



Review

Changing perspectives of mangrove management in India – An analytical overview



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ABSTRACT

The paper provides a deep insight into the managerial aspects of Indian mangroves and highlights the transition of Indian forest policies and their impacts on these extensive coastal ecosystems. Citing examples from historical past to the recent developing era, the paper highlights the transition of core mangrove management strategies and observes a paradigm shift from preventive to ameliorative management mostly through increased community participation in mainstream resource management. The paper also examines the existing framework of mangrove management, legislative and non-legislative provisions for conservation and identifies its effectiveness against the persisting extinction threats. Addressing the major gaps and challenges, the paper concludes with some key recommended strategies for an effective mangrove management in India.

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1. Introduction

India is home to a variety of coastal and marine ecosystems that includes 4662 sq. km of diverse mangrove forests ([Forest Survey of India, 2011](#)). Although these mangroves account for only 0.67% of the total designated forest area in India, their presence remain utterly important under the growing concern of global reduction of mangrove habitats and need special attention. The Indian mangroves contribute significantly toward the shrinking global mangrove reserve with approximately 2.7% of the world's mangroves exist along the 7516.6 km long coastline of India ([Giri et al., 2011](#)). Yet, the present extent of mangroves is only a modest remaining of the past. Earliest available estimation reveals that despite of considerable loss over the precedent decades, mangrove habitats in India covered close to 6000 sq. km even during 1960s ([FAO, 2003](#); [Gnanappazham and Selvam, 2011](#)). Since then, Indian mangroves suffered significant loss leading to a gross mangrove area of 4046 sq km in 1987. However, official statistics from 1987 to 2011 reveals that the extent of mangrove cover actually stabilized close to 4500 sq. km since 1995 with an apparent increasing trend ([Forest Survey of India, 2011](#); [Bhatt and Kathiresan, 2012](#)). Although, several extinction threats still persists heavily on the Indian mangroves; India, on a regional basis, sets good example in conserving and restoring this globally threatened ecosystem ([Bhatt and Kathiresan, 2012](#)).

Throughout the history, forest management and community perception played a crucial role in the continual existence or annihilation of mangroves. Mangroves are now protected under the strong legislative framework of India, yet, until the recent past, they were viewed as economically unproductive & mosquito infested wasteland. As a result, they were heavily exploited for timber and firewood and continuously ignored against developmental priorities. Much of the Indian mangroves were converted to coastal agricultural land as well as deforested for pond (shrimp) cultivation. However, under the changing perceptions about the mangroves and scientific understanding of their enormous ecological and environmental significance, conservation is now greatly promoted all across India. In the last few decades, management of the mangroves has been tailored through various discrete and differentiated policies and the transition between an exploratory to conservative policy is essentially based on the scientific realization of the extra-ordinary ecosystem & environmental services of the mangroves. Conservation & restoration of mangroves are also prioritized in the 'Green India Mission' under the National Action Plan on Climate Change (2008) which sets an ambitious target of 1000 sq. km addition to the existing mangroves by the end of 2020 ([MoEF, GoI, 2010](#)).

Importantly, India's effort for conservatory management of mangroves has been much similar to the management of any other inland forests and guided by a set of forest legislations mostly inherited from the British India. Until the recent amendments, these legislations were confined to a top-down approach of forest management where the core responsibilities are centralized and governed by the forest departments of federal or provincial

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government. Similar to most of the developing countries, the major mangrove habitats of India are densely populated, where the local communities have played a major role of ecological agents for mass & organized exploitation of mangroves as they provide rich resources of forestry based livelihood. Hence, conservation of mangroves is essentially associated with discontinuation or at least interruption of such services. This forms a critical socio-political issue largely affecting the conservation initiatives. Since the realization of such interdependence of conservation of forests and the livelihood opportunities of a larger section of poor and socio-economically vulnerable communities, the forest management scheme of the local, regional as well as the federal government has tilted toward cooperative management rather than the state owned management initiatives. The rationale of Community based Mangrove Management (CBMM) lies in the potential of local communities' involvement in accomplishing the vital activities of sustainable forest resource management ensuring the well being of both the forest and the dependent community (Datta et al., 2012). Alternatively, CBMM approach can also be defined as a bottom-up approach where socio-economic development of forest dependent communities is ensured by sharing forest rights through collaborative management between forest department and the local communities. In 1988, the forest policy of India recognized the importance of Community based Forest Management (CBFM) and the scheme of Joint Forest Management (JFM) was officially launched. Since then, co-operative mangrove management, also known as Joint Mangrove Management (JMM), gained momentum in India. The existing mangrove management model, which is a combination of preventive (legislative conservation) and ameliorative management mostly through community driven co-management schemes was mostly successful and can be credited for the gradual rise of mangrove cover since the mid nineties.

However, the problem of mangrove management is far more complicated than the forest resource management itself. India, being a rapidly developing country, puts severe stress on the existing mangrove ecosystems in terms of coastal infrastructure development and urbanization in coastal areas. Almost all the major mangrove habitat suffers acute threat of anthropogenic pollution & scarcity of freshwater. A recent study conducted to assess the nutrient stoichiometry of major intertidal mangrove habitats in India revealed that the standard Redfield ratio (Si: N: P = 16: 16:1) is largely deviated due to the presence of anthropogenic pollutants and concluded that the overall ecological status of Indian mangroves remains highly disturbed (Bala Krishna Prasad, 2012). Although several legislative arrangements for environmental protection exist in India; the mangroves continue to suffer the severe threat of environmental pollution. Under this backdrop, this paper is targeted with two specific objectives, firstly to analyze the evolution of Indian forest policies over the past century and to provide a synoptic overview of changing forest management strategies, particularly with respect to mangrove management. Secondly, it is aimed to critically analyze the situation of Indian mangroves, prospects of the existing legal framework of mangrove management and its potential shortcomings. In conclusion, the paper suggests some of the key recommendations for effective mangrove management in the country.

2. Occurrence of mangroves in India

India's long coastline and the Andaman and Nicobar Islands in the Bay of Bengal are endowed with some of the world's extensive and diverse mangrove forests. However, on a macro scale, eastern coast of India is virtually more diverse compared to the western coast because of their distinctive geo-morphological settings. The coastal zone of the Western India is essentially narrow and steep

sloped due to the presence of the Western Ghat hills and practically void of major water-flowing rivers. As a consequence, the salinity level in the western coast is much higher than the eastern coast, hence, the mangrove habitats of the western coast of India are smaller in size, less diverse and less complicated in terms of ecological and ecosystem functioning (Selvam, 2003). Mangrove habitats in the western coast are mostly limited in funnel-shaped estuaries and backwaters. It includes the inter-tidal coastline, minor river mouths, sheltered bays and backwater areas and characterized by low tidal range. On the contrary, the mangroves of the eastern coast of India are typically dense & diverse, because of the long extended coastal area with large alluvium carried out by major rivers of India, such as Ganges, Mahanadi, Godavari, Krishna etc. The eastern coast mangroves are mostly of deltaic origin and grow in the intertidal region where plenty of freshwater flow is assured by number of water channels. These deltaic areas are mostly characterized by high tidal range with associated strong bi-directional tidal current (Mandal and Naskar, 2008). The salinity is relatively low and diversity of mangroves is moderately high. Apart from this, a complete different set of mangrove habitats are found over the Andaman & Nicobar Islands in the Bay of Bengal. These are essentially the insular or island mangrove habitat and commonly found at the mouths where rivers are seen to border the open sea or in the protected intertidal zone along the island coast. In short, the entire mangrove habitats of India are broadly classified in to three classes, (a) Deltaic (Eastern Coast Mangroves), (b) Estuarine & Backwater (Western Coast Mangroves) & (c) Insular (Andaman & Nicobar Islands) [Thom's Classification of Mangrove Habitats in India; adopted from Mandal and Naskar (2008)]. Fig. 1 depicts the major mangrove habitats across the Indian coast while Table 1 summarizes the recent estimated mangrove areas of different mangrove habitats of India.

