



# Status, Biodiversity and Distribution of Mangroves in India: An overview

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## Introduction

Mangrove are one among the most productive ecosystems on the earth. They serve as custodians of their juvenile stock and form most valuable biomass (Odum, 1971). The term mangroves refer to an ecological group of halophytic plant species which is known as the salt tolerant forest ecosystem and provides a wide range of ecological and economic products and services, and also supports a variety of other coastal and marine ecosystems. 'Mangrove' has been variously defined in literature. The oxford dictionary mentioned the words 'mangrove' and 'mangrove' since 1613, indicating tropical trees or shrubs found in coastal swamps with tangled roots that grow above the ground, whereas the Americans, the Spanish, and the Portuguese used the term 'Mangle' and 'Mangue' indicating trees and shrubs of the genus *Rhizophora* (Mepham & Mepham, 1984). Later, the term 'mangrove' was referred to the individual plant or tidal forest or both, as 'Mangrove plants' and 'Mangrove ecosystem' (MacNae 1968).

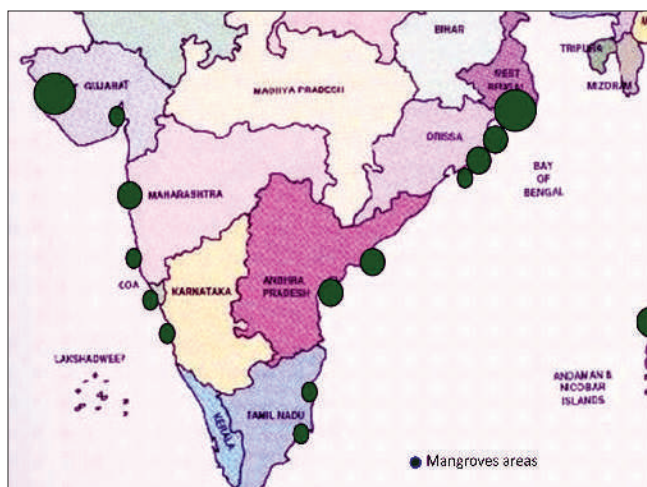
## Global Scenario

Mangroves occupy less than 1 % of the world's

surface (Saenger, 2002) and are mainly found between the Tropic of Cancer and the Tropic of Capricorn on all continents covering an estimated 75 percent of the tropical coastline worldwide. There are more than 18 million ha of global mangroves inhabiting in 112 countries and territories in the tropical and subtropical region. Around 34 major and 20 minor mangrove species belonging to about 20 genera in over 11 families have been recorded globally (Tomlinson, 1986). Mangroves of South and Southeast Asia form the world's most extensive and diverse mangrove systems comprising 41.4 percent of global mangroves. Indian mangroves make up 3.1 percent of the total global cover and are distributed along all the maritime states, except the union territory of Lakshadweep, covering an area of about 4461 km<sup>2</sup> along the 7,500 km long Indian coastline.

## Indian Scenario

India with a long coastline of about 7516.6 km, including the island territories (Anonymous, 1984), has a mangrove cover of about 6,749 km<sup>2</sup>, the fourth largest mangrove area in the world (Naskar & Mandal, 1999). These mangrove habitats (69°E-89.5°E longitude and 7°N-23°N latitude) comprise three distinct zones: East



**Fig. 1.** Distributional details of mangroves in India

coast habitats having a coast line of about 2700 km, facing Bay of Bengal, West coast habitats with a coast line of about 3000 km, facing Arabian sea, and Island Territories with about 1816.6 km coastline. In India, the states like West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Andaman and Nicobar Islands, Kerala, Goa, Maharashtra, and Gujarat occupy vast area of Man-

groves. The area under mangroves in Gujarat is the second largest along the Indian coast, after Sunderbans. Gujarat has about 23 percent of India's estimated mangrove cover of 4.88 lakh ha. Of the total mangrove cover in the state, the coastal district of Kachchh covers almost 90%. Mangroves in India account for about 3% of the global mangroves and 8% of Asian mangroves (SFR, 2009; FAO, 2007). About 60% of the mangroves occur on the east coast along the Bay of Bengal, 27% on the west coast bordering the Arabian Sea, and 13% on Andaman & Nicobar Islands. Mangroves are spread over an area of 4,661.56 km<sup>2</sup> along the coastal areas of the country. Mangrove cover has been categorised into very dense (canopy density of more than 70%), moderately dense (canopy density between 40-70%) and open mangrove cover (canopy density between 10-40%). Distribution of mangroves along the Indian coast is presented in Table 1. Gradual topography along the east coast is said to have an extensive intertidal expanse which favours major formation of mangroves in the deltaic regions (Jagtap and Komarpant, 2003). Mangrove area is larger in the east coast of India around 80% as to 20% in the west coast owing to the terrain and slope and due to the

