Contents

1.0 Mangroves ................................................................................. 3
  1.1 What are mangroves? ......................................................... 3
  1.2 What are the factors that determine area, diversity and growth of mangroves? ................................................................. 3
  1.3 What is the status of plant and animal diversity in mangrove wetlands? ................................................................. 4
  1.4 What are the unique features of mangrove plants? .................. 4
  1.5 What is the global distribution of mangroves? ......................... 5
  1.6 What are the uses of mangrove wetlands? ............................ 6

2.0 Mangroves Wetlands of India ....................................................... 7
  2.1 Geomorphic settings .......................................................... 7
  2.2 East coast mangroves .......................................................... 7
  2.3 West coast mangroves .......................................................... 9
  2.4 Andaman and Nicobar island mangroves ............................. 9
  2.5 Changes in mangrove floristic ............................................. 9

3.0 Mangrove Wetlands of Tamil Nadu ............................................. 10
  3.1 Pichavaram mangrove wetland ............................................ 10
  3.2 Muthupet mangrove wetland .............................................. 12

4.0 MSSRF's contribution to restoration, conservation and management of mangrove wetlands ................................................. 14
  4.1 Contribution to international mangroves ................................ 14
  4.2 Contribution to national mangroves ..................................... 15
  4.3 Biotechnological research ................................................... 19
1.0 Mangroves

1.1 What are mangroves?
Mangroves are defined as woody trees and shrubs that grow in places where river water mixes with seawater. These places are otherwise called estuarine or brackish water environment. An assemblage of such woody trees and shrubs is called a mangrove forest. Since mangrove forests are located in the estuarine environment, they are intersected by a number of small creeks and channels and in many cases large open water bodies are also found associated with them. Mangrove forests and associated tidal creeks, channels, canals and water bodies together constitute mangrove wetlands. Mangrove wetlands are dominant features of the coastal areas of tropical countries.

1.2 What are the factors that determine area, diversity and growth of mangroves?
The health of the mangrove wetlands with reference to hydrological and soil conditions, and the wealth of the mangrove wetlands in terms of area, species diversity, biomass and productivity are determined by:

- Degree of protection against high-waves
- Quantity and duration of freshwater flow and sediment supply
- Larger tidal amplitude and
- Gently sloping coastal topography.

Young mangrove plants of settle and grow only in coastal areas where wave energy is low or in places where the mangrove wetlands are protected by a sand barrier against high-waves. The coastline of the Muthupet region of the then combined Thanjavur District and that of Sunderbans in West Bengal are the best examples of low wave energy coasts where mangroves grow luxuriantly. In the Pichavaram mangrove wetland of Cuddalore District, wave energy along the coast is high but a sandy beach, located between the mangroves and the sea, protects the mangroves.

Most of the mangrove plants require low salinity condition for their growth and reproduction. Hence, luxuriant mangrove forests can be seen only in the estuarine regions where a large amount of fresh water is discharged for long periods of time in a year. For example, the Sunderbans mangrove forest of West Bengal, which receives fresh water from the rivers Ganga and Brahmaputra throughout the year, harbours the highest number of mangrove plant species. The forest is also very thick and the height of the trees is very high. In the Pichavaram and Muthupet mangroves, which receive only low amounts of
fresh water, that too only for a few months in a year, the number of plant species present is very low and the height of the trees is also very low. The area of the mangrove wetland is determined by tidal amplitude (difference between high tide and low tide) and the slope of the coastline. For example, tidal amplitude in the Sunderbans mangroves is about 4.8 m and the slope of the coast is also very gentle. As a result, seawater reaches up to 90 km inland from the sea and the mangrove wetland is present all along the river, up to the point where seawater reaches. The total area of the Sunderbans mangrove wetland of India is about 4,26,000 ha (actual forest cover is about 2,12,500 ha). On the other hand, the area of the Pichavaram mangrove wetland, where the tidal amplitude is only 0.65 m, is only 1,300 ha (actual forest cover is only 900 ha).

1.3 What is the status of plant and animal diversity in mangrove wetlands?

**Plants**

The plant community in the mangrove environment is classified into two types namely, true mangrove species and associate mangrove species. True mangrove species are found only in the mangrove wetlands, whereas associated species are found both in the mangrove environment and in the nearby areas. Throughout the world, a total number of 68 plant species are considered as true mangrove plants. All these species are able to grow in saline water, but only a few of them tolerate high salinity while most of them tolerate only moderate salinity. For example, a species called *Avicennia marina* (it is present in Tamil Nadu and it is called Kandal in the Pichavaram area and Alayathi in the Muthupet region) can tolerate salinity as high as 90 grams/litre (seawater contains 35 g/l of salt).

1.4 What are the unique features of mangrove plants?

Unlike other plants, mangrove plants grow only in saline water. On the basis of physiological mechanism for salt tolerance mangrove plants are classified into 3 types:

i) **Salt excreting type:** This type of mangrove plants take saline water as such through roots and only water molecules and essential salts are retained in the tissues and excess salts are excreted through salt glands.

ii) **Salt excluding type:** The roots of these mangrove plants possess an ultra-filtration mechanism called reverse osmosis by which water and salts in the seawater are separated in the root zone itself and only water is taken inside and salts are rejected (reverse osmosis mechanism is widely used in manufacturing bottled drinking water!).

iii) **Salt accumulating type:** This type of mangrove plants possess neither salt glands nor ultra-filtration system but these species have the capacity to accumulate a large amount of salts in their leaves.