2.1. The eastern coast mangroves

Mangrove ecosystems exhibit tremendous variation in their physical stature due to the climatic and local environmental conditions. On the basis of height and quality of tidal forest, Champion and Seth (1968) classified the Indian mangrove forests in two sub types- (i) 4B/TS₁ (Mangrove Scrubs) and (ii) 4B/TS₂ (Mangroves) while the later are the finest tidal forest of 20–25 m high mangroves found on the grounds flooded only by moderately brackish water during the high tide (Champion and Seth, 1968; Singh, 2000). The eastern coast of India particularly inhabits such type of dense mangroves. The rich alluvium carried out by the major east flowing rivers of India and a long stretched coastal area adjoining the Bay of Bengal forms the most favorable conditions for such mangrove forests to grow. The eastern coast of India hosts some of the major mangrove habitats of the world including the Sundarbans mangrove forests in the delta of the Ganga–Brahmaputra–Meghna (GBM) – the largest single block mangrove forests of the world. Of the remaining, the Orissa coast mangroves in the Mahanadi delta, the mangroves at Krishna–Godavari delta, the Muthupet mangroves in the Kaveri delta and the Pichavaram mangroves in the coast of Tamil Nadu are the major mangrove habitats of the eastern coast of India.

As per the latest statistics revealed by the Forest Survey of India (2011), almost 60% of the Indian mangroves are confined to the eastern coast of India. Even though, the Sundarban Mangrove Forest (SMF) is shared by India (38%) and Bangladesh (62%), the Indian Sundarban is the largest mangrove forests in India which spreads over some 103 deltaic islands complexly interlinked by tidal waterways in the southern part of the state of West Bengal. This mangrove forests is the home to some of the world's most endangered fauna including the largest known habitats of man-eating carnivores – the Royal Bengal Tiger (*Panthera tigris*), while it is also

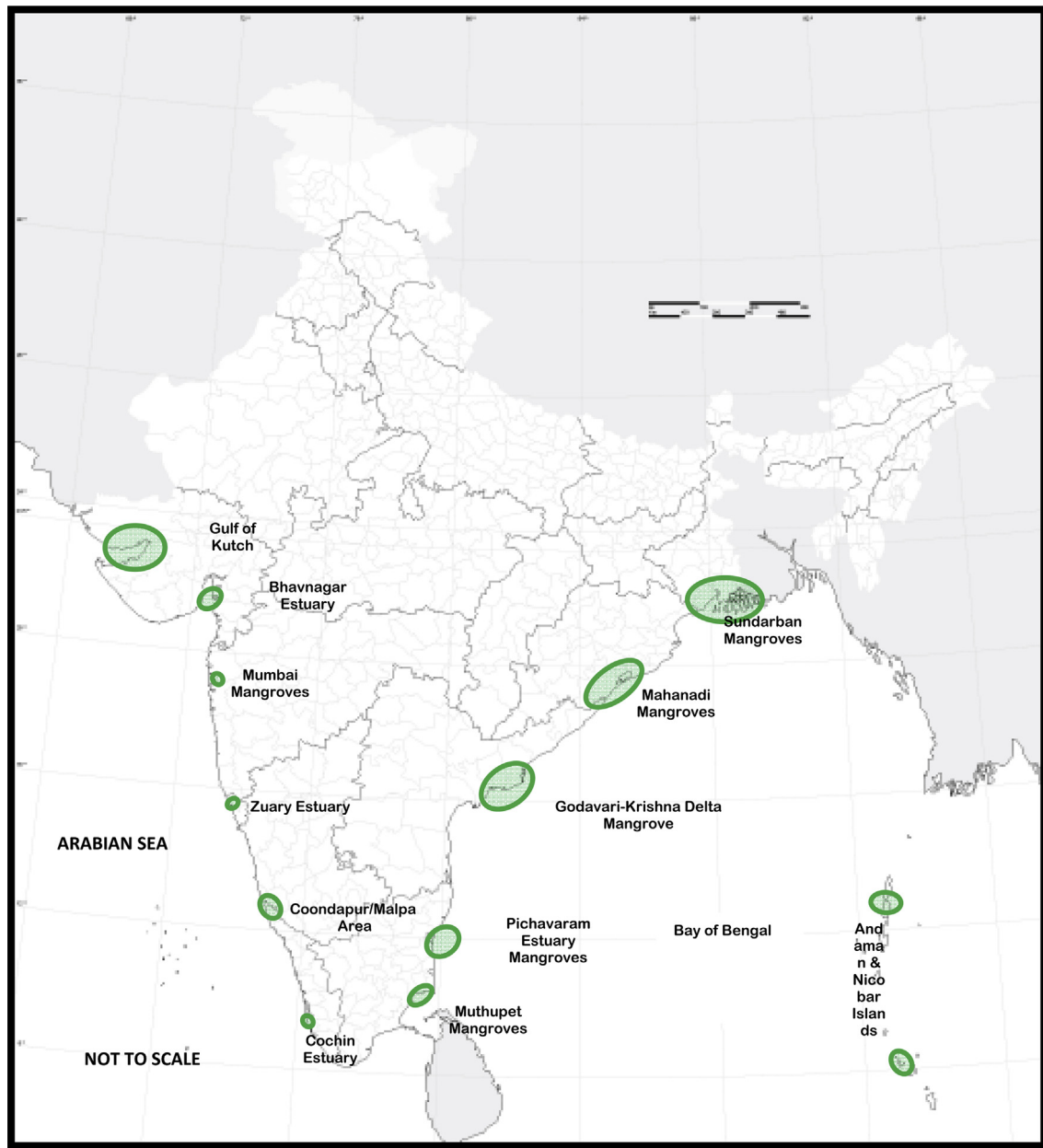


Fig. 1. Mangrove occurrence in India.

the home for some 30 true mangrove species and a total of more than 100 vascular plants including the mangroves and its associates (Gopal and Chauhan, 2006). The Sundarbans Mangrove Forest is particularly critical and a highly fragile ecosystem because of its complex geo-morphological & environmental settings, enormous population density and gradual shrinking of the islands under the rising sea. The Mahanadi river delta mangroves are situated in the state of Orissa approximately 250 km south to the Sundarbans. The Mahanadi delta mangroves in Orissa are also found over the Brhamani & Baitarani River Delta, along the Balasore coast encompassing the Bay of Bengal and the Bhitarkanika mangrove zone. The Bhitarkanika mangroves are the most important and diverse mangrove habitat famous for its rich and unique avian biodiversity. Approximately 70 numbers of mangrove and mangrove associates are found over here. The Godavari and Krishna delta mangroves in the state of Andhra Pradesh occurs along the central portion of the eastern coast of India and remains one of the

dense mangrove habitats of India. However, mangrove diversity in the Godavari & Krishna delta has been comparably lower than Sundarbans or Mahanadi Delta mangroves and mostly limited to 17 numbers of true mangroves. The Pichavaram mangroves, one of the healthiest and well managed mangrove forests in India, are located in the state of Tamil Nadu. This mangrove forests are located in between the Vellar and Coleroon estuaries and spread over 51 islets. Pichavaram harbors 13 species of true mangroves and 73 species of other plants including the mangrove associates (Kathiresan, 2000). Muthupet mangroves in the southern end of Cauvery (Kaveri) delta is a mangrove swamp forest, however, mangrove species diversity in very low and restricted to 4 species.