**Table 1: Different types of Mangroves distributed along the Indian Coast and their area (Source: Forest Survey India).**

Sl No.	State/UT	Very Dense Mangrove (Km <sup>2</sup> )	Moderately Dense Mangrove (Km <sup>2</sup> )	Open mangrove (Km <sup>2</sup> )	Total (Km <sup>2</sup> )
1	Andhra Pradesh	0	126	226	352
2	Goa	0	20	2	22
3	Gujrat	0	182	876	1058
4	Karnataka	0	3	0	3
5	Kerala	0	3	3	6
6	Maharashtra	0	69	117	186
7	Orissa	82	97	43	222
8	Tamil Nadu	0	16	23	39
9	West Bengal	1038	881	236	2155
10	Andman & Nicobar Islands	283	261	73	617
11	Daman & Diu	0	0.12	1.44	1.56
12	Puducherry	0	0	1	1
<b>Total</b>		<b>1403</b>	<b>1658.12</b>	<b>1601.44</b>	<b>4662.56</b>



river deltas of Ganges, Brahmaputra, Mahanadi, Godavari, Krishna and Cauvery which have nutrient rich alluvial soil. 60 species of mangroves are known to grow abundantly (Untawale, 1986). Sundarbans (east coast) form a major portion of mangrove forests in India, covering about 9,600 sq. km of mangrove forest and water. The Sundarban comprises essentially of numerous islands formed by the sediments deposited by three major rivers, the Ganga, Brahmaputra and the Meghna, and a dense network of smaller rivers, channels and creeks. Mangroves are the most dominant flora in Sundarbans and 30 true mangroves occur in the Indian Sundarban. Debnath and Naskar (1999) identified 36 species as true mangroves.

The east coast is endowed with the world's largest forest, the gangatic sunderbans in West Bengal. The mangrove area in Orissa is nearly 200 km<sup>2</sup> in extant and its degradation is placed at 20 km<sup>2</sup> over ten years, as per recent estimates. Andhra Pradesh possesses about 582 km<sup>2</sup> of mangrove area. Tami Nadu is one of the nine maritime states of India endowed with the second longest coastline of 1.076 km. The major mangrove wetlands in Tamil Nadu are Pichavaram mangroves and Muthupet mangroves, for which river Cauvery is the main supplier of freshwater. The area under mangrove ecosystem in Tamil Nadu is about 225 km<sup>2</sup>. One of the largest and most unspoiled mangrove forest in Tamil Nadu is at Pitchavaram in Cuddalore District, extending over an area of 1100 km<sup>2</sup>. (Venkataraman, 2007). Historically, Gujarat has an extensive and diverse mangrove ecosystem. Goa has seven major micro tidal estuaries with the swamps composed of laterite, loamy and alluvial soils. Out of 130 km<sup>2</sup> coastal wetland in the state 67.30 km<sup>2</sup> is contributed by mudflats and mangroves. These mangroves are present in the narrow intertidal mudflats along the estuary banks and are of fringing nature which is said to be due to rising topography of the coast. These habitats are been reclaimed for urbanization and agricultural purposes. The state of Orissa has a geographical area of 155707 km<sup>2</sup> with an actual forest cover of 47107 km<sup>2</sup> (30.3 %). Total area of sanctuary is 672 km<sup>2</sup> of which mangrove forests constitute 130 km<sup>2</sup>. This area receives water from three rivers, known to be rich in species diversity and trees are dense and tall like those of Sunderbans (Selvam, 2003).

The mangrove ecosystem is basically of three types, the first being the deltaic mangroves located along the mouth of major estuaries on east coast and Gulf of Kachh and Khambhat Gulf on the west coast. These cover up to 53% of the total Indian mangroves out of which Sunderbans cover about 78%. Second types are the coastal mangroves which are found along the intertidal coastlines, minor river mouths, sheltered bays, and backwater areas of the west coast this constitute 12% of the mangrove area of India and lastly the island mangroves which are found along shallow protected intertidal zones of bay islands such as Lakshadweep and Andamans. They are approximately 16% of the total mangrove area (Ingole, 2005).