**Breathing roots:** The root system and other parts of the plants which are below the ground, also require oxygen for respiration. Mangrove soil is characterized by low or nil oxygen and mangrove plants have adapted to survive in such an unpromising environment. The most striking
adaptations are aerial roots, which are otherwise called breathing roots. For example, in the species of *Avicennia marina* small finger-like roots branch out from the main root underground and protrude out into the atmosphere. These roots have small pores through which oxygen enters into the root.

**Viviparous plants:** Another distinctive feature of most of the mangrove plants is vivipary, i.e. seedlings grow when the seed is attached in the mother tree itself (in other trees, seeds fall from the mother tree and grow into seedlings [in the soil]). These seedlings are otherwise called propagules. Since the mangrove environment is harsh (salinity and low or nil oxygen in soils) most of the seeds falling from a tree might not survive and this would affect propagation of the species. To avoid this, mangrove plants produce propagules, which fall from the tree and fix themselves in the mud or float in the water and fix themselves in suitable areas and grow into trees.

**Animals**

Almost all groups of animals are present in the mangrove environment but the most striking are crabs, snails, bivalves and oysters. Interesting species among crabs are leaf eating crabs, tree-climbing crabs, fiddler crabs, hermit crabs, mud crabs, mud lobsters, etc. Among them the most colourful are fiddler crabs. The male fiddler crabs have one greatly enlarged claw, coloured in crimson, orange and intense blue, used in social displays and in jousting with rival males. Crabs of the mangrove environment are called ecosystem engineers since they modify the topography and air circulation in the soil and thereby influence the growth and productivity of the mangrove trees.

Fish is another important animal component of the mangrove environment. Many of the estuarine species are found in mangroves and constitute the fishery resources of the mangrove wetlands along with prawns and crabs.

Some of the mangrove wetlands harbour larger animals like salt-water crocodiles, sea otters etc. and the Sunderbans mangroves is famous for the Bengal Tiger. Many of the mangrove wetlands also act as feeding and breeding grounds for a variety of resident and migrant birds.

### 1.5 What is the global distribution of mangroves?

The total area of the mangrove wetlands of the world is about 181,077 sq.km or 18,107,700 ha. The area of the mangrove wetlands of some of the Asian countries is given below:

<table>
<thead>
<tr>
<th>Country</th>
<th>Area (ha.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>5,76,700</td>
</tr>
<tr>
<td>China</td>
<td>36,600</td>
</tr>
<tr>
<td>India</td>
<td>4,87,100</td>
</tr>
<tr>
<td>Indonesia</td>
<td>45,42,100</td>
</tr>
<tr>
<td>Malaysia</td>
<td>6,42,400</td>
</tr>
<tr>
<td>Myanmar</td>
<td>3,44,400</td>
</tr>
<tr>
<td>Pakistan</td>
<td>1,68,300</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>8,900</td>
</tr>
<tr>
<td>Thailand</td>
<td>2,64,100</td>
</tr>
<tr>
<td>The Philippines</td>
<td>1,60,700</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>72,31,300</strong></td>
</tr>
</tbody>
</table>
1.6 What are the uses of mangrove wetlands?

Mangrove wetlands comprise both mangrove forests and associated water bodies and hence, their uses are multiple. The economic value of the mangrove wetlands stems from:

1. Availability of wood products ranging from timber, poles and posts and firewood
2. Availability of non-wood produce such as fodder, honey, wax, tannin, dye and plant materials for thatching
3. Availability of aquatic food such as fish, prawn, crabs, mussel, clam and oysters.

Apart from these, mangrove wetlands provide a variety of amenities to coastal communities:

1. Mangroves mitigate the adverse impact of storms and cyclones in coastal areas.
2. They reduce coastal erosion.
3. They act as nursery grounds for many commercially important prawns, fish, crabs and molluscs.
4. They enhance the fishery productivity in adjacent coastal waters by providing them with large quantities of organic and inorganic nutrients.
5. The root zone of the mangrove trees provide safe havens for young fish and prawns.
6. They provide habitats for diverse marine, estuarine and terrestrial wildlife, including migratory birds.
2.0 Mangrove Wetlands of India

The east and west coasts of the mainland of India and Andaman and Nicobar Island are characterized by the presence of mangrove wetlands.

2.1 Geomorphic settings

On the macro scale, geomorphic settings of the mangrove wetlands of the east coast of India are different from that of the west coast. The coastal zone of the west coast is narrow and steep in slope due to the presence of the Western Ghats. Secondly, there is no major west-flowing river. As a result, mangrove wetlands of the west coast of India are small in size, low in diversity and less complicated in terms of tidal creek networks. On the other hand, mangrove wetlands of the east coast are larger, high in diversity and water bodies associated with mangroves are characterized by the presence of larger brackish water bodies and complex networks of tidal creeks and canals. This is mainly due to the larger deltas created by east-flowing rivers and the gentle slope of the coast. According to Forest Survey of India, out of 4,87,755 ha of the mangrove wetlands of India, nearly 56.7% (2,75,800 ha) is present along the east coast and 23.5% (1,14,700ha) along the west coast and the remaining 19.8% (96,600ha) is found in the Andaman and Nicobar islands (Table 2).