2.2. The western coast mangroves

The western coast of India facing the Arabian Sea is home for approximately 27% of the Indian mangroves. They occur in patches

Table 1
Mangrove forest area in India.

Major Mangrove habitats * (State/Union Territory)	Very dense mangroves (Area in sq. km.)	Moderately dense mangroves (Area in sq. km.)	Open mangroves (Area in sq. km.)	Total (Area in sq. km.)	% of the total Mangrove cover
East coast				2769	59.4%
Sundarban Mangroves, West Bengal	1038	881	236	2155	46.22%
Mahanadi Mangroves, Orissa	82	97	43	222	4.76%
Godavari–Krishna Delta Mangroves, Andhra Pradesh	0	126	226	352	7.55%
Pichavaram & Muthupet mangroves, Tamil Nadu	0	16	23	39	0.83%
Ariankuppam Estuary, Pondicherry	0	0	1	1	0.021%
West coast				1276.56	27.37%
Gulf of Kutch & Gulf of Kambhat, (Bhavnagar Estuary), Gujarat	0	182	876	1058	22.69%
Goa Mangroves, Goa	0	20	2	22	0.47%
Thane & Raigad, Maharashtra	0	69	117	186	3.98%
Haladi–Chakra–Kollur river estuary, Karnataka	0	3	0	3	0.06%
Cochin Estuary, Kerala	0	3	3	6	0.12%
Daman & Diu	0	0.12	1.44	1.56	0.03%
Andaman Nicobar Islands	283	261	73	617	13.23%

Prepared by authors from State Forest Report, *Forest Survey of India* (2011). The bold denotes the location and total area of the underwritten mangrove habitats and also classified 2.1, 2.2, 2.3 which is the gross categorization of Indian mangroves.

from the coast of Gujarat to Kerala; however, majority of the western coast mangrove occurs along the Gujarat coast. Again, nearly 77% of the Gujarat mangroves are confined to the Gulf of Kutch while the rest are located in Gulf of Khambhat. Species diversity of the Gujarat mangroves is essentially poor and restricted to 9 mangrove species with an apparent dominance of *Avicennia marina* (Singh, 2000). In Maharashtra and Goa, patches of mangroves are found in the Mandovi estuary, the Vasishta estuary, the Savitri estuary, the Kundalika estuary, Zuari estuary and along the creeks of the Dharamtar, Panvel, Vasai, Thane and Vaitarana. Among the other mangrove habitats, Cochin estuary in Kerala, Coondapur/Malpa area in Karnataka possess significant mangrove density (Mandal and Naskar, 2008), however, similar to the most of the west coast mangroves, the mangrove vegetation is sparse and less extended mostly due to insufficient freshwater flow.

2.3. Andaman & Nicobar Islands mangroves

The Andaman & Nicobar (A & N) Islands in the Bay of Bengal harbors one of India's most dense & diverse mangrove forest. The A & N islands are essentially an archipelago of more than 500 islands; however, most of which are still not inhabited. The area receives a good amount of rainfall (annual average: 3143 mm) and the temperature is almost constant throughout the year with a mean annual temperature of 26.3 °C (Singh et al., 1987). Such climatic conditions favor the growth of mangroves along the creeks, near bays and lagoons. The tidal creeks are often used for natural draining of rain water, hence provides the source of freshwater for this dense mangrove forests. The species diversity of the Andaman mangroves is relatively high. Approximately 45 species in 27 genera of mangroves are found in these bay islands (ENVIS, 2002). However, the recent Indian Ocean Tsunami in 2004 has destroyed some of the dense mangrove habitats in the Nicobar group of islands. Despite of the Tsunami loss, the A & N islands accounts for 617 sq. km of extremely diverse mangroves (Forest Survey of India, 2011).

3. Threats on Indian mangroves

Despite of the legislative protection and increased community participation in recent times, the mangroves along the Indian coast continues to remain critical. It has been estimated 100% of the

mangrove species, 92% of other flowering plants, 60.8% of seaweeds, 23.8% of marine invertebrates and 21.2% of marine fish are threatened (ENVIS, 2002). Out of the 39 species of mangroves that are widely encountered over the Indian coast, 37 species are considered under varied degree of extinction risk while 11 mangrove species are considered to be critically endangered (MoEF, GoI, 2008). Such extinction risks are associated with various distinct factors and more often closely linked to direct or indirect human interventions. Several habitat specific studies reported that despite of protected status, local communities continue to invade the mangroves primarily for coastal agricultural land development and shrimp (pond) farming especially in the eastern coast (Ambastha et al., 2010; Pattanaik and Narendra Prasad, 2011; Vyas and Sengupta, 2012). In the past three decades (1975–2005), India lost 17,179 ha & 7554 ha of mangroves due to agricultural land conversion and shrimp cultivation respectively (Giri et al., 2008). Although clear felling for agricultural land reclamation has reduced considerably; recent remote sensing based evidences reveal that conversion to aquaculture ponds still remains as a significant threat especially to the mangroves along the eastern coast (Pattanaik and Narendra Prasad, 2011; Ponnambalam et al., 2012). On the other hand, increased population pressure in the vicinity along the larger mangrove habitats, such as Sundarbans, provides significant risk of unsustainable exploitation of mangroves (Mandal et al., 2010).

Apart from the conventional use of mangroves by forest adjacent communities, recent industrial & infrastructural development in the coastal plains along with large quality municipal sewage discharged into the creeks and estuaries forms a formidable threat for the Indian mangroves with apparently little or no solution. Largely overlooked against developmental priorities, historically mangroves have been cleared for construction of ports and harbors and coastal cities. In the recent past, development of Mundra port in Gujarat was largely criticized for degradation of huge area of critical mangroves, unofficially reported as 3000 ha. Similarly, along the eastern coast, Paradip port was build over dense & virgin mangroves of exceptional diversity and no human population in the vicinity (Nayak and Bahuguna, 2001; Nanda, 2011). Interestingly, the tidal creeks and channels are conventionally used as drainage of large cities almost all over India. Although mangroves are much resistant to high level of organic pollution, large quantity of waste has reportedly damaged the species diversity of mangroves. For

example, *Sonneraita caseolarsis*, once abundant in Sundarbans are now almost extinct due to lack of regeneration in highly polluted lower-saline zones in Indian Sundarban (Mandal et al., 2010). A good number of studies reveal that environmental pollution, especially the discharge of heavy metals and organic wastes, remain one of the most decisive factor for overall ecological health of mangroves almost all across India (Bhattacharya et al., 2003; Agoramoorthy et al., 2007; Remani et al., 2010; Bala Krishna Prasad, 2012). On the other hand, it is believed that climate change would impact mangrove habitats worldwide apparently by an increasing sea level. The predicted Sea Level Rise (SLR) would result in the loss of 10–20% of global mangroves in future (Gilman et al., 2007, 2008). This would surely impact substantial loss of Indian mangroves, especially on the eastern coast redefining the ecosystem boundaries of the mangroves. Most importantly, a restricted upward migration in the deltas like Sundarban or Bhitarkanika would perhaps lead to considerable loss of mangroves.

