangroves are the most productive ecosystems in terms of their biodiversity. They protect the coast from erosion by acting as sea walls, provide forestry products, maintain water quality, accumulating pollutants, recycling of nutrients, and carbon sequestration in their soil (Macintosh *et al*. 2012) [6]. Mangrove associated fauna play an important role in the food web by contributing to the ecosystem functioning and mangroves productivity. They live as epifauna, infauna, and arboreal.

India constitutes 47% global mangrove cover. The mangroves of India are distributed in Sundarbans (West Bengal), Bhitarkanika (Odisha), Pichavaram (Tamil Nadu), Krishna-Godavari (Andhra Pradesh), Andaman-Nicobar Islands (Kathiresan 2018) [4]. Major proportion of mangroves can be found in Sundarbans followed by west coast and least in the Andaman and Nicobar Islands (Radhakrishnan *et al*. 2006) [8]. In India, studies on mangrove associated fauna has been carried out by Dey (2006) [3], Kesavan *et al*. (2009) [5], Pereira *et al*. (2002) [7], Radhakrishnan *et al*. (2006) [8], Shanmugam and Vairamani (2009) [13], Subba Rao (2003), Suresh *et al*. (2013) [15]. However, the studies on mangrove conservation are scarce. Hence, this review aims to give a detailed overview on mangrove conservation measures implemented in India.

Mangroves in India are threatened by climate change, development-related activities, pollution, unsustainable fishing etc (Radhakrishnan *et al*.2006; Sandilyan and Kathiresan, 2012) [8, 11]. Some of the threats faced are land filling for urbanization or dredging for navigational or harbor development projects in Kerala, conversion of mangroves into wet farmlands such as ponds, paddy fields in east and west coasts, excessive sewage disposal from the households leading to eutrophication. This disturbs the breeding activities of mangrove dwelling species.

Industrial effluents release and mixing of heavy metals mangroves causing pollution. Mangrove destruction for shrimp culture, urbanization, wood industry, domestic uses evident from Karnataka and Kerala (Radhakrishnan *et al*.2006) [8]. River diversion has been observed at river Cauvery and Sundarbans. It leads to hypersaline conditions obstructing the survival of mangrove associated fauna (Devi *et al*. 2020) [2]. Due to increased salinity the freshwater flora namely *Nypa* and *Heritaria* spp decline in number. Invasive species introduction such as oyster *Saccostrea cucullata* completes with native *Crassostrea brasiliana* causing socio-ecological impacts (Ameral et el. 2019). At Tamil Nadu, mangrove dwelling mollusc *Telescopium* spp. are overexploited for ornamental purpose and sent to the industries for lime production (Devi *et al*.2020) [2]. Table 1 shows the threats to mangroves at regional levels.

Table 1: Regional threats to mangroves of India.

Mangroves	Threats
West Bengal	Agriculture, reduction in freshwater flow and pollution, prawn seed collection
Odisha	Prawn farming, encroachment and rehabilitation, natural calamities
Tamil Nadu	Overexploitation of mangroves, invasion of alien species, reduction in freshwater flow.
Andhra Pradesh	Aquaculture, alien species invasion, agriculture and grazing, developmental activities.
Gujarat	Natural calamities, overexploitation of mangroves for development, coral reef degradation.
Maharashtra	Pollution, urbanization
Karnataka	Agriculture, deforestation, pollution
Kerala	Unsustainable aquaculture, deforestation for fuel, urbanization and industrialization, pollution
Andaman & Nicobar Islands	Agriculture, extraction for timber, Encroachment, tourism, natural calamities

Source: Sahu *et al*. 2015 [10].

The mangrove ecosystems of south India are identified as critically endangered. Nearly 20% of the assessed mangroves are at high risk and have been marked as endangered or critically endangered (Sarkar *et al*. 2016). They require conservation importance as they provide sea food, coastal stability, ecological conditions, and prerequisites for people's livelihood.