2.2 East coast mangroves

Sunderbans

Sunderbans is the largest mangrove wetland of the world. The total area of the Indian part of the Sunderbans mangrove wetland is about 4,10,000ha, of which 2,12,500 ha is occupied by mangrove forest and 1,78,100ha is water body. Large influx of fresh water into the mangrove throughout the year from the Ganga and Brahmaputra creates a highly favorable condition for mangrove plants; nearly 27 true mangrove species are present in this mangrove. The presence of flora and fauna such as the Sundari, a beautiful mangrove plant, the Bengal

Table 2: Mangrove wetlands of India

<table>
<thead>
<tr>
<th>State / Coast</th>
<th>Mangrove wetland</th>
<th>Total area of the wetland (ha)*</th>
<th>Actual forest cover (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>East Coast</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>West Bengal</td>
<td>Sunderbans</td>
<td>4,26,000</td>
<td>2,12,500</td>
</tr>
<tr>
<td>Orissa</td>
<td>Mahanadi</td>
<td>67,000</td>
<td>21,500</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>Godavari</td>
<td>33,250</td>
<td>24,100</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>Krishna</td>
<td>25,000</td>
<td>15,600</td>
</tr>
<tr>
<td></td>
<td>Pichavaram</td>
<td>1,300</td>
<td>900</td>
</tr>
<tr>
<td></td>
<td>Muthupet</td>
<td>13,000</td>
<td>1,855</td>
</tr>
<tr>
<td><strong>West Coast</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gujarat</td>
<td>Gulf of Kutchh</td>
<td>58,200</td>
<td>85,400</td>
</tr>
<tr>
<td></td>
<td>Gulf of Comby</td>
<td>53,123</td>
<td>17,700</td>
</tr>
<tr>
<td><strong>Other mangroves</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Andaman and Nicobar islands</td>
<td>Andaman islands</td>
<td>-</td>
<td>92,900</td>
</tr>
<tr>
<td></td>
<td>Nicobar islands</td>
<td>-</td>
<td>3700</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>4,87,755</strong></td>
<td></td>
</tr>
</tbody>
</table>

* Records of the State Forest Department
Joint Mangrove Management in Tamil Nadu

tiger, saltwater crocodiles, spotted deer and dolphins, is one of the important features of the Sunderbans mangroves. The Sunderbans contain about 300-500 tigers, the largest single surviving population of tigers in the world. It has been reported that about 25,000 tons of fish and prawn are harvested from the Sunderbans annually. In recent years the amount of fresh water reaching the Indian part of the Sunderbans has reduced greatly due to the tilting of the land towards east. The reduction in fresh water flow is one of the serious factors affecting this mangrove.

Mahanadi mangroves

The Mahanadi mangroves are present in the mid-region of the Orissa coast, about 250 km south of the Sunderbans mangrove. They are located in the combined delta of the River Mahanadi, the Brahmini and the Baitarani rivers. The Bhitarkanika mangrove wetland, a part of the Mahanadi mangroves is an important mangrove genetic resources centre of the world. Since the mangrove forest of the Mahanadi delta receives fresh water from three rivers, the salinity of the water and soil is comparatively less and hence, they are rich in species diversity and dense and tall like the Sunderbans. The diversity of animals is also very high in Bhitarkanika mangroves. There are several species of mammals, birds, amphibians, reptiles, fishes, molluscs, crustaceans and other invertebrates. Hence, Bhitarkanika mangroves have been declared as a Wildlife Sanctuary. It is also a habitat for a number of rare and endangered reptilians such as saltwater crocodiles, water monitor, king cobra etc. Bhitarkanika holds the largest population of endangered estuarine crocodiles in India. A larger number of villagers, located within and around these mangroves, utilise the fishery resources of the mangrove wetlands. In addition, a large amount of honey is also collected. Conversion of mangrove wetlands for agriculture and aquaculture is one of the serious problems affecting this mangrove wetland.

Godavari mangroves

The Godavari mangrove wetland is located in Andhra Pradesh, in the delta created by the river Godavari. The Coringa mangrove wetland, the largest mangrove in Andhra Pradesh, has been declared a Wildlife Sanctuary. Fresh water flows into the mangrove wetlands of the Godavari delta for a period of six months; the peak flow normally occurs during July to September, coinciding with the southwest monsoon season. During this period, the entire delta, including the mangrove wetland, is submerged under fresh water. A large bay called Kakinada Bay is associated with the northern part of the Godavari estuary. It has a long sand spit on the eastern side, which separates Kakinada Bay from the Bay of Bengal. This bay is very shallow, about 2m in depth and during low tide, many areas of this bay are exposed. Comparing the growth of the sand spit with a map prepared in 1,789, it is estimated that previously the mangrove was about 6 km inside the present shoreline. This is an indication of the expansion of the mangrove into the sea. The presence of large populations of sea otter is one of the important features of the Coringa Wildlife Sanctuary.

