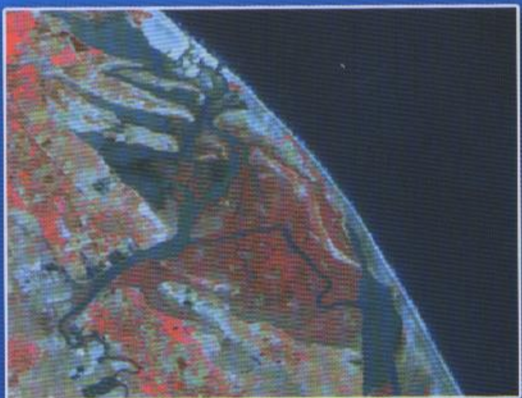
Bulletin No. 21

STATUS OF MANGROVES IN RELATION TO BRACKISHWATER AQUACULTURE DEVELOPMENT IN TAMIL NADU, INDIA



केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान

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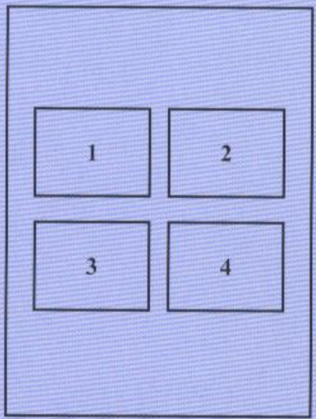

1. **IRS IC View of Pichavaram mangroves in 2004.**
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STATUS OF MANGROVES IN RELATION TO BRACKISHWATER AQUACULTURE DEVELOPMENT IN TAMIL NADU, INDIA

M. Jayanthi, P. Ravichandran and A.G. Ponniah

August 2010

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PREFACE

The rapid growth of aquaculture has focused attention on environmental impact and its sustainability in the long run. There is a growing concern about its effect on the coastal ecosystems, particularly on mangroves. Studies carried out in Philippines, Indonesia and Thailand has indicated that the mangrove conversion for aquaculture ranged from 25 to 50%, and there is a perception that the degradation of mangroves in India is also due to shrimp aquaculture development. Aftermath of Tsunami, there is a greater appreciation of the importance of the ecological services mangroves provide in terms of dissipating the energy of breaking waves, trapping sediments and reducing erosion. As efforts are on for reforestation of mangroves, it is essential to identify the factors that were responsible for the decline of mangroves in India so that suitable remedial measures are put in place along with reforestation. It is in this context, the question of the impact of aquaculture on mangroves needs to be answered. There is generally a lack of scientific studies in India to quantify the changes in mangroves before and after shrimp aquaculture development. Use of advanced scientific tools such as remote sensing techniques and geographic information systems, offer an unique opportunity to walk back in history and develop time series data that can clearly indicate the exact role of aquaculture development on the various land use patterns. It is possible to quantify the spatial expansion of shrimp culture farms and its location and clearly identify whether aquaculture development had led to loss of mangrove areas. In order to answer this question, a case study on the status of mangrove ecosystems of the State of Tamil Nadu, India was carried out and time-series changes in the land-use pattern was studied to assess the impacts of shrimp farm development. This publication clearly brings out scientific evidence to prove that shrimp farm development in Tamil Nadu did not take place at the cost of mangroves. Our efforts in bringing out this publication will help the planners, policy makers, environmentalists, NGOs, Government and other development agencies involved in mangroves restoration and shrimp farming.

Dr. A.G. Ponniah
Director

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1. INTRODUCTION

Mangroves are marine tidal forests and form a dynamic ecotone between land and sea. They are salt tolerant, evergreen, broad-leaved trees and are the dominant features of the tropical coastline where salinity undergoes constant variation due to fresh water flow. Mangrove plants include trees, shrubs, ferns and palms and require high tidal amplitude, high humidity and good fresh water flow evenly distributed throughout the year for its luxuriant growth. It is a multiple wetland ecosystem that provides protective, productive and economic benefits to coastal communities. Although once thought of as unproductive transitional systems, mangrove swamps are now viewed as highly productive, ecologically important ecosystems.

The rapid growth of aquaculture worldwide has stimulated considerable interest about its sustainability in the long run. All the major shrimp farming countries of the world have faced environmental problems due to unlimited profit motives of a section of the aquaculture community and bad pond health management practices. This has resulted in several complex social problems and litigation at national and international levels during 1996 – 97. The high rate of depletion of mangrove forests has been attributed to the development of shrimp aquaculture in countries like Philippines, Indonesia and Thailand[1].

