

Beyond the Tsunami

Current Status of Mangroves in Kerala and Tamil Nadu,
India, with regard to Vegetation,
Community Perceptions and Policy

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Nibedita Mukherjee, Farid Dahdouh-Guebas
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United Nations Team for Tsunami
Recovery Support

Author details:

Kartik Shanker

Adjunct Fellow,
Ashoka Trust for Research in Ecology and the Environment (ATREE)
659, 5th Main Road, Hebbal,
Bangalore 560092. India.

and

Assistant Professor, Centre for Ecological Sciences,
Indian Institute of Science, Bangalore 560012. India.
E-mail: kshanker@ces.iisc.ernet.in

Nibedita Mukherjee

Research Associate,
Ashoka Trust for Research in Ecology and the Environment (ATREE)
659, 5th Main Road, Hebbal,
Bangalore 560092. India.

and

PhD Student, Plant Biology and Nature Management (APNA),
Vrije Universiteit Brussel – VUB,
Pleinlaan, B-1050 Brussels,
Belgium.
E-mail: nibedita.41282@gmail.com

Farid Dahdouh-Guebas

Complexity and Dynamics of Tropical Systems,
Université Libre de Bruxelles – ULB,
Av. F.D. Roosevelt 50,
B-1050 Brussels,
Belgium.
E-mail: fdahdouh@vub.ac.be

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Executive Summary

The Indian Ocean tsunami which struck the coastline of several nations of South and South East Asia on 26th of December, 2004 caused damage to vast areas of mangroves in this region. In the Andaman and Nicobar islands in India for instance, a large number of standing mangrove trees were uprooted by the tsunami waves. However, mangroves in mainland India were not reported to have been affected severely by the 2004 tsunami. Post tsunami, a large body of research addressed the role of mangroves as bioshields and coastal protection. Ironically, there are several other critical issues threatening the existence of mangroves in the three tsunami affected states in India. For instance, mangroves provide a vast array of ecological and socio-economic services. Despite their critical role, they are under severe anthropogenic threat and are declining drastically (global decline of 1% per year between 1990 and 2000). Understanding the drivers of such changes is extremely crucial for better management of this ecosystem in the future.

Tamil Nadu was the worst affected state in mainland India due to the tsunami. Understandably, most of the research focus in this project and elsewhere has focused on this region. Though the state of Kerala on the west coast of India received less attention, the environmental pressures on mangroves and other coastal habitats are equally intense. In this report, we looked at the status of mangroves in select locations on both the east and west coasts in these two tsunami affected states.

Specific objectives

- We studied the current vegetation species composition and structure in select study sites as an indicator of mangrove health (Kerala and Tamil Nadu).
- We looked at natural resource use pattern by local communities of a mangrove area in Tamil Nadu (Muthupet).
- We looked at conservation scenarios of mangroves under different management scenarios and under different land holding categories to examine the sustainability of the system in the long term.
- We also interacted with government and non-government stakeholders of mangrove conservation and attempted to analyze policies relevant to mangrove conservation and long term persistence in the landscape.

Key findings

- Preliminary data suggested that current mangrove health is better in Kerala than in Tamil Nadu. Further data collection and analysis is required to substantiate this.
- The local community's dependence on mangrove fishery resources was documented in Muthupet. An interesting observation was that after the tsunami, motorized fiber boats increased in number compared to the number of traditional wooden boats used prior to the tsunami. Many artisanal fishermen still continue to fish in the lagoon but their numbers are declining (Figure 1). This is gradually leading to over fishing and over a period of four years the

fish catch/unit effort has declined and oil spills from boats is beginning to create a serious pollution problem in the lagoon water.

- We found that the influence of policy and its implementation needs further attention in the tsunami affected states. Policies like EFL (Ecologically Fragile Lands Act, 2007) which are currently being implemented in Kerala can be potentially applied in other coastal states as well. Awareness about policy regulations is another dimension which needs urgent attention.

Our recommendations

- The hydrology of mangroves in Tamil Nadu (both Pichavaram and Muthupet) needs urgent attention. The quantity of fresh water has declined dramatically over the years and is the most critical factor affecting mangroves in this region.
- Several existing patches of healthy mangroves in Kerala need to be brought under an appropriate management regime to protect them from further decline. The disputes over ownership of the land and access to the natural resources (e.g. fisheries) should be immediately looked into with the consent and participation of local resource users.
- Existing policies like Ecologically Fragile Lands Act [2007] can be further bolstered and implemented in other states to improve the conservation of mangroves on the ground.

Finally, there needs to be greater interaction between policy makers, local users of mangroves, mangrove biologists and representatives of NGOs. The future of mangroves does not rely on a single stakeholder group alone and neither will a single community be affected if mangroves decline and disappear. It is thereby pertinent at this juncture to seek greater collaboration amongst stakeholder groups to help conserve mangroves better.

1. Introduction

Mangroves are interface ecosystems that occur at the confluence of rivers and seas in tropical and subtropical areas (Lugo & Snedaker 1974). The term 'mangrove' describes both the ecosystem and the plant families that are adapted to live in the tidal saline environment (Tomlinson 1986). They provide a vast array of ecological and socio-economic services like coastal protection (Dahdouh-Guebas *et al.* 2005; Walters *et al.* 2008), soil conservation (Furukawa *et al.* 1997), nurseries for commercially important fishes, crabs and prawns (Manson *et al.* 2005; Nagelkerken *et al.* 2008), carbon cycling (Kristensen *et al.* 2008); fuel wood and fodder (Dahdouh-Guebas *et al.* 2006), a variety of traditional non-wood forest products (Bandaranayake 1998, 2002), and shelter to migratory birds and other fauna (Cannicci *et al.* 2008).

Despite their critical role, they are one of the most threatened ecosystems - with a reported global decline of 1% per year between 1990 and 2000 (Valiela *et al.* 2001; Lewis III 2004, Duke *et al.* 2007). According to a recent Food and Agricultural Organisation [henceforth FAO] report there are only 15.2 million hectares of mangroves left in the world and a staggering 3.6 million hectares (20% of world mangrove area) has been lost since 1980 (FAO 2007). It is worth noting here that though mangroves are often used for subsistence purposes by local populations, the major threat to mangroves worldwide are reported to be rapid urbanisation, conversion to aquaculture farms and currently tourism (Dahdouh-Guebas *et al.* 2002, FAO 2007). Even cryptic ecological degradation may deteriorate mangrove forests (Dahdouh-Guebas *et al.* 2005). It is only recently that their ecological and derived socio-economic importance are being realised and efforts are being made to manage mangrove ecosystems in a sustainable way. Today, mangrove afforestation is one of the key approaches currently being employed to address the issue of their rapid decline (Bosire *et al.* 2008).

In the light of the December 26, 2004 Indian Ocean tsunami there has been a recent surge of interest in mangroves (Mukherjee *et al.* 2007). There is a growing body of literature which has dealt with the effectiveness of mangroves as bioshields (Kar and Kar 2005; Kathiresan and Rajendran 2005; Dahdouh-Guebas *et al.* 2005; Roy & Krishnan 2005; Barbier 2006; Dahdouh-Guebas 2006; Kerr *et al.* 2006; Vermaat & Thampanya 2006). A number of studies attempted to demonstrate that bioshields played a significant protective role. This was done largely by comparing areas with and without coastal vegetation/dunes etc., and looking at human and infrastructure loss. However a few authors have criticised the analysis or assumptions. The argument of these authors was that the impact of the tsunami was highly dependent on topography (and bathymetry), distance from the shore, and other physical factors. They argued that vegetation contributed little, if any, protection to the coast. The aim of this report, however, is focus on the ecological, socio-economic and management related aspects of mangroves in two tsunami affected states, Kerala and Tamil Nadu, from a multidisciplinary perspective which has not been addressed adequately in these areas.