Krishna mangroves

The Krishna delta is the seaward-extended land mass created by sediment deposits of the River Krishna. As in the case of the Godavari mangroves, the mangrove wetland of the Krishna delta also receives fresh water for about six months in a year. However the salinity level in the Krishna mangroves is always high, as evaporation in the Krishna River is 15% more than in the Godavari; also, there is a great reduction in fresh water flow in recent years. Hence, the number of species present in the Krishna mangroves is less.

Pichavaram and Muthupet mangroves

Pichavaram and Muthupet mangrove wetlands are located in the northernmost and southernmost ends respectively of the Cauvery delta and the distance between the two mangrove wetlands is about 140 km. Unlike the other mangrove wetlands of the east coast, both the
Pichavaram and Muthupet mangroves receive fresh water mostly during the northeast monsoon season, from October to November. Thus, in these two mangrove areas, the dry season is long, extending from February to September and corresponding to it, the average salinity of the mangrove water is very high. Hence, species diversity is very less and the height of the trees is also less. Reduction in fresh water flow and closure of the mouth of the mangrove estuary during most part of the year are the serious threats to these two mangroves.

2.3 West coast mangroves
In the west coast of India, a major wetland is present in the State of Gujarat. The climate is hot with a rather cold season (subdesertic) and with very strong average annual thermal amplitude. The average rainfall in the Gulf of Kutchh is only about 470 mm and the dry season continues from October to June. No permanent river discharges fresh water into this mangrove wetland. As a result of the above harsh environmental conditions, the status of the Gujarati mangroves is comparatively poor. The total area of the mangrove wetlands of Gujarat is about 1,05,100 ha of which dense mangrove vegetation is present only in about 21,500 ha (20% of the total area) while the remaining area is degraded. A large population of camel grazes in this mangroves throughout the year.

2.4 Andaman and Nicobar island mangroves
The total area of the mangrove wetland in this group of islands is about 1,15,000 ha. The climate is humid and annual rainfall in the Andaman and Nicobar group of islands is very high, about 2,750 mm and 3,080 mm respectively. Hence, the Andaman and Nicobar island mangroves are also rich in plant and animal diversity.

2.5 Changes in mangrove floristic
In most of the Indian mangrove wetlands floristic has changed dramatically. In the Sunderbans, Heritiera fomes was the most abundant species and attained more than 30 m in height in the past. Now it has disappeared completely from the Indian part of the Sunderbans and only a limited population is present in the Bangladesh Sunderbans. Similarly, in the Pichavaram mangrove wetlands Xylocarpus granatum, Sonneratia apetala, Kandelia candel and Bruguiera gymnorhiza were present till recently but now no individual of these species is present. The palynological studies carried out in Muthupet mangrove wetland indicate that true mangrove species belonging to Rhizophoraceae were the dominant species about 150 years ago but now they are locally extinct. Dense and tall trees of Avicennia officinalis, Excoecaria agallocha and Lumnitzera racemosa constituted nearly 90% of the population of the Godavari mangrove wetlands in the 1950s, but now they constitute only 37% of the population and are replaced by bushes of Suaeda maritima and S. monica. These two species are not true mangrove species and can tolerate salinity as high as 100 g/l. In general, the current status indicates that except in Andaman and Nicobar islands, in all the mangrove wetlands of India, low-saline tolerant species are gradually disappearing and species like Avicennia marina which can tolerate a high and broad range of salinity are becoming dominant. The main reason for such changes is the reduction in the periodicity and quantity of fresh water reaching the mangrove environment.
Tamil Nadu has a coastline of about 950 km. Along the coastline major mangrove wetlands are present in two areas: one at Pichavaram in Cuddalore District and the other in the Muthupet region in Thiruvarur-Thanjavur Districts. Small patches of mangroves are also present along the Palk Bay, particularly in the Devipattinam region and also in some of the islands of the Gulf of Mannar in Ramanathapuram District.