## Biodiversity

Mangroves are being utilized for their wood construction, fuel, fodder, barks for tannin extraction, fruits and young shoots are used as vegetable, medicinal use, protection from natural calamities such as during Tsunami in 2004 mangrove populated area in Tamil Nadu, Andhra Pradesh had negligible impact and people could also take shelter in the mangroves present at the Coringa Wildlife Sanctuary (MSSRF, 2005 & WWF, 2005). The long coastlines and their mangrove vegetation have immense role in protecting coastal biodiversity. Mangrove ecosystem covered 47% world's mangrove area with 85% world's mangrove species from different habitats having an important role in coastal biodiversity of 30 countries that bordered the Indian Ocean (Kathiresan & Rajendran, 2005). As many as 55 mangrove species belonging to 22 genera and 18 families have been recorded in the Indian Ocean region. Mangrove ecosystems are rich in biodiversity and harbour a number of floral and faunal species. They also act as nurseries for finfish, shellfish, crustaceans and molluscs.

The Indian mangroves comprise approximately 59 species in 41 genera and 29 families. Of these, 34 species belonging to 25 genera and 21 families are present along west coast. There are about 25 mangrove species which have restricted distribution along the east coast and are not found on the west coast. Similarly, there are eight species of mangroves like *Sonneratia caseolaris*, *Suaeda fruticosa*, *Urochondra setulose* etc. which have



been reported only from the west coast. There are approximately 16 mangrove species reported from the Gujarat coast, while Maharashtra has about 20 species, Goa 14 species and Karnataka 10. There are hardly three to four species of mangrove which are rarely found along the Kerala coast. The associated mangrove flora is quite common to both the coasts, with minor variations in distribution. The floral diversity of mangroves of India is comprised of 38 core mangrove species (Kathiresan, 2003).

There are different types of faunal communities in mangrove waters which are dependent on the water component in one way or the other. The planktonic and benthic animal communities play a very important role in the mangrove ecosystem just like the terrestrial animals. There are a total of 105 species of fish which are typical mangrove dwellers in India. There are different species of crustaceans like *Penaeus indicus*, *P. merguensis* and *P. monodon*, while the crabs are represented by *Uca* sp. *Scylla serrata*, *Thalassina*, etc. The fishes are represented by several species like the mud skippers, carangids, clupeids, serranids, mullets, hilsa, seabass, milkfish and others.

## West Bengal

The wildlife of Indian mangrove is quite diverse and interesting. Apart from the famous Royal Bengal Tiger and estuarine crocodile (*Crocodilus porosus*), there are different kinds of monkeys, otters, deer's, fishing cats, snakes and wild pigs. The mangrove swamps of India are favoured by a variety of birds, both migratory and resident. There are many Penaeid and non-penaeid prawn and shrimp species reported in the Indian mangroves. Some of these are: *Metapenaeopsis coniger*, *Metapenaeus monoceros*, *M. affinis*, *M. brevicornis*, *M. dobsoni*, *M. lysianassa*, *M. kutchensis*, *M. moyebi*, *Parapenaeopsis longipes*, *P. sculptilis*, *P. stylifera*, *P. canaliculatus*, *P. indicus*, *P. japonicas*, *P. latisulcatus*, *P. merguensis*, *P. monodon*, *P. semisulcatus*, *P. penicillatus*, *Acetes erythraeus*, *A. indicus*, *Solenocera crassicornis*, *Macrobrachium lamarrei*, *M. idella*, *M. idea*, *M. dayanum*, *M. javanicum*, *M. malcolmsoni*, *M. mirabile*, *M. rosenbergii*, *M. rude*, *M. scabriculum*, *Palaemon concinnus*, *P. debilis*, *P. styliferus*, *P. semmelinkii*, *P. tenuipes*, *Alpheus crassimanus*, *A. paludicola*, *Caridina*

*gracilirostris*, *C. brachydactyla*, *Lucifer hanseni*, *Thalassina anomala*. (Source: FAO, 1988, Kathiresan and Rajendran, 2000).