There are several gaps in our understanding of the ecological and socio-economic aspects of mangrove systems. The overarching relevance of policy on shaping mangrove conservation in the present and future has also been completely ignored. As the scientific community progresses from unidimensional approaches in understanding natural resource management towards a more integrated, multidisciplinary approach, we have attempted to incorporate this perspective in our report. We have looked at the current vegetation status of mangroves at representative sites in Kerala and Tamil Nadu, the socio-economic benefits of mangroves, as well as the major policy interventions that have been brought into effect after the tsunami to conserve/protect mangroves.

2. Mangrove status and anthropogenic threats

2.1. Ecology

Mangroves naturally occur in the waterlogged and saline soils of sheltered tropical and subtropical shores. They are subject to diurnal and seasonal (neap/spring) tides. They usually thrive in the intertidal zone up to the high-tide mark. Mangrove forests comprise 46 genera having about 60 species of true and associate mangrove species globally (cf. Tomlinson 1986). Tidal flooding, salinity, soil nutrients, temperature, light intensity and currently sea level rise due to climate change are important physical factors affecting mangrove status in a particular region (Krauss *et al.* 2008). Sulphide levels in the soil have also been reported to be significant in determining the presence and zonation of mangroves. There are a suite of biotic factors that affect mangrove ecosystem functioning. Notable among these are herbivory by crabs, leaf feeders, wood borers, molluscs etc., and pollination by bats and ants (Cannicci *et al.* 2008). Given that a considerable portion of mangroves are degrading/ declining, we attempted to ask the following questions:

- a) What is the current vegetation status of the remnant mangrove patches?
- b) What are the major abiotic factors that affect natural regeneration of mangroves at degraded mangrove sites?

Methods

On the west coast, we conducted the study in three fragmented patches of mangroves in Kannur district in Kerala (Figures 1, 2). The number of plots laid was approximately 5% of the total mangrove cover in Kerala. The names of the plots and the number of plots are as follows:

- Villikil [TVN] - 6
- Edat [PEN] - 8
- Pattuvum [TPN] - 9

In order to investigate the abiotic factors affecting regeneration of mangroves, the following parameters were measured:

- (i) Soil - moisture, salinity, sulphide and pH
- (ii) Water - salinity, dissolved oxygen and pH

Biotic factors were not examined within the scope of this study. Other physical parameters, e.g. light and temperature were not examined since it was unlikely that they would play a significant role, as the two mangrove areas are present within the global geographic distribution of mangroves for these two factors. The impact of climate change is another area which remains to be investigated.

On the east coast, we conducted the study in two mangrove reserve forests in Tamil Nadu, namely, Pichavaram and Muthupet. 16 plots per site were studied in each of the reserve forests along river creeks. Detailed description of the study area is provided under sections 3 (1) and 3 (2). We used standard vegetation plots [5m x 5m] to study the species composition and abundance in these patches. We also collected soil and water samples from each plot and sent them to commercial laboratories for analysis.

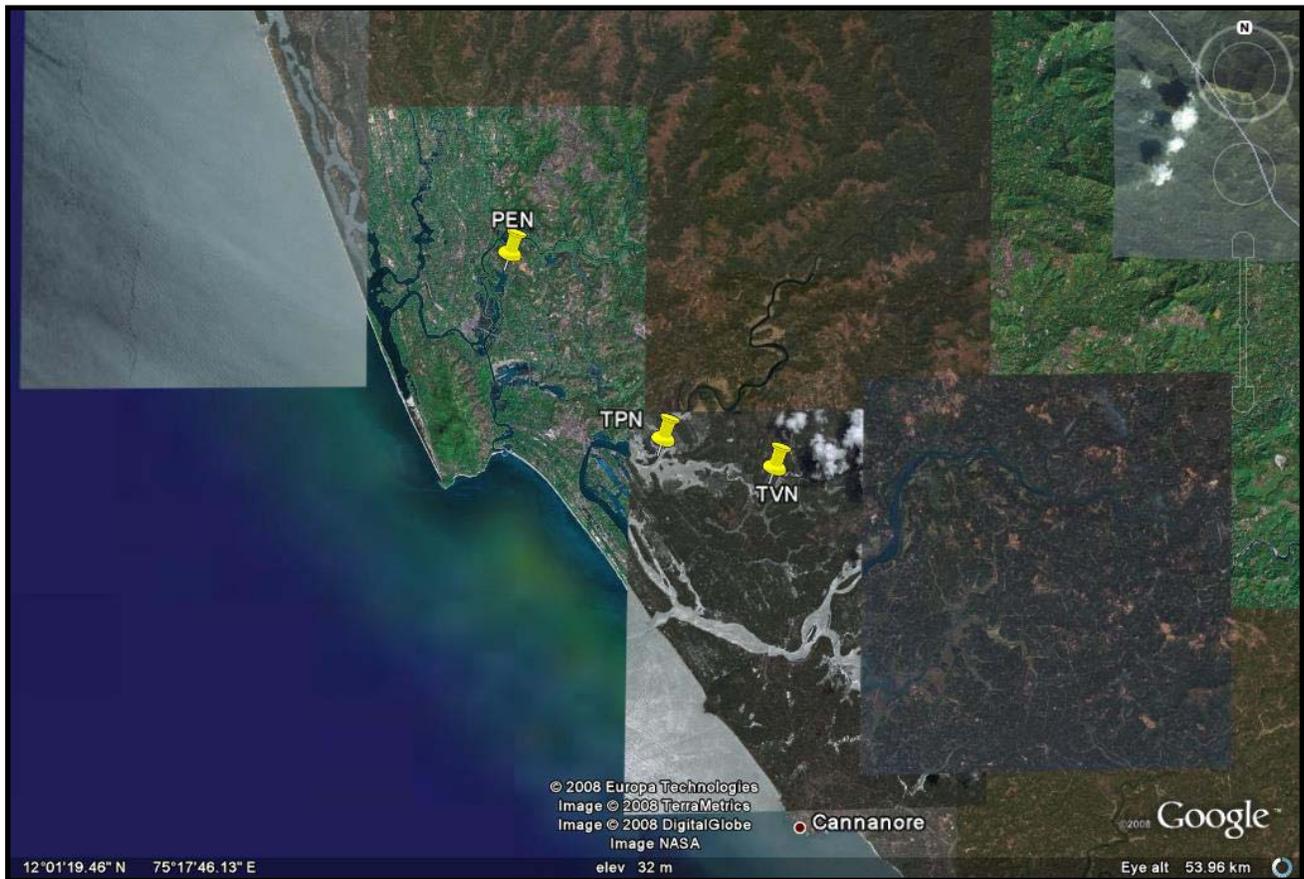


Figure 1: Location of mangrove patches studied in Kannur (Cannanore) (PEN=Payannur Edat Natural Mangroves; TPN= Talliparamba Pattuvam Natural Mangroves; TVN= Taliparamba Villikil Natural Mangroves)



Figure 2: Close up of one of the mangrove patches, Talliparamba Pattuvam Natural Mangroves (TPN), in Kerala

2.2. Socio-economic factors

Mangroves occur in areas which are often densely populated. The landscape matrix within which mangroves are situated has a strong bearing on the sustainable management and conservation of mangroves in the long term (Ellison 2008, Walters *et al.* 2008). Mangrove wetlands provide an array of products like fish, crabs, shrimps, fuelwood, fodder, etc., which are important for commercial and subsistence use. The impact of the tsunami on this local dependence on mangroves has scarcely been quantified in the published literature in the two tsunami affected states. Moreover, local support for mangrove conservation/restoration by government agencies like the Forest Departments, non-government organisations and the communities themselves are also significant for the continued persistence of mangroves in the landscape. This is particularly important in Kerala, the most densely populated state in India, as most of the mangrove occur outside protected areas.