3.1 Pichavaram mangrove wetland

The Pichavaram mangrove wetland is located about 200 km south of Chennai in the northernmost part of the Cauvery delta. It is situated between the River Vellar in the north and River Kollidam (Coleroon) in the south and connected to the estuaries of these two rivers by large brackish water canals, called backwaters. The backwater canal which joins the mangroves with River Kollidam is large and very deep. The Pichavaram mangrove wetland consists of 3 Reserve Forests (RF), namely Killai RF, Pichavaram RF and Pichavaram Extension area. According to the remote sensing data of 1986 the total area of these RFs was about 1474 ha (area in 1897 when this mangrove wetland was declared a Reserve Forest was about 1358 ha). Of this, thick mangrove forest occupied an area of 325 ha (22%) and degraded mangrove forest was found in about 375 ha (25%). The area of the water bodies associated with the Pichavaram mangrove wetland was about 380 ha (25.7%). In addition, sandy area, which is not suitable for mangroves due to higher elevation, occupied about 394 ha (26.7%). The above data indicates that nearly 53% of the mangrove forest area (not the wetland area) was in degraded state in 1986. Currently, 12 true mangrove plant species are present in the mangrove wetland. The scientific (botanical) name and local name of these species are given in Table 3. A mangrove tree species, namely, *Excoecaria agallocha*, locally called Thillai has been worshiped as a temple tree (sthala viruksham) at the Lord Nataraja Temple at Chidambaram. The images of the Thillai are seen carved in rock sculptures and being worshipped. These sculptures were made in the Nataraja temple probably in the 2nd century AD.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Botanical name</th>
<th>Local name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>Acanthus ilicifolius</em></td>
<td>Kazhuthaimulli</td>
</tr>
<tr>
<td>2.</td>
<td><em>Agiceras corniculatum</em></td>
<td>Narikandal</td>
</tr>
<tr>
<td>3.</td>
<td><em>Avicennia marina</em></td>
<td>Venkandal</td>
</tr>
<tr>
<td>4.</td>
<td><em>Avicennia officinalis</em></td>
<td>Karungkandal</td>
</tr>
<tr>
<td>5.</td>
<td><em>Bruguiera cylindrica</em></td>
<td>Pannukulthi</td>
</tr>
<tr>
<td>6.</td>
<td><em>Ceriops decandra</em></td>
<td>Sirukandal</td>
</tr>
<tr>
<td>7.</td>
<td><em>Excoecaria agallocha</em></td>
<td>Thillai</td>
</tr>
<tr>
<td>8.</td>
<td><em>Luminitzera racemosa</em></td>
<td>Thipparathai</td>
</tr>
<tr>
<td>9.</td>
<td><em>Rhizophora mucronata</em></td>
<td>Surrapunnai</td>
</tr>
<tr>
<td>10.</td>
<td><em>Rhizophora apiculata</em></td>
<td>Surrapunnai</td>
</tr>
<tr>
<td>11.</td>
<td><em>Rhizophora natural hybrid sp</em></td>
<td>Surrapunnai</td>
</tr>
<tr>
<td>12.</td>
<td><em>Xylocarpus mekongensis</em></td>
<td>Somundhri</td>
</tr>
</tbody>
</table>
Among the 12 species found in Pichavaram, *Avicennia marina* (Venkandal) alone constitutes 74% of the tree population.

**Unique features of these mangroves**

- Trees of *Rhizophora* (Surrapunnai), which are evergreen, are important from biodiversity point of view. The population of *Rhizophora* in the other mangrove wetlands of India, except in Andaman and Nicobar islands, is very less.
- Another interesting point is the presence of a natural hybrid of *Rhizophora* species. This hybrid species is born out of cross-pollination between *Rhizophora apiculata* and *Rhizophora mucronata*. It is highly vigorous in growth and tall trees of this are found all along the border of tidal creeks and canals.
- Harvestable forest resources are limited in the Pichavaram mangroves. No timber and non-timber forest produce is available. Fodder and limited firewood are available but collection is banned.

**Uses of the mangroves**

The Pichavaram mangrove wetland is rich in fishery resources. About 237 tons of fishery produce is harvested every year from the Pichavaram mangrove wetlands, of which prawns alone constitute 208 tons (82% of the total catch) whereas fish and crab constitute 19 and 9 tons respectively. Both prawns and crabs are mainly exported. In addition to these, edible oysters and green mussels are also available in large quantities; the green mussels are harvested and exported to Kerala.

People belonging to 17 hamlets of 5 revenue villages, namely, C.Manambadi, Killai, Pichavaram, T.S.Pettai and Thillaividangan, utilise the wood, non-wood and fishery resources. Among the 17 hamlets, 9 are fishing and 8 are farming hamlets. The purpose and intensity of use of mangrove resources differ from one hamlet to the other; overall, only 8 hamlets are intensively using the resources. One of the serious concerns in these hamlets is that nearly 41% of the employable age group (15-55 years) has no stable occupation. Declining fish catch in the mangrove waters, erosion of traditional fishing rights and degradation of the mangrove wetlands are some of the major concerns of the communities that use these mangrove resources.

Changes in the physical structure of the mangrove wetland due to past unscientific management practices and reduction in freshwater flow are the main causes of degradation (elaborated in Section 4). Grazing by cattle, particularly in the peripheral areas during the monsoon season when new seedlings establish is the important secondary factor for degradation. Till the late 1980s, the Forest Department permitted grazing in the peripheral area of
the mangrove wetland through a permit systems but this has been stopped now to prevent the adverse effects of grazing.

3.2 Muthupet mangrove wetland

The Muthupet mangrove wetland is located in the southernmost part of the Cauvery delta with Palk Strait in the south and extensive mudflats in the north. Many of the drainage arteries of the Cauvery River, namely, Pamini, Korayar, Marakakoryar, Pattuvanachi and Nasuvini, empty their water into the Muthupet mangrove wetland. The Muthupet mangrove wetland comprises healthy and degraded mangroves, large lagoon and canals, and creeks and man-made fishing canals.