The rapid expansion of aquaculture in India has led to a growing concern about its impact on the coastal ecosystems, particularly on mangroves and agriculture lands. The perception that shrimp aquaculture has been responsible for degradation of mangroves has stemmed from studies carried out in countries like Philippines, Indonesia and Thailand and indicated that conversion of mangroves for aquaculture ranged from 25 to 50%[1]. Shrimp aquaculture was also blamed for large scale conversion and salinization of agricultural lands and drinking water resources adjacent to shrimp farms. Issues raised due to shrimp aquaculture led to the matter being examined by the Honourable Supreme Court of India as a Public

Interest litigation (Writ petition No.561 of 1994). In 1996, the Apex Court ordered the closure of all extensive and semi-intensive shrimp farms located within the Coastal Regulation Zone (CRZ) except the traditional farms and the establishment of the Coastal Aquaculture Authority to regulate all shrimp farming activities in the country.

This bulletin presents an analysis of data using remote sensing and Geographical Information System (GIS) to clearly show that contrary to general perception, the development of shrimp aquaculture in Tamil Nadu has not been due to conversion of protected mangroves.

1.1 Importance and threats

Ecologically, mangroves provide nursery ground for a number of commercially important fishes, shrimps, crabs and molluscs. It also enhances the fishery production by enriching coastal water through exporting nutrients and detritus. Mangroves are important in maintaining and building the soil, and act as a reservoir in the tertiary assimilation of waste and in the global cycle of carbon dioxide, nitrogen and sulphur. It acts as a barrier against cyclones, floods and other natural hazards such as Tsunami by dissipating the energy of breaking waves. It prevents the entry of saline water inland during storm surges. They play a significant role in coastal stabilization and promoting land accretion, fixation of mud banks, dissipation of winds, tidal and wave energy. They trap sediments and thus contribute to land building and prevent excessive shifting of coastline sand. They provide habitats for wildlife ranging from migratory birds to estuarine crocodiles[2].

Mangroves provide timber, firewood, fodder, tannin, honey, wax, wood chip, dye and materials for roof thatching such as poles and posts. They help to increase the availability of aquatic products such as finfish, shellfish (shrimp, crab, mussel and clam) etc. Pulp for paper, matchsticks, household utensils, agricultural implements and toys are some other products obtained from mangroves.

With increased comprehension of the importance of mangroves, there has been a greater focus on activities that endanger mangroves. Today mangrove forests are considered as one of the most threatened habitats in the world. The main threats on the mangroves are cutting for fuel wood, industrial development, tourism development, dumping of sewage, solid and toxic waste, oil spillage from pipe lines or ships and salt manufacture[3]. Large areas of land have been reclaimed for agricultural purposes and urban development. Traditional aquaculture has a long history, with pond construction for fish and shrimp cultivation and some of these have been near mangroves and it is difficult for the general public to differentiate conversion and destruction of mangroves due to reasons other than aquaculture development.

1.2 Ecology of mangroves

Mangroves are coastal habitats usually found in tropical salty waters, typically near the mouth of a river. Mangroves exhibit two relatively unique reproductive strategies: hydrochory and vivipary. Hydrochory (dispersal by water) is a major means by which mangroves spread seeds, fruit, and/or propagules. These reproductive strategies help mangroves to propagate in a complex ecological background. Tidal action can carry mangrove diaspores great distances from their point of origin[4]. Vivipary refers to the condition in which the mangrove embryo germinates while still attached to the parent tree. The embryo breaks through the seed coat but remains enclosed in the fruit wall until detachment. Upon falling into the water, the thin pericarp is quickly shed, extruding the seedling. Vivipary increases the chances of successful establishment in an unpredictable environment where germination of seeds would typically be inhibited. They grow well in coastal areas where wave energy is low or in places protected by sand barrier against high wave energy. The optimum salinity condition ranges between 5 and 15 ppt[4]. The salt tolerant variety *Avicenna marina* tolerates higher salinity of around 90 ppt[4]. The tidal amplitude, slope of the coast line, availability of fresh water flow and availability of nutrients all have a strong influence on the ecology of mangroves.