Importantly, the threats are diverse and discrete in nature and vary extensively among the different habitats. The Planning Commission of India demarcated 17 numbers of potential threats highlighting the vulnerability of the major habitats in the country (Planning Commission, 2007). A further classified summary of these 17 habitat specific threats has been furnished in Table 2.

4. Evolution of forest management in India

Throughout the history of India, forests including the mangroves have been an integral part of the Indian society, their culture and religious practices. Local communities not only depended on forests but also managed the forests in a sustainable manner. However, as the Indian civilization progressed under different administrative regime, local communities gradually lost their

traditional right over the forest. In this section, a brief analysis of the evolution of the Indian forest management and their potential consequences has been discussed in short.

4.1. Ancient India

In ancient India, forests were closely associated with the existence of local communities and the forest dependency of people were institutionalized through a variety of cultural and religious mechanisms such as sacred groves, temple garden and worship of certain trees. Local communities developed indigenous techniques for forest management to ensure prolonged and sustainable use of the forest resources (Shashi Kant, 2001). In most of the cases, the utilization of the forests was managed under a common property regime, however, the ownership of forests were largely confined to the ruling kings and the permission for exploitation of forest resources were granted by the king (Iftekhar, 2008).

Earliest evidence of organized management of forests in India dates back to 321–226 BC which has been well documented in the 'Arthashastra of Kautilya' – written by Chanakya, the prime minister of Chandra Gupta Maurya. Mauryan Empire created a Department of Forest Products, headed by an official called a "Kupyadhyaksta". The forests were classified into three major categories, viz. (a) Reserved Forest to cater the need for the elephants of king's army (*Gaja-vanas*) (b) Forests given to eminent priests and scholars (c) Forests for the subsistence need for the public. Even though the concept of mangrove was not known at that time, the forests of Bengal including the mangroves were termed as 'Angireya-vana' (Barlow, 2009; Iftekhar and Islam, 2004). The dictums of Chanakya continued till the 8th Centuries AD and except the forests donated to the Priests, the remaining were managed mostly by the local communities and near forest dwellers even though technically the

Table 2
Threats on Indian mangroves.

Threats	State/Province									
	West Bengal (Sunderbans)	Orissa (Mahanadi Delta)	Andhra Pradesh (Godavari Kaveri Delta)	Tamil Nadu (Pichavaram)	Andaman & Nicobar islands	Gujarat (Gulf of Kutch)	Maharashtra	Goa	Karnataka	Kerala
Anthropogenic factors										
Cattle grazing	+	+	+	+++	+	++	–	–	–	–
Tree felling for firewood	++	+	++	+++	+	+	+	+	–	–
Over exploitation of fishery resources	+++	+	++	+++	+	–	–	+	–	++
Reclamation for agriculture	++	+	+	–	–	–	+	–	+	++
Aquaculture	+	–	+	–	–	–	–	–	–	–
Urbanization	++	+	–	–	+	+	++	+	–	+
Lack of freshwater supply due to dam	+	–	+	++	–	++	–	–	–	–
Tourism	–	–	–	+	+	–	–	–	–	–
Pollution & discharge of effluents	++	–	+	–	–	+++	++	+	–	++
Port/harbor development	+	–	–	–	–	+++	–	–	–	–
Mining	–	–	+	–	–	++	+	–	–	–
Lack of people participation	–	+	+	+	+	++	+	+	+	++
Environmental factors										
Hyper salinity	+	–	–	++	–	++	–	–	–	–
Shoreline/geomorphic changes	+	–	+	++	–	++	+	–	–	++
Natural calamities	++	+	++	++	+++	++	–	–	–	–
Siltation and sedimentation	++	+	++	++	–	++	–	–	–	–

+ (Intensity of threats), – (Insignificant threat).

Source: Prepared by Authors from the Report of the Task force on Islands, Coral reefs, Mangroves & Wetlands in Environment & Forest, Planning Commission, Gol, 2007

management rights belonged to the king (Shashi Kant, 2001). The Mauryan empire were instrumental for implementation of forest management scheme in India while the great Mauryan King Ashoka, largely implemented the concept of social forestry and religious conservation practices in ancient India which has been documented in number of his scriptures. On the fall of Mauryan Empire, Gupta's continued the earlier practices and tried to improve the existing forest policies. However, after the Gupta dynasty (320–415 AD) there was no stable management of the forests hence it belonged mostly to the local communities in and around the forests. During the ancient regime, natural forests were explored primarily for wood and such practices were by and large sustainable. To be specific about mangroves, because of their geographical occurrence in critical inaccessible areas, mangroves were largely intact and did not suffer much exploitation.

4.2. Medieval India

During the Mughal Empire, the forests also remained largely intact and Mughals were particularly responsible for social forestry such as road side plantation (Shashi Kant, 2001). However, in the latter half of the Mughal Empire, land based revenue systems which involved conversion of forestland to agricultural purposes were initiated throughout the country. The Mughal established small administrative units, known as 'Parganas', which were capable of producing revenue. In a way, the Mughals were the first who formally penetrated the great mangroves of Sundarbans establishing the first 'Parganas' (Ambarabad) in 1734 (Barlow, 2009). The land based revenue system continued and eventually taken up by the British who further strengthened such systems by a network of 'zamindari' – a local landlord based revenue collection system initiated by the Mughals.

4.3. British colonial regime

'Zamindari' system continued under the British regime with much more aggression as more and more deforestation took place during 1830–1875. Historically, the formal and organized reclamation of Sundarban mangroves was initiated by Calude Russel & later by Tilmen Henckell as early in 1770 (Mandal et al., 2010). The British government encouraged the conversion of open forests into agricultural land under the 'Zamindari' system as this assured increased revenue. Historical record reveals that Sundarban Mangrove experienced a loss of 5100 sq. km by the end of 1873. Even though, diversion of forest to agricultural purpose continued after independence, the British administration in India was largely instrumental for the massive exploitation of forest resources during its colonial regime. However, they were also responsible for development of a scientific management system of the existing forest resources. The first documented evidence of a forest management policy was the National Forest Policy, 1894. This policy categorized the entire forest resources of the country into four classes such as (a) Critical Forests that occur on hill slopes-such type of forests were recommended for in-situ conservation and theoretically these were conserved with a broader aspect of landslide risk reduction. The next class of forests were the (b) Forests which can supply valuable timbers; these forest were earmarked for commercial exploitation (c) Minor forests-which was denoted by the inferior quality of wood to fulfill the requirement of common people and a (d) pasture land-forests for grazing purposes. The mangroves were mostly classified under the minor forest with little economic values. The Indian Forest Act, 1927 were mostly a reflection of the earlier forest policy of 1894. One important aspect of the Indian Forest Policy, 1894 and the Indian Forest Act, 1927 was that the British Government established complete legal rights over

the forest and the communities were deprived of many of the traditional rights which they enjoyed for generations (Balooni, 2002). The forest dwelling communities, mostly the marginalized tribal population reacted violently, however, failed to establish their rights over the forests.

Deforestation under the British regime was mostly directed to agricultural land reclamation, however, forest were also cleared for setting up cities and harbors. Indian mangroves were cleared for both the purposes. While revenue generation in form of agricultural land acquisition was instrumental for degradation of Sundarban mangroves, urbanization in coastal areas were largely responsible for deforestation of mangroves in Mumbai. Historical records of the Mumbai city reveal that there were at least seven islands around Mumbai during 1670 which the British government reclaimed for commercial purposes. They deforested the fringing mangroves and reclaimed these islands into one continuous land-mass, which later came to be known as "Greater Bombay".