According to the 1996 remote sensing data, the total area of the Muthupet mangrove wetland is about 12,000 ha and for administrative purposes it is divided into 6 Reserve Forests. The different categories of wetlands found in these RFs are given in Table 4. The presence of two large lagoons of about 1,700 ha, which are contiguous, is one of the characteristic features of the Muthupet mangrove wetlands. The data also shows that the area of the healthy mangrove forest is only about 1855 ha whereas nearly 7,178 ha of mangrove forest is in degraded condition.

Only 5 mangrove species namely, Acanthus illicifolius, Agiceras corniculatum, Avicennia marina, Excoecaria agallocha and Lumnitzera racemosa are present in the Muthupet mangrove wetland. Among them, Avicennia marina, which is locally called Alaiyathi (alai = waves; athi = mitigate) is dominant, constituting more than 95% of the tree population. But unlike Pichavaram, trees of Avicennia marina are very tall in Muthupet and form a beautiful line along the banks of the tidal creeks, lagoons and canals. Hyper salinity in soil and water is the main reason for the presence of low number of mangrove species.

<table>
<thead>
<tr>
<th>Category / Reserve Forest</th>
<th>Healthy mangroves</th>
<th>Degraded mangroves</th>
<th>Water body (lagoon etc)</th>
<th>Other vegetation</th>
<th>Salt pan</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muthupet RF</td>
<td>950</td>
<td>4,553</td>
<td>1,100</td>
<td>200</td>
<td>0</td>
<td>6,803</td>
</tr>
<tr>
<td>Thuraikadu RF</td>
<td>350</td>
<td>1,687</td>
<td>600</td>
<td>0</td>
<td>0</td>
<td>2,637</td>
</tr>
<tr>
<td>T.Vadakadu RF</td>
<td>60</td>
<td>312</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>372</td>
</tr>
<tr>
<td>Maravakkadu RF</td>
<td>75</td>
<td>525</td>
<td>0</td>
<td>0</td>
<td>890</td>
<td>1,490</td>
</tr>
<tr>
<td>Thamarankottai RF</td>
<td>350</td>
<td>27</td>
<td>0</td>
<td>150</td>
<td>0</td>
<td>530</td>
</tr>
<tr>
<td>Palanjur RF</td>
<td>70</td>
<td>74</td>
<td>0</td>
<td>25</td>
<td>20</td>
<td>189</td>
</tr>
<tr>
<td>Total</td>
<td>1,855</td>
<td>7,178</td>
<td>1,700</td>
<td>375</td>
<td>912</td>
<td>12,021</td>
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</tbody>
</table>
Like the Pichavaram mangroves, the harvestable forest resources such as timber and non-timber produce are very limited in the Muthupet mangroves. Though fodder is available in the wetland, no regular grazing is practised since mangrove forest is located far away from the villages and access is very difficult due to muddy soil. Use of mangroves for firewood for household consumption is also very less but about 75 families, mostly headed by destitute women and widows, collect dead wood and dry twigs of the mangroves and sell them at the local market for their livelihood.

People belonging to 26 hamlets of 16 revenue villages live around the Muthupet mangrove wetlands. Out of these, 22 are fishing hamlets. The total population of these hamlets is about 37,255 but average use of the mangrove wetland for fishing is only limited. Only during the monsoon season (October to December) fishers of all these fishing hamlets are engaged in fishing in the mangrove lagoon and trough-shaped degraded area (locally called thottam); in other seasons, the number of people fishing in the mangrove waters is limited. During the non-monsoon period, most of the fisherfolks fish in the nearby coastal water. The main concerns of the fishing families of the Muthupet region are

1) declining fish and prawn catch in the mangroves
2) shrinking mouth of the mangrove lagoon due to silt deposition
3) reducing depth of the mangrove lagoon, again due to silt deposition
4) over-exploitation of fishery resources in the coastal waters by trawlers and
5) Reduction in the mangrove forest cover.

One of the interesting aspects of the Muthupet mangrove wetland is the practice of the traditional fishing method called canal fishing (vaaiikkal meenpidippu), which integrates mangrove and fishery development. In this method, long canals about 1.5 to 2 km are dug across degraded areas of the mangrove wetlands through which tidal water flows freely in and out. The young fish and prawns that migrate into the mangrove wetlands from the sea through these canals are trapped and allowed to grow for about 3 to 4 months, after which well-grown fish and prawn are periodically harvested using a unique trap. This traditional method is being followed for more than 200 years by some of the fishing families, particularly of Maravakkadu and nearby fishing hamlets. These man-made canals prevent stagnation of tidal water in the mangrove wetlands but allow tidal water to flow freely in and out during the high tide and low tide. As a result, soil salinity becomes low and soil moisture becomes high, which help the mangrove plants to establish and grow. In fact, in the Muthupet mangrove wetland, a large area of healthy mangrove forest is present only in the places where the canal fishing method is being followed.

As in the case of the Pichavaram mangrove wetland, changes in the physical structure of the mangrove wetland due to past unscientific management practices and reduction in fresh water flow are the main causes of degradation.
4.0 MSSRF’s contribution to restoration, conservation and management of mangrove wetlands

From 1990, the work of the M.S.Swaminathan Research Foundation has led to an upsurge of national and international interests in restoration, conservation and sustainable management of mangrove wetlands.