Mangrove conservation and management in India

1. The conservation plan was proposed for the management of the mangroves of Sundarbans in 1892. Then 1976 National Mangrove Committee was established by the Ministry of Environment and Forests to advise the Indian Government about mangrove conservation. A scheme was introduced by government of India with the advice of the Committee introduced for mangrove protection. The scheme aims at identification of mangroves of conservation importance, preparation of a management plan preparation and promotion of mangrove research, multidisciplinary approach towards restoration by state governments, universities, research institutions and local organizations. National Mangrove Committee works towards mapping of Indian mangroves using remote sensing and field surveys, in time series to understand their degradation, collects data on climate, mangrove growth and seasonal changes in environmental parameters, assessing the sites for reserve forests, initiating conservation programmes.
2. According to the recommendation of National mangrove Committee's, 15 mangrove regions have been given conservation importance. Funding has been provided by Indian government for the implementation of Management plans for their conservation. Forest Conservation Act (1980) states that no forest area should be cut for developments without prior approval of the Government.
3. The Environment (Protection) Act, 1986, and the Coastal Regulation Zone (1991), classifies mangroves to retain them as wild areas.
4. Environmental Management and Policy Research Institute (EMPRI) has been involved in conducting research on mangroves.
5. Under the central sector scheme of National Coastal Mission Programme on Conservation and Management of mangroves and coral reefs, annual Management Action Plan (MAP) restrictions have been implemented in all the coastal States and Union Territories and mangroves conservation.
6. Rules have been implemented under the Coastal Regulation Zone Notification (2019), Wild Life (Protection) Act, 1972, Indian Forest Act, 1927, Environment (Protection) Act, 1986, Biological Diversity Act, 2002 to protect mangroves.
7. Magical Mangroves Campaign highlighted the conservation need of mangroves to 15,600 citizens of the country through webinars.
8. The Government under Centrally sponsored scheme for conservation & Management of Mangroves, extend assistance to Coastal State/UTs for implementation of action plans including survey and demarcation, alternation and supplementary livelihood, protection measures and education and awareness activities.
9. Under the Coastal Zone management mangroves were planted in Gujarat, Odisha and West Bengal to conserve coastal habitats.
10. Mangrove Cell, for mangrove conservation has been built by state government of Maharashtra, Mangrove and Marine Biodiversity Conservation Foundation was created by the State Government for increasing mangrove cover and for research. Mangroves were planted in Vemband and Kannur of Kerala under this scheme.
11. According to India State of Forest Report (ISFR) 2023, mangrove cover of the country has increased by 0.34% in year 2023 than the previous years.

Ministry of Environment, Forest and Climate Change initiated MISHTI (Mangrove Initiative for Shoreline Habitats & Tangible Incomes) provides financial support to local communities to plant mangroves. Besides, conducts capacity building programmes to create awareness to people about their role in protecting the mangrove wetlands. Sustainable Aquaculture in Mangrove Ecosystem (SAIME) aims at constructing integrated mangrove aquaculture systems for sustainable farming. According to the reports of Sahu *et al*. (2015) [10] a total of 4195.28 ha area of mangroves has been restored South India from 2002 to 2006 (Table 2).

Table 2: Restored mangroves in Indian states (Sahu *et al*. 2015) [10].

State	Areas in ha
Andhra Pradesh	1978
Tamil Nadu	840
Karnataka	1244
Kerala	134.78

Future perspectives

Strengthening of existing legal and policy measures like Environmental Impact Assessment,1986, Indian Forest Act,1927, and Forest Conservation Act,1980. Ecological conservation should include identifying suitable regions for mangrove restoration for planting mangroves. Establishment of buffer zones and green belts around the mangrove forests to retain the ecological integrity. Retaining the mangrove sediments by the regulation of wetland soil elevation by construction of barriers on rivers to prevent the flow of sediments. Connecting the mangrove with the terrestrial forest for conservation. For example, in the east coast Sundarbans mangroves are connected to Sundarban National Park. Research and development, declaring major mangroves as 'Mangrove Germplasm Preservation Centres' for better management. Streamlining international cooperation and funding for disaster management and to conserve mangrove ecosystems. Use of time series remote sensing and GIS techniques, drones in the mapping of mangroves and their loss (Ruwaimana *et al*. 2018) [9]. Correlation of mangrove loss with coastal erosion over the years. Use of mangrove vulnerability index to check the effects of storms and tsunamis (Yunus *et al*. 2018) [16].

Conclusion

Mangroves are depleting at faster rate than any other coastal ecosystems. However, some efforts have been implemented in India for their conservation at regional levels. Nevertheless, few mangrove sites have been restored in the Indian coast and many mangroves are facing higher risk and being lost at faster rate every year. Mangrove reforestation programmes are working towards conservation in Indian states. National Mangrove Committee, MISHTI, SAIME programmes are developed for funding mangrove research, afforestation, mangrove aquaculture to conserve biodiversity. Effective governance, climate change mitigation, planning to recover degraded mangroves and

understanding mangrove loss and restoration using novel technologies are prerequisites to protect and restore the mangrove wetlands.

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