In short, during the British colonial regimes, the government granted the clear felling of forests, including the mangroves, to increase the taxable agricultural land. However, the economics of the exploitation changed in due course of time when the forest products became more valuable than the agricultural revenue which in turn stopped the exploitation of virgin forests. The British government, during 1875–1876 declared the un-leased forests as reserve forests and placed them under the jurisdiction of the forest department – a process that perhaps saved the unexploited forests, e.g. the remaining of today's Sundarbans.

4.4. Post independence

India got its independence in 1947; soon after, it mostly inherited the British legal frameworks pertaining to forest resource management. The Government of India formulated a National Forest Policy in 1952 and proposed a functional classification of Indian forests- (a) Protected Forests (b) National Forests (c) Village forests and (d) tree lands. This classification was almost similar to the earlier division made in the Indian Forest Policy, 1894. More so, the directives of the Indian government was in line with the earlier policies which restrict the traditional forest uses of the forest dwelling community and advocate for an entirely state driven management of forests. The Indian State continued with the Forest Act of 1927 and subsequently modified the act for several times, mostly to curtail the local uses of forests (Balooni, 2002). However, alike the British Forest management policies, the forest policies of independent India were somehow directed to conservation as the federal government of India did not look up to the forests as only a mean of revenue generation. Again, promotion of conservation was endorsed through a wide autocratic administrative framework but it left out the traditional forest user and forest dwelling community. Such initiatives of a state owned management of forests were by and large unsuccessful in protecting the forest resource; instead, it resulted in some serious conflicts between the state and the community.

On the other hand, the federal government also failed to promote conservation through the forest department. It was obvious, with the limited resources, the vigilance of the forest department largely proved insufficient countering the encroachment and deforestation. More so, there were conflicts with community interest; which in turn prompted the federal government to implement the Forest Conservation Act in 1980 and subsequently to redraft the Forest Policy in 1988. While the forest conservation act theorized the judicial use of forest resources, the National Forest Policy, 1988 encouraged the community participation in forest management, regeneration and plantation. The Indian Forest Act, 1927 was also amended to allow people participation in 1989. In

short, during 1985–1990, the Indian forest management experienced a paradigm shift toward sustainable management rather than sole conservation. This forest conservation act which was more regulatory than prohibitory in nature may be seen as an effective interface between conservation and development.

The most important aspect of the forest policy of 1988 was to involve the local communities in the protection, conservation and management of forests through Joint Forest Management Program. It also gave the rights for exploitation of forest resources, mainly in terms of meeting the requirement of fuel wood, fodder, minor forest products to the rural and tribal populations and on the contrary it envisaged people's participation in safeguarding the forests and the bio-diversity. However, the concept of Joint Forest Management evolved well before 1988 with the successful implementation of the 'Arabari experiment' – a participatory management model developed by the local forest department in the Arabari Range of Forests in Midnapore district of West Bengal. At present, some 63,618 Forest Protection Committees are in existence which governs over 14.09 million ha of forestland; 22% of the entire forest cover of India (Balooni, 2002).

The existing model of forest management in India is somewhat a combination of legislative conservation as well as sustainable exploitation of forests & forest products through cooperative management. Interestingly, the federal government policies now seek for more community empowerment in forest governance. In the year 2006, the federal government passed an important resolution in form of the Tribal Forest Right Act. This act provides the legal rights of the forestland to the traditional forest dwelling communities and also extends the right of forest exploitation for traditional livelihood practices. Even though this act was severely criticized by a group of conservationists on the basis of the fear that it would encourage deforestation and exploitation of forests, the act may be defined as an end to the long standing conflict between the tribal communities and the local government. Moreover, the 'Green India Mission' strongly envisages community level organizations to handle the key responsibilities in forest restoration. Fig. 2 describes the schematic evolution of forest management in India.

5. Existing framework for mangrove management India

Indian mangroves were very much a part of the vast forest resources of the country and were managed accordingly. It received a special discrimination only after the Ramsar Convention (1971), followed by Convention concerning the Protection of the World Cultural and Natural Heritage (1972). These two conventions lead to steady conservative initiatives restricting deforestation of mangroves. However, scientific understanding of the importance of the mangroves was realized earlier. The Ministry of Food and Agriculture of the Government of India conducted two symposia during 1956–1957 in form of the 9th Silvicultural Conference (1956) and the Mangrove Symposium (1957) where the ecological importance of the mangroves were highlighted (Azariah et al., 1992). Prior to that, some of the Indian mangroves were classified in any of the four categories as described in the forest policy of 1952.

The Convention on Wetlands of International Importance, popularly known as the Ramsar Convention was particularly important in promoting mangrove conservation in India. Several Asian countries have ratified in the Ramsar Conventions on Wetland and have designated mangrove areas as Ramsar Sites or as National Park, Reserves or Wildlife sanctuaries (ENVIS, 2002). India, a signatory member of the convention, formulated a comprehensive management plan to conserve the mangroves soon after the convention. The Government of India formulated the National Mangrove Committee in the year 1976. On the other hand, major initiatives toward conservation of forest resources were directed after the Stockholm Declaration (United Nation Conference on Human Environment) in 1972. The federal government amended the constitution of India in 1976 in order to accommodate the guidelines of the Stockholm declaration. For example, Article 48 (A) of the Indian Constitution states that the state shall endeavor to protect and improve the environment and safeguard the forest and wildlife of the country. Similarly, the Article 51A (g) imposes similar responsibility for every citizen of India to safeguard the environment.

The National Mangrove Committee (NMC) was formed as an advisory body to the Government of India to promote conservation

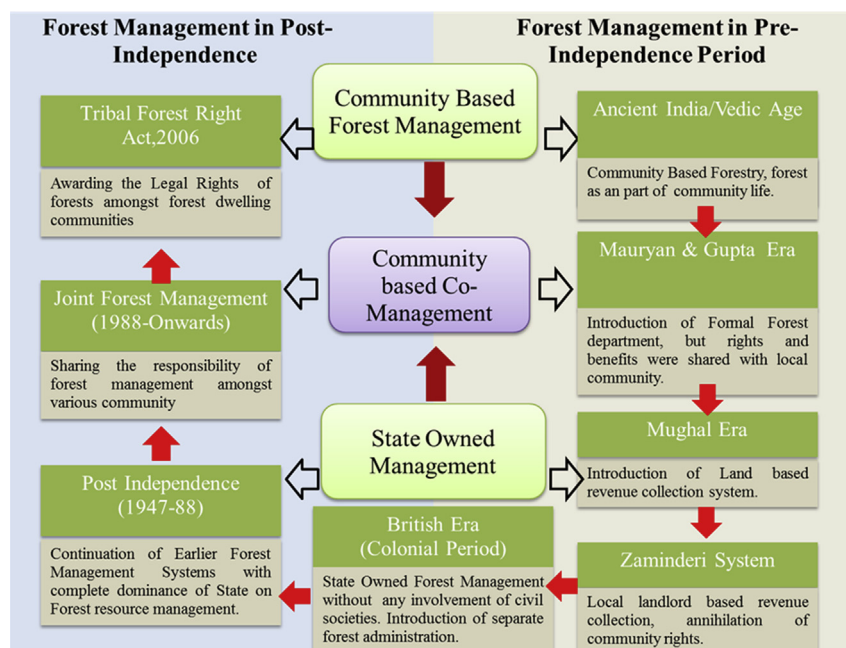


Fig. 2. Schematic diagram of forest management in India.

Table 3

Areas selected for management of mangroves by NMC in 1987.