## Pondicherry

In the Pondicherry mangroves, among the macro fauna, fishes (Class: Osteichthyes) are plentiful with 39 species belonging to 24 families under 7 orders. 77% of these fishes belong to the order Perciformes. The most abundant fish species are *Chanos chanos*, *Arius jella*, *Atule mate*, *Oreochromis mossambica*, *Terapon jarbua* and *Gerrus filamentosus*. Fishes such as mullet, milk fish and tilapia are caught at high reaches towards north of Murungapakkam and Thengaithittu. *G. filamentosus*, *Kathala axilaris*, *Caranx* sp. Occur mostly near the mouth. Mangrove specific fishes- *Lutjanus argentimaculatus*, *Siganus canali-culatus*, *S. javus* (Kathiresan 2000) are caught near the areas where branches of *A. marina* are submerged. *Ambasis commersoni*, *A. mate*, *C. chanos*, *Eetroplus suratensis*, *Johnius carutta*, *Kathala axilaris*, *Lutjanus russelli*, *Monodactylus argenteus*, *Nibea maculata* and *Sillago sihama* are commercially important and seasonal (Saravanan et al. 2008). Kathiresan & Rajendiran (2002) reported 102 and 86 species of fin fishes from Pichavaram mangroves and Vellar estuary, respectively. They recorded 72 fin fishes of Pondicherry region, while in the present study only 39 species were found. There is an observed loss of 46% of fish species when compared to the previous report (Kathiresan & Rajendiran 2002). While From Pichavaram mangroves, 197 species coming under 68 families and 17 orders were recorded by Rao, 1995 and from Sundarban Mangrove ecosystem, 139 species of finfishes was recorded (Mandal and Nandi, 1989; Braj Gopal & Chauhan, 2006).

There are eight penaeid prawn species abundant in Pichavaram mangroves (Kathiresan & Bingham, 2001) are found in Pondicherry mangroves, while various finfishes are also found in this mangrove area like *Ambassys gymnocephalus*, *A. commersoni*, *Arius subrostratus*, *Chanos chanos*, *Eetroplus suratensis*, *Gerres filamentosus*, *G. abbreviates*, *Liza parsia*, *L. macrolepis*, *L. subviridis*, *Lates calcarifer*, *Lutjanus argentimaculatus*, *Mugil cephalus*, *Osteomugil cunnesius*, *Pomadasy*



*kaakan*, *Plotosus canius*, *Scatophagus argus*, *Siganus javus*, *S. canaliculatus*, *Terapon jarbua* (Kathiresan, 1999).

## Kerala

At west coast in Ayiramthengu mangroves, Kollam district, Kerala, twenty seven species belonging to 17 families have been reported. Of the 17 families, Mugilidae has the highest representation with 4 species followed by Carangidae and Cichlidae with 3 species each and Ambassidae, Gerreidae and Siganidae with 2 species each. The remaining 11 families were represented each by a single species (Jisha. *et al.*, 2004).

## Andhra Pradesh

Mangroves of Andhra Pradesh are moderately rich in diversity. Thirty five species of mangroves occur in the Godavari and Krishna estuaries. Of these 16 are true mangroves which require both sea water and river water. Nineteen associated species (plants that can survive both in terrestrial and estuarine conditions) occur in these wetlands. Mangroves play an important role in coastal fisheries production. The fishermen community living in 39 villages use mangrove resources of Godavari mangroves for artisanal fishing. The mangrove areas are rich in crustacean, molluscs and finfish resources. Fish species such as catfish, mullets, snappers, milkfish, carps, tilapia and mudskipper are common in mangrove areas. Snails, crabs, prawns and molluscs are also found. Prawn species such as *Penaeus monodon* and *P. indicus* are quite common. Many varieties of edible crabs live in mangrove areas, and giant fresh water prawns in swampy areas.

## Goa

Mangroves flora in Goa comprises of 15 species generally dominated by *Rhizophora mucronata*, *Avicennia alba*, *Sonneratia alba*, *S. caseolaris*, *Exoecaria agallocha* and *Acanthus ilicifolius*. *Kandelia candal* found in the oligohaline region has better formation in Goa as compared to other state (Jagtap & Singh, 2004). A wide variety and assortments of fish, molluscs, crabs and prawns inhabit here. The amphibious mud-skipper fish such as *Periopthalmus* sp. and *Boleopthalmus* sp. arouse considerable interest. The fauna also found are Whale Shark, Tiger Shark, Hammer Headed Shark, Saw fish, Guitar fish and some common edible fish e.g., *Hilsa*

*ilisha*, *Setipinna breviceps*, *Setipinna taty*, *Gudusia chapra* etc. Among the crustaceans, commonly found are the One Armed Fiddler Crab (*Uca* spp) and the two species of trilobite (*Tachypleus gigus* and *Carcinoscorpius rotundicauda*). The latter is also known as the Horse Shoe Crab, which is known as a living fossil and needs serious protection owing to its medicinal value and uncontrolled collection by quack doctors for commercial purpose. Sundarban Mangroves is a home to many endangered species like Royal Bengal Tiger (*Panthera tigris*), *Estuarine crocodiles* (*Crocodilus porosus*), *Marsh crocodiles* (*Crocodilus palustris*), Fishing cat, Wild pig, Deer and Marine turtles (*Lepidochelys olivacea*, *Eretmochelys imbricata* and *Chelonia mydas*).