It all began in September 1989, at an international conference in Tokyo on global environment and sustainable development. At the conference, Dr.M.S.Swaminathan warned that global warming in future years would lead to a rise in sea levels, flooding coastal areas with sea water. He said that mangroves could help avert such a calamity because of their salt tolerant and soil-binding characteristics. He called for anticipatory research so that scientists could transfer the salt-tolerant properties of mangrove plants to crop varieties, so that they can be grown in saline affected areas. He also urged integrated effort towards the conservation, evaluation, classification and sustainable utilisation of mangroves to protect the ecological security of coastal regions and the livelihood security of coastal communities.

4.1 Contribution to international mangroves

Establishment of Global Network of Mangrove Genetic Resource Centres

Dr.Swaminathan’s remarks and suggestions aroused much interest. They led the International Tropical Timber Organization (ITTO) to support MSSRF to conduct a project design workshop for establishing a global grid of mangrove genetic resource centres. They also led to the setting up of the International Society for Mangrove Ecosystems (ISME) at Okinawa, Japan, in 1990. Dr.Swaminathan was elected its first President.

On the basis of the recommendations of the project design workshop, two teams of scientists visited 23 mangrove sites in South and Southeast Asia, Oceania and West and Central Africa. These two teams conducted intensive surveys in 1992 and evaluated the sites using 10 criteria. On the basis of the recommendations of the teams, four sites, Bhitarkanika (Orissa, India), Sandakan (Malaysia), Baimuru (Papua New Guinea) and Mouanko (Cameroon) were selected for establishing mangrove genetic resources centres.
Following this, an international training programme on “Conservation of mangrove forest genetic resources” was organized in Chennai with the aim of training the managers of the mangrove centres on all aspects of mangrove conservation, evaluation, documentation and utilisation. Candidates from 12 countries took part in the training and prepared a Charter of Mangroves for their respective countries.

**Establishment of Mangrove Ecosystem Information Services**

Using the information collected from 23 mangrove sites in various countries as well as information collected from other mangroves, the Mangrove Ecosystem Information Services was established at MSSRF in 1993. It has four databases: Mangrove Expert Database, Mangrove Bibliographic Database, Mangrove Resources Database and Mangrove Genetic Variability Database. This Information Service formed the basis for the development of the Global Mangrove Information Service (GLOMIS). The International Tropical Timber Organisation supported all the above activities.

**4.2 Contribution to national mangroves**

**Establishment of a Mangrove Genetic Resource Centre at Pichavaram**

Immediately after the project design workshop, a Mangrove Genetic Resource Centre was established in about 50 ha of forestland provided by the Tamil Nadu Forest Department with the support of the Ministry of Environment and Forests, Government of India. An area called Periaguda in the Pichavaram mangroves has been selected for the Centre and now the genetic resource centre of this area is being protected with the help of local communities.

**Restoration of degraded mangroves**

The 1992 survey, conducted in various mangrove wetlands of India and other countries showed that most of these mangroves were in a highly degraded condition. In order to restore these areas, MSSRF initially started a project in Pichavaram and Muthupet mangrove wetlands in 1993 with the support of the Canadian International Development Agency. The aims of this project were i) to identify causes of degradation of Pichavaram and Muthupet mangrove wetlands and ii) to develop and demonstrate techniques to restore the degraded areas.

**Identification of the causes of degradation**

Grazing by cattle and felling by local community were commonly sited as the major causes of degradation of the Pichavaram and Muthupet mangrove wetlands. But ecological study conducted by the MSSRF team unearthed the real reasons for the degradation. It was found out that “coupe-felling” that was followed in Pichavaram from 1911 to the late 1960s was the main cause of degradation. Coupe-felling is a system of management followed by government agencies whereby trees are felled on a rotation basis every 20 to 30 years for revenue generation. Studies indicated that coupe-felling in Pichavaram exposed large areas of mangrove wetlands to sunlight, which in turn caused evaporation of soil water (mangrove soil contains nearly 80% of water). As a result, soil in the coupe-felled area shrank, changing the flat topography into a trough shape. Saline water which entered the trough-shaped portions during the high tide became stagnant. Evaporation of stagnant water increased soil salinity to a level lethal to mangroves. As a result, no regeneration of mangrove plants was seen in the coupe-felled area.
The same situation is responsible for large-scale degradation in the Muthupet mangroves. Here, clear felling of trees started as early as the 1700s, when this mangrove was under the control of the Kings Ekoji and Saraboji of Tanjore. These kings constructed a number of rest houses (chatrams) for the convenience of pilgrims to south India from the north. Food and accommodation for overnight stay in the chatrams were provided free of cost. According to available records, the king of Tanjore decreed that these chatrams should be maintained by the revenue generated by mangrove wood, which was cut and sold as timber and firewood. After the British took over the mangroves in 1799, they set up a separate Chatram Department and continued the same practice of cutting and selling mangrove wood to generate revenue to maintain numerous chatrams. This practice was followed by the Forest Department even after independence, till the 1970s. As explained in the case of the Pichavaram mangrove wetland, such large-scale felling of mangrove trees caused several changes in the biophysical condition of the mangrove wetland, finally leading to the development of the hypersaline condition. The problem of hypersalinisation has been further aggravated in recent times due to the reduction in fresh water flow into these mangrove wetlands.