We thereby attempted to address the following questions:

- 1) What are the local community and NGO perceptions about mangroves?
- 2) What are the local uses of mangroves?
- 3) What is the level of local awareness about mangrove conservation?
- 4) What are the perceptions of the implementation agency (Forest department) about mangrove conservation/restoration efforts?

Methods

In Kerala, the number of local fishermen in our study area was quite sparse to conduct a systematic survey. We thereby interviewed ten individual fishermen on an opportunistic basis.

In Muthupet in Tamil Nadu, we interviewed 64 local fishermen with the help of OMCAR foundation to study local perceptions about mangroves. We also conducted a questionnaire based survey in various Forest Department offices in the two states and interviewed several local NGOs engaged in mangrove conservation.

3. The sites

3.1. Mangroves of Kerala

The mangroves of Kerala are under great threat due to anthropogenic pressure. There is documented evidence in literature that there has been a drastic decline of mangrove area. There are estimates as high as 14,00,000 ha for mangrove area in Kerala [CED Report]. It has been reported that in the recent past Kerala had 70,000 ha under mangrove cover (Mohanan 2004). There are few (if any) comprehensive baseline studies which have documented the status of mangroves in Kerala. Basha Chand's survey about 17 years back in 1991 reported a figure of 17 km² for the mangrove cover in the entire state (Chand 1991). This figure is often quoted even now as the 'current' mangrove area. Rapid urbanisation, conversion of mangrove area to coconut plantations and agriculture and ecotourism are the main drivers of mangrove loss in the state (Mohanan 2004). It is therefore necessary to assess the total mangrove cover in the state and to bring into force stringent policy interventions to stem the rapid decline.

The focus of this report was restricted to mangroves occurring in the two northernmost districts of Kerala: Kasargod and Kannur. The choice of the districts was based on the fact that currently a significant portion of mangroves in Kerala is restricted to these two districts. The Kerala Forest Department has also been proactive in mangrove conservation in these two districts. There is also support from a local NGO, Society for Environmental Education in Kerala [SEEK], towards mangrove conservation.

Study area

The mangrove ecosystem of Kerala is nested within the backwater ecosystem of this state. Kerala has more than 900 km of interconnected waterways, rivers, lakes and inlets that together constitute the Kerala backwaters¹. This interlinked network of waterways forms an excellent matrix for the dispersal of mangrove propagules and the regulation of soil salinity: the two crucial factors determining mangrove presence and long term persistence in a landscape. Figure 3 shown below is a representative map of the coastal backwater system in Kerala.

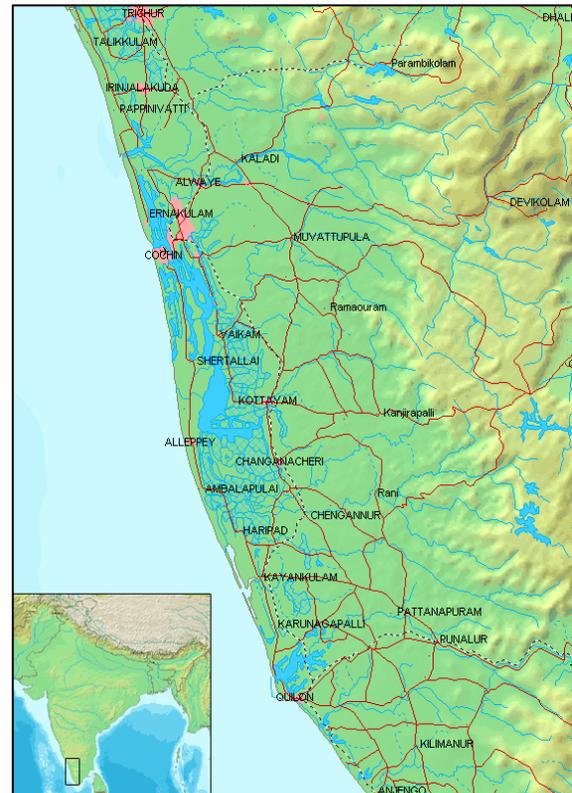


Figure 3: Backwater system of Kerala¹

¹ http://en.wikipedia.org/wiki/Kerala_Backwaters

Vegetation status

The distribution of mangroves in Kasargod and Kannur is extremely patchy, though there may have been extensive mangrove forests in the past.

Species composition

The species composition consisted of both true and associate mangrove species. *Avicennia officinalis* was the dominant species followed by *Rhizophora mucronata* Lamk. There was a clear zonation observed with *Kandelia candel* on the outward zone, followed by an assemblage of *Rhizophora mucronata*, *Bruguiera cylindrica*, *Ceriops decandra*, *Excoecaria agallocha* and *Aegiceras corniculatum*. In the core area, there are large old growth *Avicennia officinalis* trees.

We conducted the study at three selected natural mangrove sites in Kannur namely Villikil, Kunhimangalam and Pattuvam. Broadly, the geographical boundary of the study region is the crestline of the Brahmagiri ranges of the Western Ghats in the East, the coastal lowland merging into the Arabian Sea in the west, wetlands of Kasargod district in the north and Valapattanam river basin in the south. These mangrove sites are located along water bodies which are often 20 km inland. These wetlands have tidal influence and are interconnected to the Kavvayi backwaters towards the North and the combined estuary of the Kuppam and Valapattanam rivers in the south. Kunhimangalam mangrove area is parallel to the coast at approximately 20 km and has an outlet at Thurthi. The Peruvamba and Kavvayi, drain into these backwaters. The average annual rainfall for the region is 3400 mm. Figure 4 below is a climate diagram of the weather station nearest to the study sites.

An interesting observation made here was the presence of *Sonneratia alba*. This species can grow up to a height of about 15 m and has conical pneumatophores. This species was not recorded during our study period on the east coast in Tamil Nadu. The presence of regenerating individuals (saplings and young trees) of this species in natural mangrove patches is an indicator that such sites can harbour luxuriant mangrove vegetation. We recorded a total of nine (see Tomlinson 1986) true mangrove species in our plots in addition to five associate mangrove species like *Acrostichum aureum*, *Acanthus ilicifolius* and *Dolichandrone spathacea*. The fruiting trees ranged from a height of 2 m (*B. cylindrica*) to a height of 12 m (*Sonneratia alba*). The canopy cover was almost complete (>95%) in most of these patches. Natural regeneration was not quantified but direct field observations indicate that there was profuse natural regeneration.