Location	Area (in Ha)
Northern Andaman Nicobar	34840
Sunderban, West Bengal	258477
Bitarkanika, Orissa	6000
Mahanadi Delta, Orissa	5000
Krishna Estuary, Andhra Pradesh	2651
Coringa, Andhra Pradesh	22450
Godavari Delta, Andhra Pradesh	—
Point Calimere, Tamil Nadu	120
Pichavaram, Tamil Nadu	1358
Goa	2000
Gulf of Kutch, Gujarat	—
Kundapura, Karnataka	—
Achra/Rantagiri, Maharashtra	20000
Vembanad, Kerala	17924

Source: ENVIS, 2002

of mangroves in India. The Committee, on its first recommendation in 1979, suggested for scientific assessment and evaluation of the mangrove habitats in the country. The committee further identified 15 sites for conservation of mangrove habitats during 1987 (Table 3). On the basis of such recommendation, the Ministry of Environment of Forests also launched a scheme on Conservation and Management of Mangroves and Coral Reefs during 1986–87. The goal of this scheme was to develop the degraded mangrove ecosystems, maintain and enrich the biological diversity in mangrove areas and creating public awareness for protection of mangrove ecosystems at provincial level. The federal government also provided guidance and financial assistance to the provincial governments and Union territories for the preparation and implementation of 'Management Action Plans' for the conservation and development of the degraded mangrove ecosystems (Kumar R., 2000). Majority of the coastal states and union territories with mangrove habitats participated in the scheme and initiated conservative measures for the mangroves. The National Committee on the mangroves and coral reefs were given the task of watchdog for implementation of such scheme. Implementation of the scheme has been by and large successful, with a reported increase of mangrove cover during the 1991–1999. The Forest Survey of India reported an increase of 616 sq km of mangroves during the same period (Forest Survey of India, 2011), however, during the following decade the mangrove cover again declined. Such reduction of mangroves may be attributed to the Indian Ocean Tsunami which destructed much of the island mangroves in Andaman & Nicobar Islands.

5.1. Legislative protection of Mangrove forests

5.1.1. Declaration of protected areas

Presently, most of the Indian mangrove habitats enjoy the legislative protection under the Indian Forest Conservation Act, 1980 & the Wildlife (Protection) Act, 1972. The two acts essentially categorize the forests in to various classes with respect to their degree of ecological importance. This categorization closely resemble with the different types of IUCN classified protected areas. Presently, the mangroves habitats are classified in either of the following category such as National Park (IUCN category II), Wildlife sanctuary (IUCN category IV), Reserve & protected forests (IUCN category IV/VI) and community reserves (category VI). More so; the designated status is often upgraded to provide more legal protection to the mangroves. For example, the core area of the Sundarban mangrove forests were initially declared as Tiger reserve in 1973, the same was declared as Wildlife sanctuary in 1977 and later in the year 1984, it received the status of National

Park (IUCN category II). Similarly, the core areas of Bhitarkanika mangroves of Orissa were initially declared as Bhitarkanika Wildlife Sanctuary in 1975, later it was converted to a National Park in 1998. The Indian mangroves receive special attention under the Wildlife Protection Act, 1972 as designated Marine & Coastal Protected Areas (MCPAs). However, such concept of MCPA, though widely used to denote national parks, sanctuaries or tiger reserves declared in coastal or marine areas under the Wild Life Protection Act of 1972, is not a specific category in an Indian legal context (Rajagopalan, 2011). Presently, there are 31 designated MCPA in India, most of which involves mangrove habitats. The Marine and Coastal Protected Areas are classified into 4 categories as per the geo-environmental conditions of the protected areas. National parks & Sanctuaries having entire areas in intertidal or sub-tidal areas are classified as Category I, while marine ecosystems in Islands are considered as category II. Sandy beaches beyond seawater with occasional seawater interaction and evergreen forest and semi evergreen forests are classified as category IIIA & III B respectively (MoEF, GoI, 2008). Table 4 lists the major sites for protection of mangroves along with their conservation status under the Indian legislation framework.

5.1.2. Coastal zoning for effective management

Coastal Zoning is essentially important to conserve the mangroves and to restrict coastal urbanization and other developmental activities. For such purpose, the Ministry of Environment & Forests (MoEF), Government of India issued the Coastal Regulation Zone (CRZ) Notification under the Environmental Protection Act, 1986. This notification declares coastal stretches of seas, bays, estuaries, creeks, rivers and backwaters, which are influenced by tidal action in the landward side up to 500 m from high tide line (HTL) and the land between the Low Tide Line (LTL) as Coastal Regulation Zone (CRZ Notification, 1991; revised in 2011). The Ministry also constituted National and State/UT Coastal Zone Management Authorities under the Environmental Protection Act, 1986 for enforcing and monitoring the CRZ notification (MoEF, GoI, 2008). Further, MoEF classified the Coastal Regulation Zone into four distinct categories, such as

- CRZ I (Ecologically Sensitive Area and essentially no developmental activities is permitted and such areas are recommended for in-situ conservation)
- CRZ-II is mostly concerned with developed coastal areas; development in such zone is permitted on fulfillment of certain legal requirements.
- CRZ –III refers to rural areas where developments like tourism can be extended beyond 200 m on the landward side.
- CRZ –IV includes the coastal stretches of Andaman & Nicobar Islands and Lakshadweep islands.

Under the present coastal zone regulation, all the Indian mangroves are covered under the CRZ I and receives strong legal protection under the Environmental Protection Act, 1986. The Environmental Protection Act also regulates other activities that may adversely affect the sensitive ecosystems through the Environmental Impact Assessment Notification (EIA), 1994. Furthermore, Coastal Aquaculture Authority Act, 2005 is also considered a recent development with respect to the protection of mangroves.

Several other legislative measures (Acts & Policies) are also in place which can be indirectly attributed toward the conservation of mangroves. Table 5 lists some of them.

5.1.3. Management of 'ecosystem stress' & restoration initiatives

Although, the overall mangrove area is not deteriorating further, it is highly imperative that the ecological and ecosystem services

Table 4

List of MCPA with Mangrove habitats & their protection status.

Name of the MCPA	Conservation status with year of incorporation				
	State/Location	Wildlife sanctuary (WL)	National park (NP)	Biosphere Reserve (BR)	MCPA type
MG Marine NP	Andaman	—	1983	—	Category I
Rani Jhansi Maine NP	Andaman	—	1996	—	Category I
Lahabarrack Sanctuary	Andaman	1987	—	—	Category I
North Buttan NP	Andaman	—	1987	—	Category II
Middle Buttan NP	Andaman	—	1987	—	Category II
South Buttan NP	Andaman	—	1987	—	Category II
North Rees Island Sanctuary	Andaman	1987	—	—	Category II
Parkinson Island Sanctuary	Andaman	1987	—	—	Category II
Mangrove Island Sanctuary	Andaman	1987	—	—	Category II
Blister Island Sanctuary	Andaman	1987	—	—	Category II
Great Nicobar Biosphere Reserve	Nicobar	—	—	1989	Category II
Galathea Bay Sanctuary	Nicobar	1997	—	—	Category II
Gulf of Kutch	Gujarat	1980	1982	—	Category I
Khijadiya Bird Sanctuary	Gujarat	1981	—	—	Category I
Malavan Sanctuary	Maharashtra	1987	—	—	Category I
Bhitarkanika	Orissa	1975	1998	—	Category I
CoringaWL Sanctuary	Andhra Pradesh	1978	—	—	Category I
Krishna Sanctuary	Andhra Pradesh	1999	—	—	Category I
Pulicat Lake Bird Sanctuary	Andhra Pradesh	1999	—	—	Category I
Pulicat Lake Bird Sanctuary	Tamil Nadu	1980	—	—	Category I
Point Calimere Sanctuary	Tamil Nadu	1967	—	—	Category I
Gulf of Mannar NP	Tamil Nadu	—	1980	1989	Category I
Sunderban	West Bengal	1977	1984	1989	Category I
Halliday Sanctuary	West Bengal	1976	—	—	Category I
Sajnekhali Sanctuary	West Bengal	1998	—	—	Category I
Lothian Island	West Bengal	1998	—	—	Category I

Source: Prepared by Authors from Rajagopalan (2011) & MoEF, GoI, 2008

Table 5

List of secondary legislation for Mangrove protection.