Grazing by cattle, which is a problem in the Pichavaram mangrove wetland and felling by a few families in the Muthupet mangroves, could be considered only as a secondary cause of degradation.

**Restoration technique**

On the basis of the above findings, MSSRF developed a simple technique to restore the degraded areas and successfully demonstrated it in the Pichavaram mangrove wetland between 1993 and 1996. A canal system, consisting of main and feeder canals, was designed and dug in the degraded area. The main canals were connected to natural canals nearby. This enabled tidal water to flow freely in and out of the degraded area (instead of stagnating), thus decreasing soil salinity and increasing soil moisture. Planting mangrove saplings completed the task of restoration. This technique was demonstrated in a degraded area plot of about 10 ha. The Tamil Nadu Forest Department as well as the Ministry of Environment and Forests, Government of India, evaluated this technique through a sub-committee, which considered this technique as the best available method to restore degraded mangroves and included it in the National Mangrove Action Plan.
Joint Mangrove Management

At the end of the demonstration described above, the following questions were raised: who would maintain these artificial canals if they silted-up? Who would restore other degraded areas? Who would protect plantations in the restoration area? This led to the genesis of community-based mangrove restoration, conservation and management, otherwise called as Joint Mangrove Management. This was started in the Pichavaram mangrove wetland and later extended to Muthupet mangroves and further to Godavari and Krishna mangroves of Andhra Pradesh, Mahanadi and Bhitarkanika mangroves of Orissa and Sunderban mangroves of West Bengal. The aim of this project was to build the capacities of the local communities, government agencies and grass-root institutions such as Panchayats, to restore, conserve and utilise the mangrove wetlands in a sustainable manner through participatory analysis and action.

The project's integrated approach to mangrove restoration, conservation and management is visible in a wide range of activities—technical, socio-economic and administrative. The approach encompasses many implementing agencies, and includes all the stakeholders: the mangrove user
communities, MSSRF, the FD of different states, other government departments, rural agencies such as Panchayats, local NGOs, schools and private companies. This project has so far achieved the following results in the states of Tamil Nadu, Andhra Pradesh, Orissa and West Bengal.

- Established 28 village mangrove councils for Joint Mangrove Management (JMM) involving 5,240 families as members
- Restored about 1,500 ha of degraded mangroves and planted 6.8 million mangrove saplings with 75-80% survival
- About 12,000 ha of prime mangrove forest brought under JMM
- Organized 194 Self-help Groups including 104 women SHGs through which a number of poverty alleviation programmes were implemented
- Empowered women and women groups, youth and men groups technically, socially and economically to participate in JMM.

After seeing the success of JMM, the Ministry of Environment and Forests has increased its funding for community-based mangrove restoration programmes in many of the states and now mangrove restoration and conservation has become a people’s movement.

**Joint Mangrove Management in Tamil Nadu**

Joint Mangrove Management programmes were implemented both in the Pichavaram and Muthupet mangrove wetlands with a tripartite agreement between the Tamil Nadu Forest Department, MSSRF and local mangrove user communities. In Pichavaram region, JMM is implemented through the Village Mangrove Councils (VMCs) of Vadakku Pichavaram, Thandavarayan Sozhan Pettai (T.S.Pettai) and Kalaingar Nagar and MGR Nagar of Killai town Panchayat. A total number of 480 families are members in the VMCs. These VMCs restored about 250 ha of degraded areas in Pichavaram mangroves and the remaining areas are now being restored by the Forest Department. Thus, the entire Pichavaram mangrove has been restored, which is considered as one of the outstanding successes of MSSRF’s initiatives in mangrove conservation and management. In the
MSSRF's contribution

19

Transfer of salinity-tolerant gene from mangrove tree to rice through VMCs and SHGs with the participation of different government departments. Three of the VMCs of the Muthupet region have also been adopted by the Forest Development Agency.

4.3 Biotechnological research

Since 1990, the Department of Biotechnology has been supporting the MSSRF’s on-going programme for genetic enhancement of the coastal ecosystem using modern biotechnological interventions. Despite the ecological and economic potential of mangroves, studies on mangrove genetics have received little attention. With the anticipation of rise in the sea level as a result of global warming in the years to come, MSSRF has initiated work on molecular mapping of major mangrove plant communities with an aim of isolating novel genetic combinations from mangrove species that offer tolerance to coastal salinity, and utilise such genes to develop location-specific and stress-tolerant cultivars. The major emphasis of this programme is to

- Analyse genetic diversity and species relationships among Indian mangrove species and other economically important crop species, using molecular marker technology as a prelude to genetic conservation and
- Isolate and characterise stress-tolerant genes to develop salt-tolerant crop varieties for coastal agri-eco-systems.

The ultimate objective of this activity is to develop a number of location-specific salinity-tolerant crop varieties – an approach immensely important in view of the increasing salinisation of coastal regions in the years to come. Currently, a saline-tolerant rice variety has been developed using mangrove genes, which is under limited field trials as per the norms of the Department of Biotechnology, Government of India.
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