Parameters affecting vegetation

We analysed a total of 8 soil samples and 8 water samples. The soil pH varied from 4.2 to 6.2 and salinity varied from 5 ppt to 11 ppt. The soil Hydrogen sulphide varied from 0.1 to 1.1 mg/l, and the total organic carbon was found to be 4.8%. The water parameters were fairly uniform with pH values ranging from 6.3 to 7.5, salinity ranging from 26 to 29 ppt and dissolved oxygen varying from 7.0 to 7.6 mg/l. Such low salinity values are not surprising because coastal Kerala being on the windward side of the Western Ghats receives an average of 3107 mm of rainfall. Therefore, salinity is not a major determinant affecting vegetation status in the study areas. Thus, these physical parameters were found to be conducive to mangrove growth and regeneration, and thereby not limiting mangrove survival in this region.

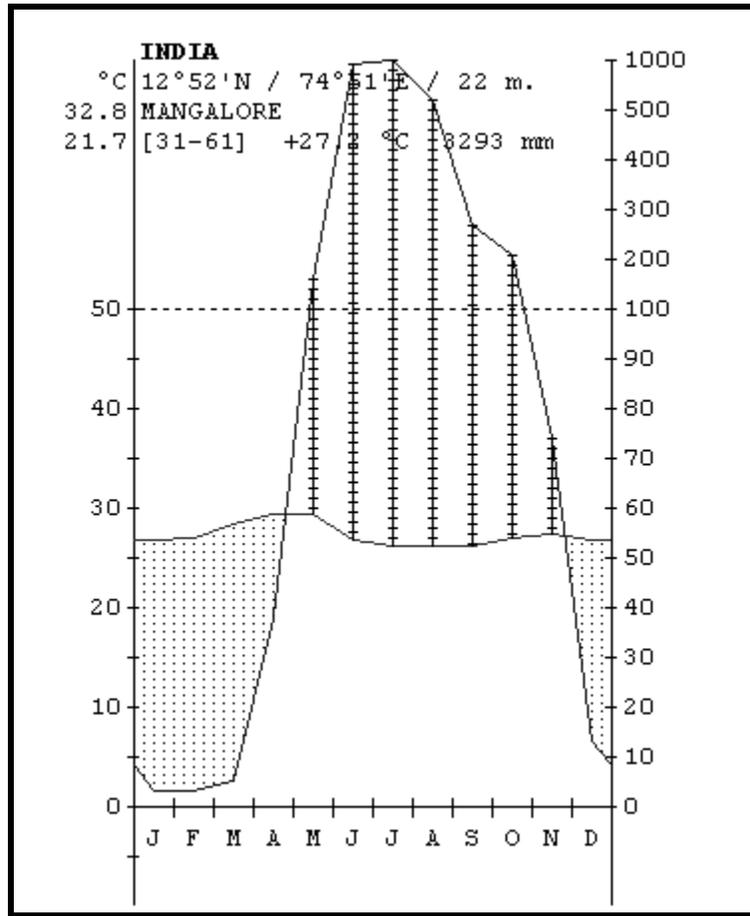


Figure 4: Climate diagram of Mangalore city, which is nearest to the study areas in Kerala (Source: <http://www.globalbioclimatics.org/plot/in-manga.htm>)

Socio-ecological status

Since mangrove cover has declined over the years, the locals' awareness and dependence on mangroves have subsequently decreased. The media attention given to the tsunami has, to an extent, increased the level of awareness about the importance of mangroves for coastal protection. Moreover, most of the patches studied are not under any protected area system and are in a densely human dominated landscape. This is coupled with the fact that changing lifestyles and economic changes have led to changes in natural resource usage in mangroves. We conducted structured and semi structured interviews with three different stakeholder groups (Forest Department, NGO and local residents in mangrove areas) to understand local perceptions about mangroves post tsunami.

Forest Department and NGOs

The Divisional Forest Department Office at Kannur is responsible for the forest ranges in both Kasargod and Kannur. The Forest Department has taken several steps towards mangrove conservation and restoration in this region. These include planting of mangrove saplings in areas close to natural mangrove patches, and implementing the Forest Conservation Act, 1980 to prevent the illegal felling of mangrove trees. The presence of Forest Department officials in village common lands where mangroves are currently being planted has also led to awareness about this critical ecosystem. The Taliparamba Range Forest Office for instance has booked over a 100 cases relating to illegal felling of mangrove trees under the Ecologically Fragile Zone Act, 2006. The Forest Department is also engaged in fencing natural mangrove patches to prevent encroachment and illegal conversion to shrimp farms. These interventions can go a long way in ensuring the continued presence of mangroves in the landscape (see text box on next page).

There was only one local NGO called Society for Environmental Education in Kerala [SEEK] which is involved in mangrove conservation in Kannur (Figure 5). We conducted a structured interview with the President Shri Padmanabhan. This NGO has been actively engaged in environmental education about wetland resources in North Kerala particularly mangroves. Though they are not involved in direct plantation of mangroves, the NGO has bought a plot of 4 acres of mangrove land and is actively engaged in conserving it.



Figure 5: Members of SEEK

Local communities

Traditionally, the Pulaya fisherfolk communities in Kannur and Kasargod would fish in the mangrove backwaters; the Pulaya community is engaged in catching a diverse range of fauna like fish, shrimp, crabs, shells etc. (Nayak *et al.* 2000). However, the number of fishermen fishing in the mangrove waters has declined over the years. Currently fishing in the open sea is preferred over inland fishing owing to better economic returns. Moreover, conversion of agricultural fields and mangrove areas to coconut plantations and shrimp farms has reduced the natural resource base for these local fisherfolk.

Ecologically Fragile Zone Act

It is important to highlight the Ecological Fragile Zone Act (2005) and its amendments (2006-07) in this context. This law is aimed at conserving ecologically fragile habitats in Kerala. Mangrove forests are also offered protection under this act. The Forest Department of Kerala is in the process of documenting most of the remnant natural mangrove patches and is attempting to bring a large portion of these patches under a Reserved Forest network. The process of notification began in early 2007 and is currently ongoing. Once this has been institutionalised, it is hoped that at least some of these patches will be conserved better. Our observations in the field and regular interactions over a period of six months with the Forest Department officials who are implementing the act indicate that it is perhaps the best possible management scenario to protect mangroves. This Act can be implemented in other coastal states as well to bring mangrove forests which are currently not under any protected area system and are being depleted. Given that mangrove decline is a global phenomenon and these forests occur in intensely human dominated landscapes, such policies could have positive impacts.

3.2. Mangroves of Tamil Nadu

In Tamil Nadu, two protected areas (Reserve Forests) primarily have mangrove vegetation. They are:

- 1) Muthupet mangroves comprising six Reserve Forests (Muthupet, Thuraikkadu, Thamarankottai, T. Vadakadu, Marakkadu, Palanjur) spanning Nagapattinam, Thiruvarur and Thanjavur districts.
- 2) Pichavarm mangroves comprising three Reserve Forests (Killai, Pichavaram and Pichavaram Extension area) in Cuddalore district.

Though there have been a large number of studies on Pichavaram mangroves, there are relatively fewer studies on Muthupet mangroves. There are also a few minor mangrove patches in Ramanathapuram and Tuticorin districts in the Gulf of Mannar Marine National Park. However these remnant natural mangroves have been studied less extensively as compared to the former two mangrove patches.