## Tamil Nadu

An account of the food web pattern of 67 species of fishes, belonging to 51 genera and 33 families, of the Pichavaram mangrove ecosystem has been reported. Of these, 32 species are omnivores, 30 species carnivores, and only 5 species are herbivores.

## Pondicherry

Seven true mangrove floral species belonging to 3 family have been identified in this area. About 16 mangrove associated floral species belonging to 12 families are reported along the inundated and the adjacent regions. 39 species of fishes belonging to 24 family under 7 orders have been identified. 77 percent of the fishes identified at the study area belong to the order *Perciformes*. *Gerrus filamentosus*, *Leiognathus bindus*, *L. brevirostris*, *L. splendens*, *Mugil cephalus*, *Oreochromis mossambicus*, *Siganus canaliculatus*, *S. javus*, *Sillago sihama*, *Terapon jarbua* and *Terapon puta* observed in abundance. Commercially important species such as *Ambasis commersoni*, *Atule mate*, *Chanos chanos*, *Etroplus suratensis*, *Johnius carutta*, *Kathala axilaris*, *Lutjanus russelli*, *Monodactylus argenteus*, *Nibea maculata* and *Sillago sihama* occur seasonally and are caught by fishermen in this mangrove waters. 15 species of decapod crustaceans are identified in which are penaeid prawns and 9 are brachyuran crabs. All the prawns and some crabs such as *Scylla serrata*, *Portunus pelagicus* and *Portunus sanguinolentus* considered as of fishery importance. During rainy season, the availability of prawn are abundant. Totally, 15 species of mollusks



were identified. Four of them belong to the class Bivalvia and the rest 9 species belong to the class Gastropoda.

## Potential threats

Stress on wetlands has increased due to the rapidly growing population, technological development, urbanisation and economic growth. Additional pressures on wetlands from natural causes like subsidence, drought, hurricanes, erosion etc., and human threats coming from over exploitation, encroachment, reclamation of vast wetland areas for agriculture, commercial and residential development, and have altered the rate and nature of wetland functions particularly in the last few decades. Even though mangroves have such important values they were treated as unwanted plants used mainly as a source of timber and charcoal which caused depletion during the last two decades. Recent surveys quote that deforestation is the cause which destroyed about 44% and 26% of mangroves along the west and east coast, respectively (Upadhyay, *et al.*, 2002). This caused a critical need for understanding the biodiversity of the mangrove ecosystems.

This ecosystem is a nursery for juvenile of economically important fish and prawn species. Great amount of detritus food supporting a variety of young fish and shrimps is generated from mangroves (Ingole, 2005). In private areas or khazans land mangroves face severe threat due to the conversion of these lands for aquaculture, agriculture and other developmental activities and reclamation causes damage to saplings and small mangrove plants in general.

## Conservation and Management status

Mangroves in India are one of the most valuable coastal habitats providing enormous benefits (both tangible and non-tangible) to the local communities as well as the ecology and environment surrounding them. Tangible benefits of mangroves comprise timber and non-timber products, fishery and other livelihood support systems whereas non-tangible benefits include ecological and social functions, such as coastal protection against wave and current abrasion, shelter and habitat for wildlife, and ecotourism. Globally, mangrove resources are seriously threatened and have

been disappearing due to intensive human as well as developmental interactions. Human settlements, expansion of agricultural or salt-making lands, development of industries and ports, the expansion of coastal aquaculture, have been identified as the critical factors that have resulted in depletion and degeneration of mangrove resources.

Mangroves need protections from natural disasters in which coastal zone is a dynamically unstable where of one or the other kind like sea intrusions, cyclones, tsunami, etc., strike year after year. Last few decades have experienced gradual increase and unusual accumulation of CO<sub>2</sub> in the atmosphere mainly due to industrial activities, global warming, ice melt increase in water in oceans, tidal waves.

Conservation and reforestation programmes of mangroves in the central west coast of India was initiated to increase public awareness with regards to the importance of mangroves; intertidal mud banks control; new avenues for forestry and social forestry activities; biomass increase along the estuaries to influenced biological productivity; and improve bird and animal life (Untawale, 1996). Goa Government has banned felling of 15 species of mangroves according to the Goa, Daman and Diu Preservation of Trees under Act, 1984. Government of India declared these areas as ecologically sensitive areas under the Environment (Protection) Act, 1986 putting a ban on their exploitation and by the CRZ Notification 1991 prohibited development activities and disposal of wastes in these areas. Ministry had made a plan-scheme for conservation and management of mangroves and coral reefs in 1986 and constituted National Committee to advise the Government on relevant policies and programs. Due to their recommendations 15 mangrove areas in the country were identified for intensive conservation (Anon, 1997; Jagtap *et al.*, 2002).