1.3 International status of mangroves

Globally mangroves are distributed across tropical and sub tropical forests and estimated to be around 168,810 to 181,077 sq.km[4]. As per the estimates of FAO, the most extensive area of mangroves is found in Asia, followed by Africa and South America[5] (Table 1). Four countries (Indonesia, Brazil, Nigeria and Australia) account for 41% of all mangroves. The trend analysis indicate that the world has lost 5 million ha of mangroves over the last 20 years. After 1990, the rate of mangrove deforestation has declined. The major deforestation occurred in South America followed by Asia and North America.

Table 1. Global status and trends in mangrove area extent by region

Region	1980	1990	2000	2005	Overall change 1980-2005	
	(in '000 ha)				(in 000 ha)	%
Africa	3,670	3428	3218	3160	510	-13.9
Asia	7,769	6741	6163	5858	1911	-24.6
Oceania	2,181	2090	2012	1972	209	-9.6
North & Central America	2,951	2592	2352	2263	688	-23.3
South America	2,222	2073	1996	1978	244	-11.00
World Total	**18794**	**16925**	**15740**	**15231**	**3563**	**18.96**

Mangroves of South-East Asia are spread over an area of 60,000 km^2 and account for more than 35% area of global mangrove vegetation. It is believed that the area under mangroves, on a global scale, is shrinking by 1,000 km^2 annually[6]. Degradation of mangroves is a cause of national and international concern because of the loss of ecological services due to degradation and the resultant impact on living organisms, impairment of water quality for human use and adverse impacts on fishery resources and human health. Among south-east Asian countries, the mangrove forest in Thailand depleted from 360,000 ha in 1960 to 174,000 ha in 1991 and that in Malaysia, decreased from 505,300 ha to 269,000 ha between 1980 and 1990[7]. In Indonesia, 75% of the major cities having over 100,000 inhabitants are located in coastal areas, most of which were mangrove forests. By 1990, about 269,000 ha of mangroves in Indonesia were converted to fishponds[8]. Even in small nations such as Fiji, major urbanization has taken place by converting the mangroves of its coastal zones. In Philippines, aquaculture remains the major cause – around half of the 279,000 ha of mangroves lost from 1951 to 1998 were developed into culture ponds[9].

1.4 Status of mangroves in India

Mangroves in India account for about 5% of world's mangrove vegetation and are spread over an area of about 4,581 km^2 along the coastal States/Union Territories[10]. About 80 % of the mangrove forests are found in East Coast where the coastal profile is typical with a less steep shelf, with rivers and estuaries better developed. The distribution of mangrove ecosystem on Indian coastline indicates that the Sundarban mangroves occupy a very large area followed by Andaman - Nicobar Islands with undisturbed mangrove communities. Rest of the mangroves occupy a comparatively smaller area. Other mangrove areas on the East Coast are associated with the estuaries of the Mahanadi, Godavari, Krishna and Cauvery Rivers. The Forest Survey of India (FSI) is assessing the mangroves using remote sensing since 1987 on a two-year cycle (Table 2)[10-11]. Major mangrove areas are present along the East Coast (60%) while only about 25% is located in the west coast and the remaining 15% is in Andaman & Nicobar Islands.

Mangrove wetland of India can be classified into tide dominated (Sundarban and Mahanadi mangroves), river dominated (Godavari, Krishna, Muthupet, Pichavaram mangroves) and drowned river valley

(Gujarat)[12]. The tidal amplitude and fresh water inflow is high in the north at Sundarban mangroves and reduces gradually towards the south. The state-wise trend analysis indicates that the mangrove deforestation has mainly occurred in Andhra Pradesh and Andaman and Nicobar Islands. In all other states, there is an improvement in the extent of mangroves. As per FSI estimate, only 25% of the country's mangroves are under dense category while 37% is moderately dense the remaining 38% is of open type. In India, mangroves have been traditionally exploited by the coastal population for fuel wood except in the Indian Sundarban and Andaman Islands, where selective system of rotational felling has been practiced.

1.5 Mangroves in Tamil Nadu

Tamil Nadu is one of the nine maritime states of India endowed with the second longest coastline of 1,076 km. The continental shelf of Tamil Nadu is narrow in most places varying 4.0 to 6.0 km in width from the coast except Vedaranyam- Muthupet stretch of Thiruvarur –Thanjavur District where extensive mudflats are present. The major mangrove wetlands in Tamil Nadu are Pichavaram mangroves and Muthupet mangroves, for which river Cauvery is the main supplier of freshwater. The geographical location of major mangroves is shown in Fig.1, as red circle.