Study area

In this report we focused on the two major mangrove areas, namely, Muthupet and Pichavaram, since these mangroves were located in areas which were worst hit by the tsunami. Pichavaram is located on the southeast coast of India ($11^{\circ} 23' - 11^{\circ} 30' \text{ N}$ and $79^{\circ} 45' - 79^{\circ} 50' \text{ E}$). The 11 km^2 patch of Pichavaram consist of 51 islets, and half its area is covered by forest, 40% by waterways, while the remaining consists of mud and sand flats (Krishnamurthy and Jayaseelan 1983).

Muthupet and Pichavaram mangroves are both situated in the Cauvery delta, and the river Cauvery is the main supplier of freshwater to these two wetlands. The quantum of freshwater reaching the two mangrove areas is extremely critical to their survival and regeneration. Unfortunately however, both the periodicity and quantum of freshwater reaching the two mangrove wetlands have declined phenomenally over the last century. There is ample testimony to this fact from Public Works Department of Tamil Nadu state. For instance, the amount of water discharged into the Coleroon River was 73 TMC in the 1930s, while in the 1990s it was only 3-5 TMC. This is also strongly correlated to the quantum of sediment reaching the mangrove areas. Several mangrove biologists have attributed the local extinction of many true mangrove species and changing species diversity over time in these two areas to this reduction in freshwater supply (and resulting increase in salinity). However, little action has been taken to improve the hydrological imbalance. This problem is aggravated by the fact that this area has a pronounced dry season between January to July when the temperature can reach up to 36° C in the hottest month. This is indicated in the climate diagram of Nagapattinam below (Figure 6).

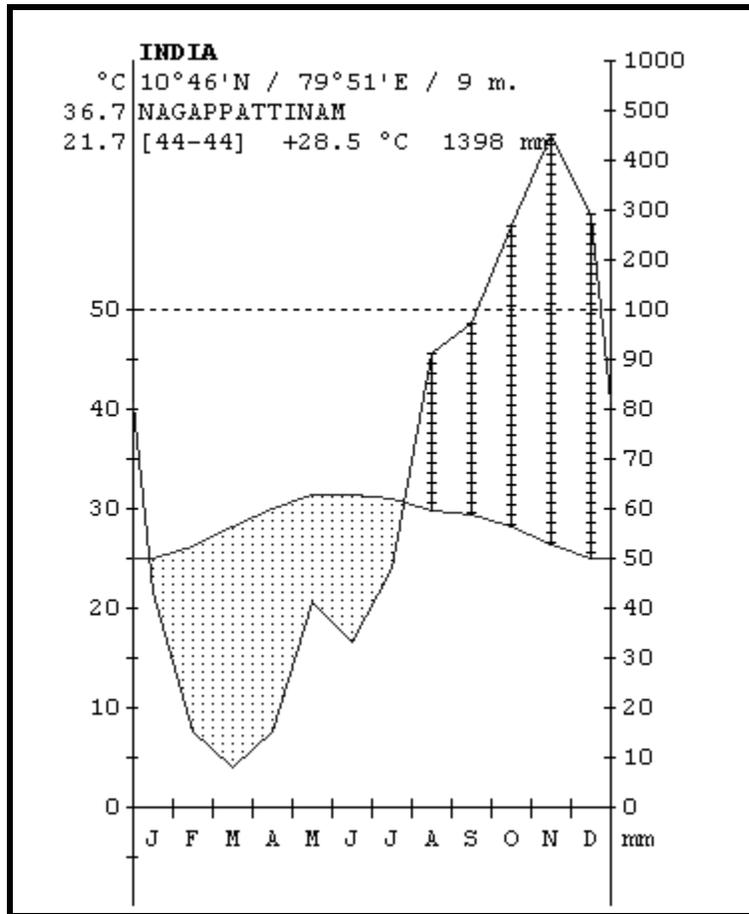


Figure 6: Climate diagram of the weather station Nagappattinam, which is nearest to the study areas in Tamil Nadu (Source: <http://www.globalbioclimatics.org/plot/in-nagap.htm>)

Vegetation status

Both Muthupet and Pichavaram are dominated by *Avicennia marina* trees. In Pichavaram, the fringes of waterways are colonised by *Rhizophora mucronata* and *R. apiculata* species. *B. cylindrica* and *Ceriops decandra* can also be found in this zone though their numbers are markedly lower (Figure 7). *Avicennia marina* is the dominant species and covers most of the interior of the delta. The average height of the trees is also markedly lower than that of Muthupet (Figure 8).

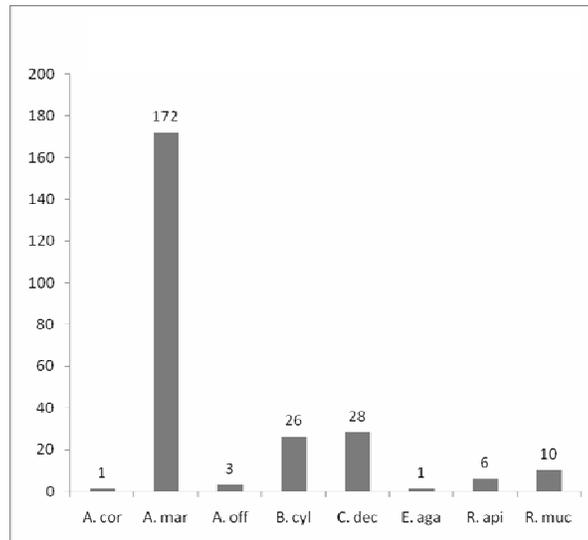


Figure 7: Species composition of mangroves in Pichavaram (Legend: A. cor=*A. corniculatum*, A. mar=*A. marina*, A. off=*A. officinalis*, B. cyl=*B. cylindrica*, C. dec=*C. decandra*, E. aga=*E. agallocha*, R. api=*R. apiculata*, R. muc=*R. mucronata*)

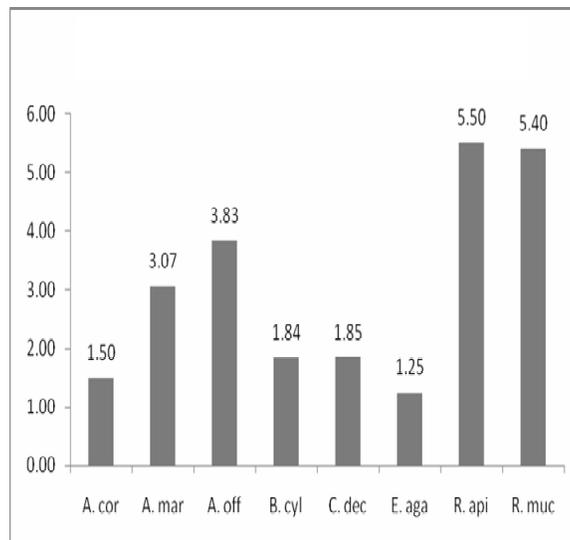


Figure 8: Average height of trees (metres) in Pichavaram

In Pichavaram, the Forest Department has been following a restoration technique called ‘fish bone technique’ which is basically aimed at bringing in tidal water to help in flushing out the excess salinity in the soil. This has resulted in the entire landscape in Pichavaram being crisscrossed with channels. Given below is a recent Google Earth image of Pichavaram mangrove forest which illustrates the above (Figure 9).