Acts	Year	Key features in Mangrove protection
Indian fisheries act	1897	Regulates the uses of dynamites and explosives for fishing, control of fishing in eco-sensitive areas.
Indian port act	1908	Regulates the port, movement of vessels & safety.
Coast guard act	1950	Responsible for controlling of water pollution in marine & estuarine environment, control of illegal poaching & intrusion.
Merchant shipping act	1958	Regulates and controls shipping pollution in marine environments.
Water (prevention & control of pollution) act	1974	Control discharge into marine environment (from Land).
Maritime zone act	1976	Describes various zones such as the EEZ, continental shelf etc
Marine fishing regulation act	1978	Provides guidelines to regulate fishing in territorial waters, regulate mesh sizes, zones for fishing sectors.
National environmental tribunal act	1995	Provision of compensation for damaging life, property & environment due to the use of hazardous substance and their release in environment.
Coastal pollution regulation zones (COPOCS Program)	1982	Assess pollution status in coastal areas.
Coastal ocean monitoring and prediction systems (COMAPS)	1991	Assess the health of coastal waters, pollution monitoring, regulation & legislation recommendation
UNCLOS	1995	Provides legal framework for issues related to oceans and seas
Review of CRZ notification by Swaminathan committee	2004	Incorporation of more integrated and scientific management of Coastal Zones.
Coastal aquaculture authority act	2005	Regulates development of aquaculture pond in coastal areas

(Source: Prepared by Authors from MoEF, GoI, 2008)

are restored simultaneously (MoEF, GoI, 2010). Mangroves provided valued ecological and environmental services in the past, especially; the preventive role of mangroves in storm protection and disaster risk reduction has been proved vital in time of critical disasters such as Orissa cyclone (1999) & Indian Ocean Tsunami (2004) (Badola and Hussain, 2005; Kathiresan and Rajendran, 2005; Das, 2012). Notably, an increased community perception about the protective role in time of intense disaster significantly contributed to mangrove conservation (Badola and Hussain, 2005; Gnanappazham and Selvam, 2011). Therefore, ecosystem stress reduction and rejuvenation of the ecosystem services of mangroves are considered as an important component of mangrove management. In order to reduce the primary anthropogenic stress, alternative livelihood development remains the most important aspect. Many provincial governments have made some institutional arrangements promoting economic upliftment of the mangrove dependent communities. For example, Sundarban Development Board which was created in 1973 has been recently upgraded to a separate ministry under the provincial government. A good number of NGOs and regional organizations are also working for raising awareness and capacity building for secured livelihood in mangrove areas (Pattanaik and Prasad, 2011).

Satisfyingly, over the last decade, restoration initiatives also gained momentum all across the major mangrove habitats in India (Bhatt and Kathiresan, 2012; Vyas and Sengupta, 2012; Pandey and Pandey, 2012), however, there is little or no framework to safeguard the existing mangroves from the environmental pollution generated from upstream anthropogenic activities. Also, the rising salinity level and drastic reduction of freshwater flow provides considerable challenges for restoring the ecological services. Most importantly, the water quality continues to degrade despite of sufficient environmental legislation. For example, the Indian Sundarbans receives a pollution load of as much as 22900 kg/day (Mandal et al., 2010). Among the best practice observed in recent past, the case of Gujarat may be narrated where the provincial government categorized the mangroves based on their

vulnerability to anthropogenic stress and according management strategies were defined (Pandey and Pandey, 2012). Nevertheless, actions need to be more prioritized in order to cope with the perceived threat such as Sea level Rise and a restricted freshwater flow in the Indian rivers, especially across the dense mangrove habitats along the eastern coast.

5.2. Non-legislative protection of mangroves

5.2.1. Community protection of mangroves through Joint Mangrove Management

India is particularly strong on the policy front with adequate legal support for conservation of mangroves, however, effective implementation of such legislations are often hampered by the lack of financial and human resources (ENVIS, 2002). More so, the institutional mechanism for forest management in India, at all level of governments may be characterized by poor infrastructure, lack of man power and lack of political will to implement such policies. As discussed, the conservation of mangroves is essentially related to the loss of livelihood and moreover most of the Indian mangroves are situated in complex inaccessible areas, hence, the forest department has failed to establish its statutory rights over the mangroves. As a result, the vigilance over the mangrove habitats has been historically poor. Since the implementation of Joint Forest Management scheme by the Government of India and subsequent modification in the National Forest Policy of 1988, community based co-management is now greatly promoted. Joint Mangrove Management (JMM) has been particularly important; given the context of the Indian mangroves and their inaccessible geographical locations. Also, the sub-committee formed by the Ministry of Environment and Forest (MoEF) to review the restoration protocol and Joint Mangrove Management highlighted JMM as the best possible approach under the present circumstances (Selvam et al., 2012).

Presently many of Indian mangroves are managed through Community based Co-Management where the community develops some kind of sustainable model for mangrove management in consultation with the local forest department, scientific bodies, NGOs and other stakeholders (Fig. 3). Effective contributions from

all the stakeholders are ensured through periodical discussions and workshops. Apart from the targeted mangrove conservation and restoration, several short and long term developmental goals are also implemented through this community based organization, popularly known as Forest Protection Committee (FPC). For example, 54 FPCs along with some 14 Eco-Development Committee (EDC) are given the responsibility of managing approximately 64000 ha of the Indian Sundarbans. The Eco-Development Committees, on the other hand, are responsible for creating public awareness. In all such cases, forests are primarily protected by the local communities and the near forest dwellers who in turn enjoys their traditional claim over the Non timber Forest Products (NTFP) such as wax, honey etc; also in the majority cases local communities are given 25% share of the annual revenue generated from rotational felling or ecotourism. JMM is particularly prominent in the state of Tamil Nadu, Orissa, West Bengal and Gujarat.

5.2.2. Role of NGOs in Joint Mangrove Management

Recognizing the degraded conditions of the mangroves and the poor implementation of earlier conservatory policies, the Government of India undertook rehabilitation and conservation project in collaboration with several national and international NGOs. The induction of NGO in the forest management was typically important because of the prolonged disbelief of the local community in the governmental policies. The role of NGOs has been typically important with many aspects of mangrove management in India. Such aspects are mostly related with the effective communication between the forest department and the local community, creating community awareness, development of alternative livelihood opportunities and educating the local community in terms of the requirements of an effective mangrove management. A good number of NGOs & regional organizations are now working on Indian mangroves and the coastal communities, especially on promotion of bio-diversity & creating community awareness. The MS Swaminathan Research Foundation (MSSRF), Worldwide Fund for Nature (WWF), Wild Life Protection Society of India (WLPSI) and Mangrove for Future (MFF) are some of the leading organizations working on Indian mangroves apart from several other scientific institutions that are involved in research and development activities.