Main factor for consideration to develop a management strategy for mangroves is to create buffer zones limiting anthropogenic activities around the demarcated corridor of the wetland which could revive its natural functioning (Castelle *et al.*, 1994). It is important to identify the functional values, magnitude and source of disturbance, adjacent land use and to project the possible impact of such stress in long term,



etc. Buffer zone might be consisting of diverse vegetation along the perimeter of water body, preferably an indigenous one serving as trap for sediments, nutrients, metals and other pollutants, reducing human impacts by limiting easy access and acting as a barrier to invasion of weeds and other stress inducing activities (Stockdale, 1991).

In fact, until about 1960s, mangroves of Gujarat were considered as 'economically unproductive areas' and hence, they had faced destruction caused by expansion of economic as well industrial development activities (Hirway and Goswami, 2007). However, after many years of wide spread destruction and degradation, significant efforts have been made in recent years by the State Government and the International agencies to restore and regenerate the mangrove stock in Gujarat. According to FSI report there was a constant increase in the mangrove cover in Gujarat state since 1987-1999 but in 2001 it decreased from 1031 sq km to 911 sq km. But ever since 2001 the state saw an increase of 135 sq km. There is also a report that Gujarat showed an increase in mangrove cover mainly because of the plantation and protection measures taken by the state in recent years.

Gujarat has decided to undertake a major drive of mangrove plantation along the coastal regions of Kutch and Jamnagar under Gujarat Forestry Development Project. The state forest department has commissioned about Rs. 830 crore project for restoration and development of mangrove plantations. Accordingly, the project aims to conserve existing forest cover and also provide viable livelihood options to the tribals. The project has been envisaged for an eight-year period, starting from 2007-08 to 2014-15. The project activities is confined to the forest areas of eastern tribal belt of the state, reserved grasslands in Rajkot district, mangroves in Kori Creek, Kutch Coast, Marine National Park in Jamnagar Division.

### Suggested Management Plan (SMP)

Pollution mitigation practices to decrease the cause of non-point source of pollution through source reduction; waste minimisation and process control; afforestation with native species in deserted areas around the wetland to manage silt entry from runoff; shorelines of the lakes are lined with bricks or stones to control shoreline erosion; constructed wetlands for the

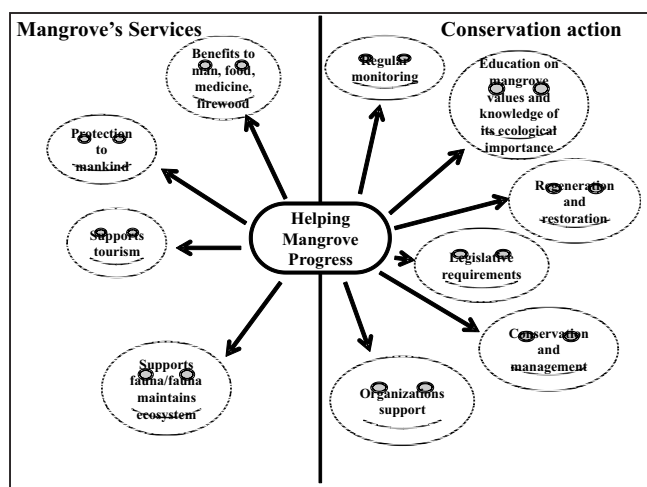
purpose of storm water management and pollutant removal from the surface water flows; infiltration trenches for reducing the storm water sediment loads to downstream areas by temporarily storing the run-off; and regular monitoring of estuaries, which are basic.

Reinstatement programs with ecosystem approach with the help of Best Management Practices (BMPs) helps correcting point and non-point sources of pollution. Regulations and planning for wildlife habitat and fishes along with this helps arresting the deteriorating water quality and the rate of loss of wetlands. Goals require thoughtful planning, authority and funding along with financial resources and active participation from all levels of organisation such as governmental and non-governmental organisations (NGOs), research organisations etc. through interagency and inter-governmental processes all made good in innovating and starting the restoration programs. Educational institutions, researchers, NGO's and the local people network are said to assist restoration of the fast perishing wetland ecosystem and conserve the ones at the point of extinction by creating viable plans, policies and management strategies.