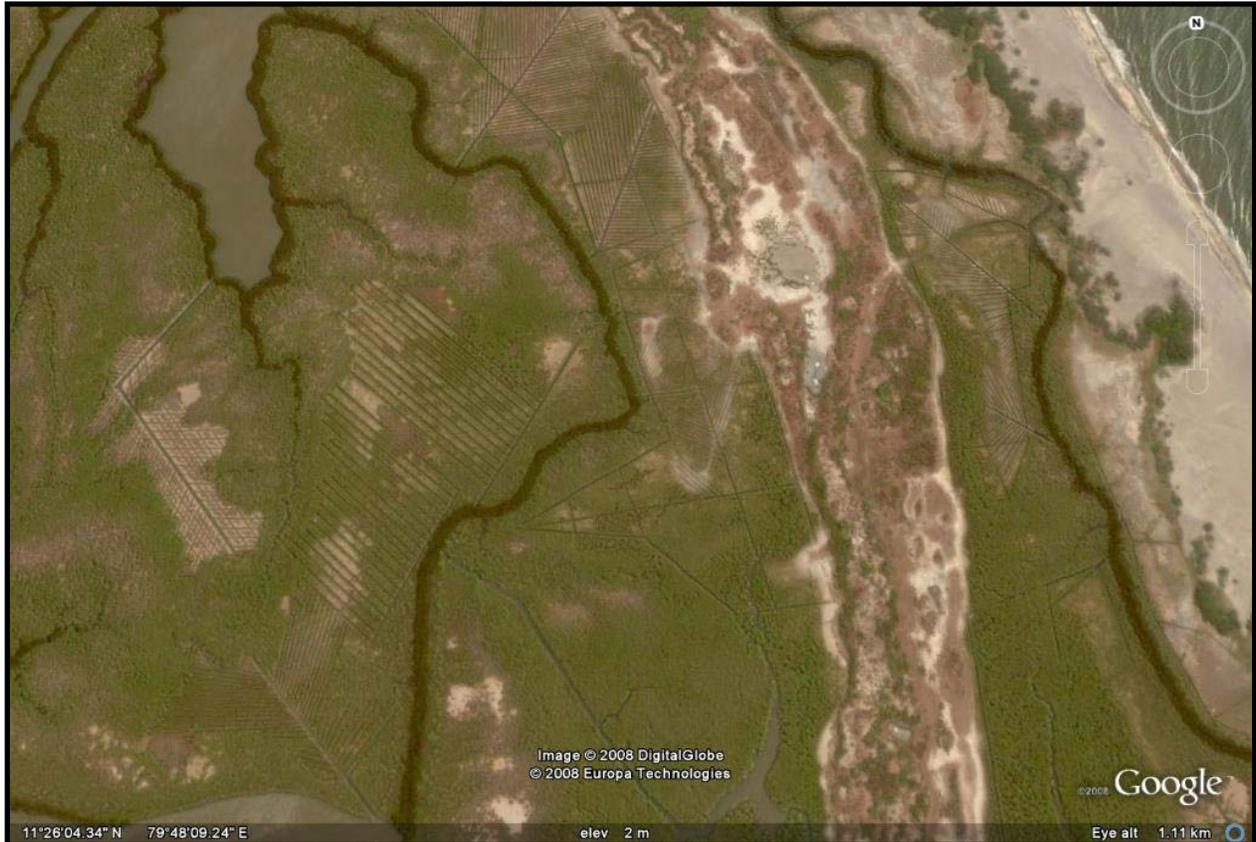


Figure 9: Fish bone channels in Pichavaram

Though salinity is still the major problem affecting the mangroves in this region, *A. marina* saplings can be found along these man-made creeks. While the edge of the waterways is covered by tall trees (10–12 m), as one moves inside the tree height reduces drastically to less than a metre for adult fruiting individuals of *A. marina*. Almost no other species is encountered in the interior. A considerable portion of the standing biomass consists of dead or dying trees. Though it is difficult to establish for certain, there is enough reason to speculate that high salinity is the major cause for this decay and stunted growth of trees. An MSSRF report mentions soil salinity to be in the range of 95–99 ppt in the interior landmass of Pichavaram (Selvam *et al.* 2002). The situation is alarming and needs urgent attention.

In Muthupet, the current situation is even more dismal. The fringes of the lagoon are covered by *A. marina* interspersed with *R. mucronata* and *B. cylindrica* (Figure 10). The average height of trees of *A. marina* is however higher than that observed in Pichavaram (Figure 11).

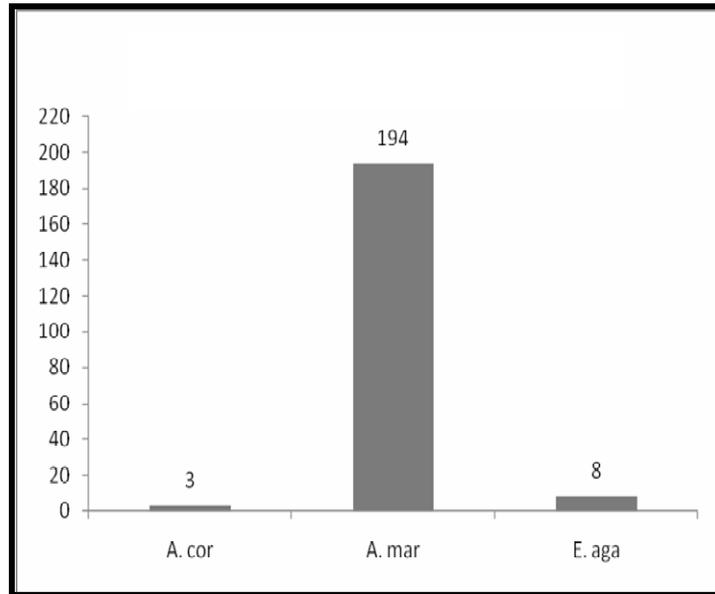


Figure 10: Species composition of mangroves in Muthupet

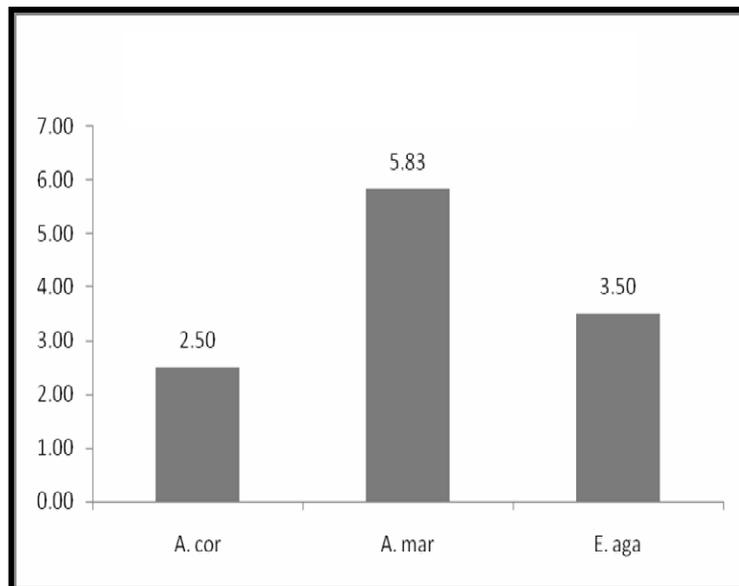


Figure 11: Average height of trees (metres) in Muthupet

Vast tracts of land in the interior of the landmass are absolutely barren owing to high salinity. One even encounters *Prosopis sp.* along the banks of the Koraiyar River, away from the lagoon. There was very little regeneration noted in Muthupet. A large number of dead and dying *A. marina* trees were noted in the interior landmass. The map below [as of 22nd September, 2008] shows the barren land inside Muthupet Reserve Forest which was once reported to be completely covered with mangroves (Figure 12). Aquaculture is a growing concern here owing to the pollution caused by it. As pointed out by several authors, aquaculture is one of the biggest threat to mangroves globally (Walters *et al.* 2008).