The Pichavaram Mangroves is located in the northern most end of the Cauvery delta whereas Muthupet Mangroves is located in the southern most end. The coastal areas of Tamil Nadu receive high rainfall during Northeast monsoon season mainly during November and December. Pichavaram Mangroves receive freshwater from the Coleroon River, which is one of the tributaries of the Cauvery riverine system. Muthupet Mangroves receive freshwater from a number of small tributaries of Cauvery River namely Pamini, Koraiyar, Marakkakorayar, Nasuvini, Pattuvanachi and Kilaithangi. Punnakayal mangroves are located near Tuticorin and receives fresh water from Tamirabarani River.

Table 2. State wise status of mangroves area and development of brackishwater aquaculture

State	Mangroves area (in '000 ha)										Overall change (ha)	Brackishwater aquaculture (ha)
	1987	1989	1991	1993	1995	1997	1999	2001	2003	2005		
Andhra Pradesh	495	405	399	378	383	383	397	333	329	354	-14,100	95,810
Goa	0	3	3	3	3	5	5	5	16	16	1,600	860
Gujarat	427	412	397	419	689	901	1,031	911	916	991	56,400	2,469
Karnataka	0	0	0	0	2	3	3	2	3	3	300	3,644
Maharashtra	140	114	113	155	155	124	108	118	158	186	4600	1,881
Orissa	199	192	195	195	195	211	215	219	203	217	1800	12,800
Tamil Nadu	23	47	47	21	21	21	21	23	35	36	1300	7,112
West Bengal	2,076	2,109	2,119	2,119	2,119	2,123	2,125	2,081	2,120	2,136	6000	51,427
Andaman and Nicobar	686	973	971	966	966	966	966	789	658	635	-5100	-
Pondicherry	0	0	0	0	0	0	0	1	1	1	100	-
Kerala	0	0	0	0	0	0	0	0	8	5	500	15,071
Daman& Diu	0	0	0	0	0	0	0	0	1	1	100	-
Total	4,046	4,255	4,244	4,256	4,533	4,737	4,871	4,482	4,448	4,581	53,500	1,91,074