### Conclusion & Recommendation

Proper monitoring is imperative to prevent illegal activities such as poaching of mangrove fruits, fishing activities, movement of barges etc so that young plants do not get damaged, fish germplasm is not depleted. Fisheries should be encouraged with proper vigilance and legislation so as to avoid damage to the existing mangroves. The speed of the barges should be maintained. Aquaculture should be practiced at thinly populated mangrove areas. With proper planning for activities such as aquaculture, agriculture, construction, mining, industrialization etc, proper survey, prop staff for monitoring and properly restoration can be done.

Along with the restoration work, awareness should be campaigned, educational materials should be made available to improve knowledge on mangrove habitats, resources, relevant legislation, policies and conservation strategies with the help of media like magazines, films, posters, pamphlets, documentary, exhibitions, bird watching tours, study tours, competitions on mangrove knowledge etc. Learning can be more easy with better



**Figure 2:** Benefits of mangroves (left), Man's service towards conserving mangrove (right).

vision on the mangrove health and conservation when it is done through research by learning its taxonomy, diversity and distribution, current status of health, conservation measures, restoration measures, different human and natural impact assessment studies. Information centres should be put up so as to keep all the information on the resources. Most important problem which forced people into illegal collection of

fuel, wood, timber etc is poverty so these if provided at a nominal price could reduce its illegal attempt.

These buffers created by the God are still considered as wastelands. Services which mangroves provides and man's services towards them are shown in Figure 2. Some parts of the mangrove area are taken over by construction companies for raising buildings, garages etc. They are considered as dumping grounds for wastes from industrial and municipalities without having an insight what we would have to pay for this damage (decline in fisheries, no support from natural calamities like tsunamis and climate change-increasing the level of seawater in turn causing flooding etc). Oil pollution created by the barges, casinos ships (Caravella etc which remain floating in the water) have increased to attract tourism in the state thereby increasing the economy but increasing other risks due to the destruction of mangroves.

If we think about the short term benefits we get from developing the mangrove areas rather than thinking about the long term gains through conservation, things would be out of control. If we do not protect this wetland ecosystem created for us they would not be in any position to protect and help us.

## References

- Anon. 1997. Estuaries of India: State of the Art Report. ENVIS, Publication Series, 2/97.
- Brij Gopal and Malavika Chauhan. 2006. Biodiversity and its conservation in the Sundarban Mangrove Ecosystem. *Aquat. Sci.* 68 (338-354).
- Castelle, A.J., Johnson, A.W., & Conolly C. 1994. Wetland and stream buffer size requirements: A review. *Journal of Environmental Quality*, 23(5), 878-882.
- Debnath, H.S. & K. R. Naskar, 1999. A comparative study on the mangroves and associated flora in the Ganga delta (Sundarbans) and Bay Islands (Andaman and Nicobar). In: D. N. Guha Bakshi, P. Sanyal and K. R. Naskar (eds.), *Sundarbans Mangal*. Naya Prokash, Calcutta, pp. 277-292.
- FAO (1988). Worldwide compendium of mangrove associated aquatic species of economic importance. FAO Fisheries Circular No.814 (FIRI - C814), Rome, 236 pp.
- FAO, 2007. The world's mangroves 1980-2005. Forestry Paper No. 153, Rome, 77 p.
- Hirway, I. and S. Goswami. 2007. Valuation of Coastland Resources. The Case of Mangroves in Gujarat. Academic Foundation. India.
- [http://www.goaforest.com/forestsofgoa/body\\_mangroves.htm](http://www.goaforest.com/forestsofgoa/body_mangroves.htm)
- Ingole, B. 2005. Indian ocean coasts, coastal ecology. *Encyclopedia of Coastal Science*. pp 446-554.
- IUCN/WWF. 2005. Forests and Natural Disasters *Arborvitae*. (27).
- Jagtap, T. G., Chavan, V., Untawale, A. G. (1993). Mangrove ecosystems of India: A need for protection. *Ambio*, 22(4). pp 252-254.
- Jagtap, T. G., Komarpant, D. S. (2003). Evaluation of Mangrove Ecosystem of India for Assessing its Vulnerability to Projected Climatic Changes. *Assessment of Climate Change in India and Mitigation Policies*. Ed. SK Dash & Prakash Rao, WWF, New Delhi. p 39-51.
- Jagtap, T. G., Singh, C. 2004. Mangroves - Nursery For Fishes. *Know our shore Goa*. p 47-56.
- Jagtap, T.G., Murthy, P.S., Komarpant, D.S. 2002. Mangrove ecosystem of India: conservation and management. In Hosetti, B.B. (ed.). *Wetlands Conservation and Management*, Jaipur, India. Pointer Publishers. p 35-67.
- Jisha S., C.M. Aravindan and S.D. Ritakumari, 2004. Checklist of fish fauna of Ayiramthengu mangroves, Kollam district, Kerala, India. *Seshaiyana Vol.12 No.2* (2004).