Figure 12: Fringing mangroves in Muthupet

Parameters affecting vegetation

Soil and water parameters were studied in a single visit in Muthupet because a recent post tsunami study had already looked at these parameters in Pichavaram. We found that soil salinity ranged from 2 ppt to 55 ppt for a total of 15 samples. Such high salinity is not conducive to mangrove growth and seedling establishment. There was very high variability in soil pH with some sites having highly acidic soils [pH 3], and some alkaline soils [pH 8.2]. The soil Hydrogen sulphide levels varied from <0.05 mg/l to 1.5mg/l which is higher than that recorded at the sites in Kerala.

The water pH varied from 6.1 to 8.5. The water salinity varied from 6 ppt (close to the junction of the river and the lagoon) to 45 ppt (at the mouth of the lagoon towards the sea). The dissolved oxygen was found to vary between 3 to 4.5 mg/l.

Socio-ecological status

In Tamil Nadu, we conducted structured and semi-structured interviews with two different stakeholder groups (Forest Department officials and local residents around mangrove areas) to understand the local perceptions about mangroves after the tsunami. Compared to the mangrove sites in Kerala, mangroves in Tamil Nadu have a greater economic role in the lives of local communities. Both the sites studied in Tamil Nadu are under a protected area system (Reserve Forests) and are much larger in area as compared to individual patches in Kerala. We conducted a questionnaire based survey in the Muthupet lagoon area as this Reserve Forest was used more intensively by local communities as compared to Pichavaram.

Forest Department

The Pichavaram Forest Department has been engaged in plantation of mangroves from as long back as 1945. What is interesting is the fact that little has changed in the plantation *modus operandi* over the years. As mentioned earlier, the Forest Department uses a technique called ‘fish-bone technique’ for restoration. In our interviews with the Forest Department officials, it became evident that availability of freshwater is the major factor determining the decline of mangroves in the area. Grazing is also a common problem in the Muthupet area (Figure 13). It leads to the problem of soil compaction as well as predation of mangrove propagules.



Figure 13: Grazing in Muthupet mangroves

After the tsunami, two national projects were launched:

- (i) Emergency tsunami reconstruction project, and
- (ii) National cyclone risk mitigation project.

Under these two projects, about 700 hectares of mangroves were scheduled to be planted in Tamil Nadu alone. The forest department offices in Pichavaram and Muthupet were actively involved in this process and over the last three and a half years, considerable plantation activity has taken place. However most of these activities have resulted in monoculture plantations of *A. marina* since other mangrove saplings are unable to establish themselves under such high salinity conditions. While the forest department officials have been attempting to the best of their ability to revive mangrove forests in this region, it is extremely difficult to do so under the current hydrologic regime. It is thereby important at this juncture to evaluate how best one can increase the fresh water inflow into the two mangrove forests over a longer time span. A piecemeal plantation approach, as is already in place, will not be able to address the larger question of mangrove restoration in the long term.

Local communities

The majority of local people around Muthupet lagoon belong to the fisherfolk community. We interviewed 64 fishermen who were primarily dependant on the fish resources of the lagoon and the adjoining sea (Figure 14). All of them (N=64) practiced fishing as their primary occupation. The secondary occupations (in addition to fishing, indicated in Figure 14), were agriculture (6), daily wage labour in agriculture (2) and diesel mechanic (1).

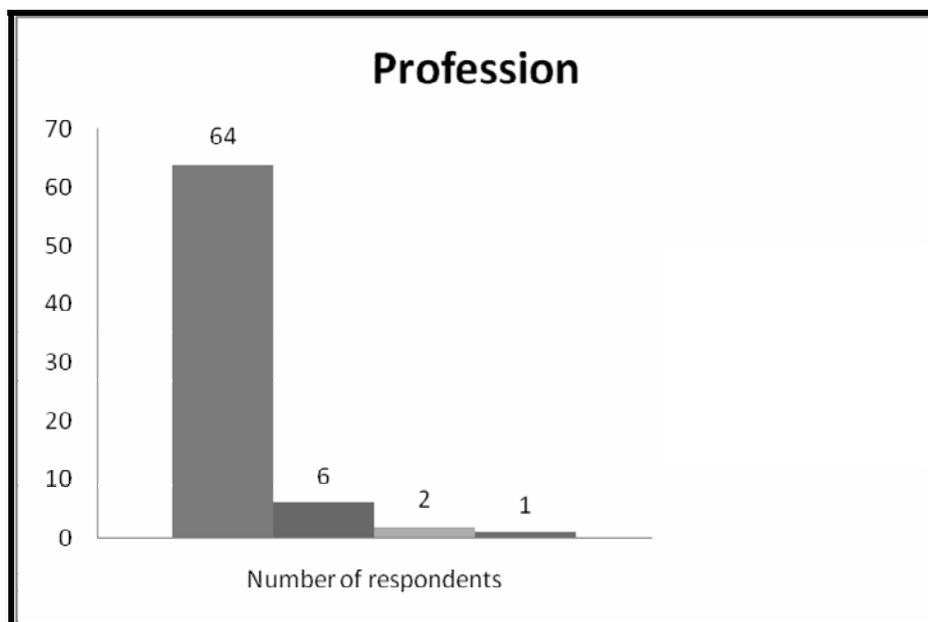


Figure 14: Occupation of respondents around Muthupet lagoon area (in sequence – fishing; agricultural labour, agriculture, diesel mechanic) (cumulative of primary and secondary)

These individuals were randomly selected from five different fishing villages around Muthupet-Pettai, Asathnagar, Veeranvayal, Jambavanodai and Kovilur (Figure 15).

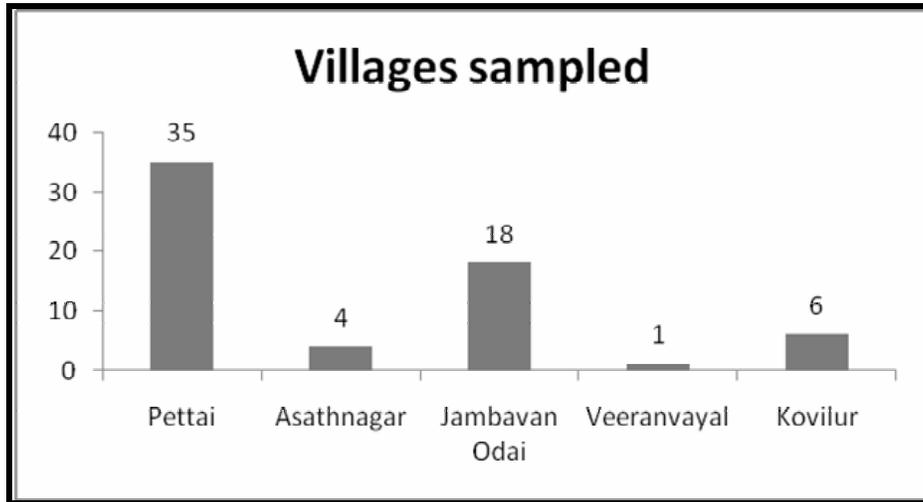


Figure 15: Number of respondents in the villages around Muthupet that were sampled

The observations were:

Prior to the tsunami, the fisherfolk used traditional wooden boats with a mast, which were not motorised. Many artisanal fishermen still continue to fish in the lagoon and do not use boats, though their numbers are declining. However, after the tsunami motorised fiber boats increased in numbers (Figure 16).