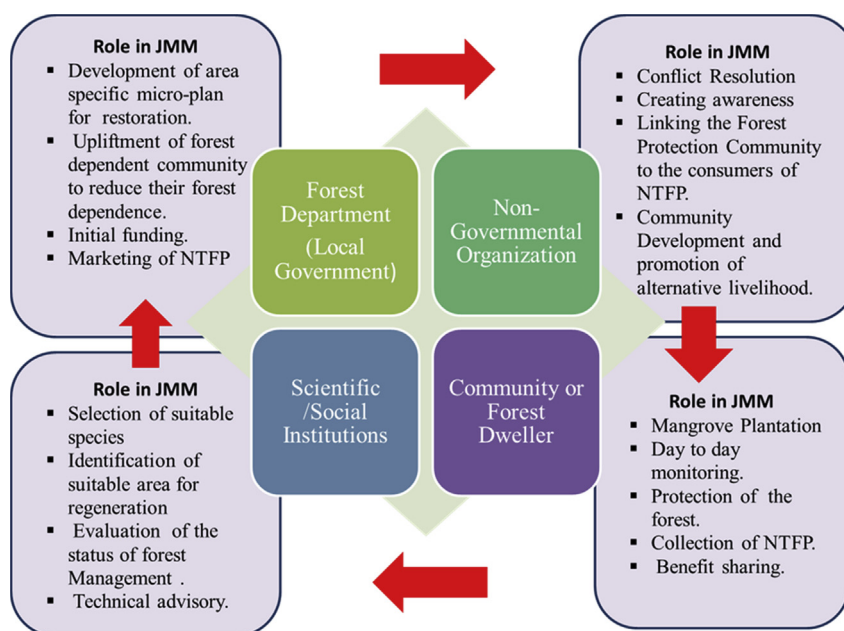


Fig. 3. Schematic diagram of Joint Mangrove management.

The M.S. Swaminathan Research Foundation (MSSRF) needs a special mention as it has been a pioneering NGO working on the Indian mangroves since the inception of JMM concept. It was instrumental for restoration of mangroves in Pichavaram which was otherwise remained heavily degraded (MSSRFa, Selvam et al., 2003). The MSSRF was initially introduced as a technical consultant to investigate the cause of mangrove degradation. It formed four village level institutions, known as Village Mangrove Committee (VMC) to restore the Pichavaram mangroves. In turn, the members of VMC were given training on mangrove restoration and offered a portion of revenue. Reclaimed mangroves also helped the fishing communities with greater number of fish catch. Apart from the mangrove restoration, several SHGs were formed from the mangrove dependent communities to promote Self employment opportunities under the administrative guidelines of the local government. Micro-enterprises, both group based as well as individual based was initiated. More so, the Provincial government recognized such VMCs and accorded permission to the Range Officer of the respective area to function as 'Secretary' of such institutions (MSSRF, 2003). The success of Pichavaram mangrove restoration project essentially inspired several provincial governments to implement JMM. One of the important features of the Pichavaram model was that the mangrove restoration was essentially linked with poverty eradication, alternative livelihood and self employment. The MSSRF further implemented JMM in different mangrove habitats with highly satisfying results. At present, MSSRF established 28 village mangrove councils (VMC) for JFM involving 5240 families in the States of Tamil Nadu, Orissa, Andhra Pradesh & West Bengal. These VMCs are responsible of restoration of 1500 ha of mangroves and also manages about 12000 ha of mangrove forest. Similar to the Pichavaram mangrove restoration project, 194 Self Help Group (SHGs) was also formed in these provinces.

Joint Mangrove Management (JMM) in India has so far yielded better level of mangrove protection compared to the state owned forest management strategies. For example, in Pondicherry, NGO led mangrove restoration projects have resulted in better reclamation compared to the local government reclamation projects (Datta et al., 2012). Similar instances are found almost all-over India where motivated community organizations are more active toward mangrove reclamation and conservation projects.

6. Recommended strategies & way forward

The Indian mangroves have experienced serious exploitation in the past as a result of misdirected policies. Even though, during the post independence regime, strong legislative measures were taken to conserve the mangroves, such policies were unsuccessful in safeguarding the mangrove habitats. The implementation of JMM was particularly a path breaking event in the effort of mangrove conservation. However, integrated management of mangroves requires some further efforts and initiatives. Some of the key challenges and its probable mitigation measures are furnished below.

6.1. Issues in Joint Mangrove Management

JMM is now widely evolved as an alternative mangrove management; however, it requires further fine tuning. For example, a recent study which evaluated the performances of 14 community based eco-development committee in the Indian Sundarban reported that only half of them functions actively while rest remain dormant (Datta et al., 2010). One common problem that is encountered in Joint Mangrove Management—that more often community efforts are heavily directed to commercial resource harvesting rather than effective conservation. In many cases, local leaders lead the community organizations at ground level and they are often

motivated to fulfill their political interests rather than conservation of forests. As a result, mass support for restoration & conservation projects gradually fades out. Importantly, most of the cases community organizations suffer lack of tenurial security and legal sanctity. Another important aspect of JMM is the stratified societies of India with various caste and creeds. It has been reported that the community often gets bifurcated on specific issues impacting the successful implementation of JMM and their desired implications. On the other hand, in some cases top-down approach by the local forest department also deactivates community initiatives. It makes the community responsible for afforestation and maintenance of the existing forests, while they may not have the one responsible for the degradation. However, the most important issue of Joint Mangrove Management is the benefit sharing of forest resource and economic incentives. Unequal distribution of resources and lack of transparency in resource harvesting and inadequate economic incentives often led to conflicts and loss of community interest in participatory management. Notably, as the population increases in the vicinity around the mangroves, it would be hard to find exploitable forest resources in a sustainable manner. Hence, it is important to link these community organizations to alternative livelihoods arrangements more precisely in addition to the forest resource harvesting. Also, funding for running community organizations remain as major constraint. Forest Protection Committees (FPCs) are mostly funded by the local government; however, such funds are inconsistent. Involvement of external funding agencies and supportive NGOs are also limited. Hence, these critical issues need to be resolved for more effective implementation of JMM.

6.2. Issues in managing the emerging threats

As discussed, majority of the Indian mangrove habitats are now threatened by various other factors such as reduction in freshwater flow, marine & coastal pollution, siltation & sedimentation and excessive salinity. The deltaic and the insular mangroves, especially the mangroves at the eastern coast are most likely to suffer the intense stress of sea level rise in near future while industrial and infrastructural development will continue to stress the western coast mangroves. It is highly imperative that these potential threats are considered more seriously in overall coastal management. Moreover, mainstreaming adaptation in coastal areas is extremely crucial given the uncertainties of climate change impacts on the coastal areas (Khan et al., 2012). Management of mangroves also needs to be linked with broader perspective of disaster risk reduction as the eastern coast continues to remain the hotspots of tropical cyclones. Following the Indian Ocean Tsunami in 2004, countries like Indonesia & Malaysia mandated coastal barrier plantation; however, India is yet to develop similar strategies. On the other hand, problem of marine and coastal pollution is very much prominent all across India. The Environmental Protection Act of 1986, especially the Coastal Regulation Zone Notification was certainly a crucial step toward the protection of fabulous coastal resources of the country, yet, it requires more stringent implementation; particularly in the industrialized provinces at the western coast. Finally, the level of community perception about the mangroves needs to be further strengthened and sustained. Conservation linked to a broader perspective of ascertaining environmental security, reducing disaster risks and as an anticipatory adaptation measure essentially holds the clue for a futuristic and effective management.

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