- Kathiresan K., & Rajendiran H. 2002. Fishery resources and economic gain in three mangrove areas on the south east-coast of India. *Fisheries Management and Ecology* 9: 277-283.
- Kathiresan, K. & B.L. Bingham. 2001. Biology of mangroves and mangrove ecosystems. *Advances in Marine Biology* 40: 81-251.
- Kathiresan, K. and Rajendran, N. 2000. Flora and fauna in Indian mangrove ecosystem: East coast. In: Kathiresan, K. (Ed.), *Flora and fauna in Mangrove ecosystems: a manual for identification*, pp. 1-49.
- Kathiresan, K., 1999. Impact of mangrove biodiversity on associated fishery resources and fishers' income. A project final report submitted to WWF, Washington DC.: 142 pp.
- Kathiresan, K., 2003. How do mangrove forests induce sedimentation? *Revista de Biología Tropical* 51, 355-360.
- Kathiresan, K., Rajendran, N. 2005. Mangrove ecosystem in the Indian Ocean region. *Ind. Jour Mar. Sci.* (34)1. p 104-113.
- MacNae, M. 1968. A general account of the fauna and flora of mangrove swamps and forest in the Southwest Pacific region. *Advances in marine biology*. 6: 73-270.
- Mandal. and Nandi, 1989. Fauna of Sundarban mangrove ecosystem. *Records of Zoological Survey of India*, 1-27.
- Mepham, R. H. & J.S. Mepham, 1984. The flora of tidal forests-a rationalization of the use of the term 'mangrove'. *South African Journal of Botany* 51: 75-90.
- Naskar, K. and R. Mandal. 1999. *Ecology and Biodiversity of Indian Mangroves*. Daya Publishing House, Delhi, India. pp. 386-388.
- Rao, K.V.R. 1995. *Pisces. Wetland Ecosystem Series 1: Fauna of Chilka lake*. *Records of Zoological Survey of India*, 95: 483-506.
- Saenger, P. 2002. *Mangrove Ecology, Silviculture and Conservation*. Kluwer Academic publishers, Dordrecht, The Netherlands. pp. 11-18.
- Saravanan, K.R., Ilangoan K. & Khan, Anisa B. (2008). Floristic and macro faunal diversity of Pondicherry mangroves, South India. *Tropical Ecology* 49(1): 91-94, 2008.
- Selvam, V. (2003). Environmental classification of mangrove wetlands of India. *Current Science*, 84: 757-765.
- SFR, 2009. *Forest Survey of India 2007. India State of Forest Report*, Dehradun, pp. 27-31.
- State of Forest Report 2011. *Forest Survey of India*.
- Stockdale, E. 1991. Fresh water wetlands, urban storm water and non point source pollution control: A literature review & annotated bibliography. Olympia, WA: Washington Department of Ecology.
- Tomlinson, B. P. 1986. *The Botany of Mangroves*. Cambridge Univ. Press, Cambridge, USA.
- UNESCO. (1992). Coastal systems studies and sustainable development. *Proceedings of the COMAR Interregional Scientific Conference*, UNESCO, Paris, 21- 25 May, 1991. UNESCO, Paris. p 276.
- Untavale, A. O. (1986). Mangroves of India. In: *Mangroves of Asia and the Pacific-status and management*. UNDP/UNESCO Project Research and Training Pilot Program on Mangrove ecosystems. (RAS/79/002. UNOP/UNESCO. Manila).
- Untawale, A.G. (1996). Restoration of mangroves along the Central West Coast of India. In *Restoration of mangrove ecosystems*. p 111-112.
- Upadhyay, Y.P., Rajan R. & Singh, J.S. 2002. Human-mangrove conflicts: The way out. *Current Science*. 83(11). p 1328-1335.
- Venkataraman, K. 2007. Coastal and Marine wetlands in India. *Proceeding of Taal 2007: the 12th world lake conference*: 392-400.
- WWF. 2005. Tsunami update. [http://www.wwf.org.uk/News/n\\_0000001426.asp](http://www.wwf.org.uk/News/n_0000001426.asp)