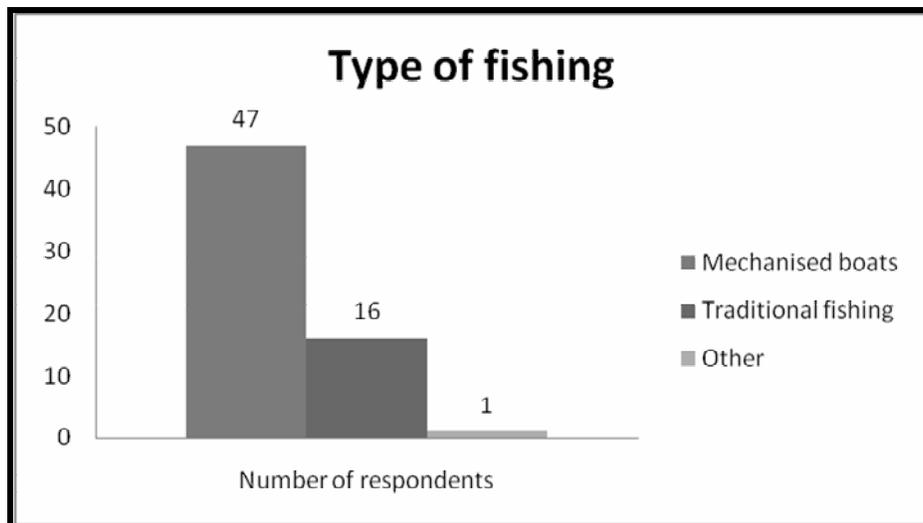


Figure 16: Type of fishing currently in practice in Muthupet lagoon

A large number of international and national donor agencies fuelled this rapid transition from a traditional eco-friendly harvesting system (and certainly more sustainable) to a more polluting and resource-demanding system (Figure 17, 18). Over a period of four years the fish catch/unit effort has declined, and oil spills from boats has started creating pollution in the lagoon water.



Figure 17: Traditional fishing in Muthupet lagoon



Figure 18: Motorised boat being used post tsunami in Muthupet lagoon

On an average, the fishermen travel 7 km on a daily basis for fishing. The main uses of the mangroves according to the local fishermen were that of fisheries in addition to natural disaster mitigation, ecosystem services and tourism (Figure 19).

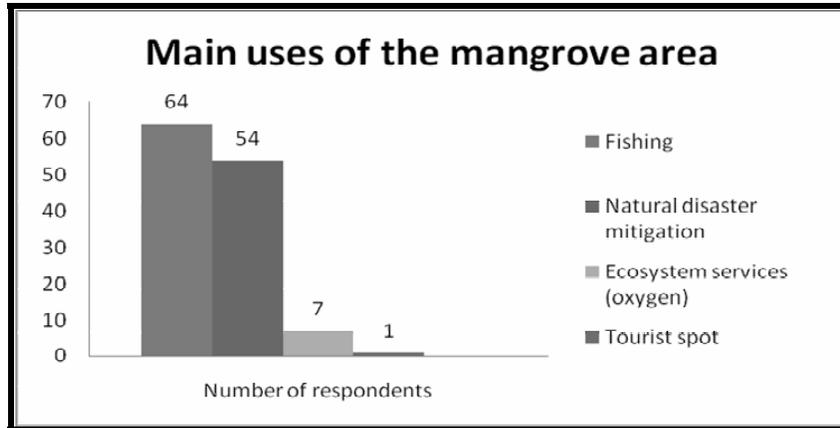


Figure 19: Community perception of uses of mangrove areas in Muthupet

Out of the total fish catch, we were interested in knowing what proportion was used by the fishermen themselves for subsistence and what proportion was sold. We found that about 5-33% of the total catch (fish, shrimps, crabs) is consumed, while the rest is sold. A majority of the respondents (29 out of 64) consumed only 10% of their total fish catch (Figure 20).

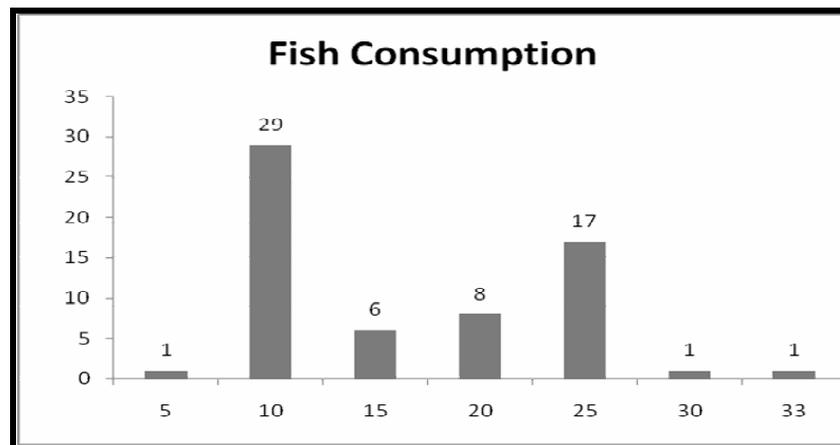


Figure 20: Percentage of fish catch consumed by respondents around Muthupet lagoon

Almost all the fishermen are ignorant about any policy regulations regarding mangroves or fisheries. A majority of them believe that fishery resources have declined in the past four years and this decline is due to overfishing. There was unanimous agreement on the fact that shrimp farms have led to higher soil salinity and water pollution in the region.

4. Discussion

This preliminary study seeks to provide insights into what might be potentially beneficial in the long term for mangroves. This report has dealt with only a few facets of mangrove biology and the myriad factors affecting it. This was only a baseline study which aimed at addressing some of the issues which had hitherto been neglected in the backdrop of the tsunami. Clearly, there cannot be a single tailor-made solution which can address the problem of mangrove decline in all parts of our coast.

As seen from this study, in some places ecological parameters like salinity may play a determining role, while in others it might be the socio-economic milieu within which the mangrove forest is nested. Thus focusing efforts on mere plantation of mangrove saplings may not be the best long term solution for the conservation of mangroves. The drivers of change, e.g., shortage of fresh water flow in our study sites in Tamil Nadu, should first be identified, followed by stringent measures to address the issues.

The influence of policy and its implementation needs further attention. Policies like the Ecologically Fragile Land (EFL) Act, which is currently being implemented in Kerala, can be potentially applied in all other coastal states as well. Another dimension which needs to be looked into is that of awareness about policy regulations.

From a holistic perspective, there needs to be greater interaction between policy makers, local users of mangroves, mangrove biologists and representatives of NGOs. The future of mangroves does not rely on a single stakeholder group alone and neither will a single community be affected if mangroves decline and disappear. It is thereby necessary at this juncture to seek greater collaboration amongst stakeholder groups to help conserve mangroves better in the region.

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