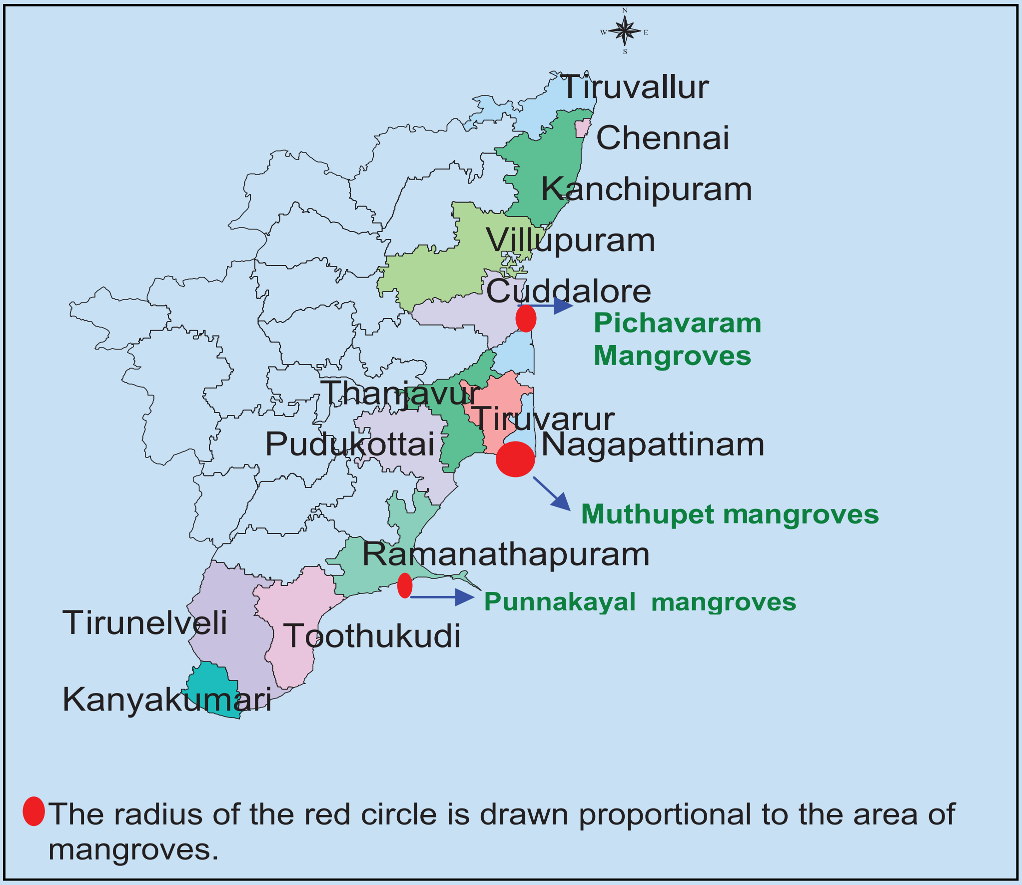


Fig. 1. Tamil Nadu - Coastal districts and the location of major mangroves

Pichavaram and Muthupet mangroves have received freshwater for nearly six months from July to December till 1924. Thereafter, a number of major and minor dams were constructed both on the River Cauvery as well as tributaries and distributaries. Consequently, the anaicut area has increased and a large quantity of freshwater is being diverted for irrigation. This has resulted in the gradual decline of the quantity and periodicity of the water discharged into the mangrove wetlands. The fresh water led into Coleroon River was reduced from 73 TMC to 5 TMC during 1930s to 1990s[4]. The reduction in freshwater flow has increased the annual average salinity that resulted in the survival of salt tolerant mangrove varieties.

The salinity sensitive mangroves have disappeared in large numbers in Tamil Nadu mangrove wetlands. Literature indicates that salinity sensitive species such as *Rhizophora and Sonneratia* that were once dominating the Muthupet wetlands before 150 years have completely vanished. In Pichavaram wetlands, species like *Xylocarpus granatum, Kandelia candel, Sonneratia apetala and Bruguiera gymnorriza* that were present earlier have disappeared[4].

2. SHRIMP FARMING

2.1 Global status

Shrimp culture continues to dominate the crustacean aquaculture at global level. More than 20 species of shrimps are being commercially cultured in various countries but the major contribution of production is from 6 species of shrimps – *Penaeus monodon, Litopenaeus vannamei, Fenneropenaeus merguiensis, F. indicus, P. chinensis and Marsupenaeus japonicus*. It has grown from 0.8 million tonnes in 1991 to 3.3 million tonnes in 2007 with the corresponding value of 5.1 billion US$ to 13.4 billion US$ during the period[13].

2.2 Indian scenario

Brackishwater farming in India has its origin in an age-old system confined mainly to the *bheries* (man made impoundments in coastal wetlands) of West Bengal and *pokkali* (salt resistant deepwater paddy) fields along the Kerala coast. Out of the total potential area of 1.20 million ha available for brackishwater aquaculture, hardly 16% has been developed for shrimp farming which includes 4% of traditional farming in West Bengal, Kerala, Goa and Karnataka. The area under shrimp culture has been more or less static during 1997 to 2007 at around 140,000 to 150,000 ha. Similarly shrimp aquaculture production showed a phenomenal increase between 1990 to 1995 and thereafter there was stagnation during 1996 to 2000. From 2000 onwards there was a gradual increase in production which reached a maximum of 1,40,000 MT in 2006-07[13].

The shrimp farming areas are mainly located in the coastal states of Andhra Pradesh, West Bengal, Kerala, Orissa, Tamil Nadu, Karnataka, Maharashtra, Gujarat and Goa. Though species like *E. indicus* (Indian white shrimp), *F. penicillatus* (Red tail shrimp), *P. semisulcatus* (green tiger Shrimp) and *F. merguiensis* (banana shrimp) are farmed in India, *P. monodon (*Black tiger shrimp*)* forms the mainstay of shrimp aquaculture in the country.

2.3 Shrimp culture in Tamil Nadu

Tamil Nadu is the second longest coastline of 1,076 km. Here has 56,000 ha of potential shrimp farming area, of which 6,248 ha has been developed so far for shrimp farming and the area under shrimp culture was 3684 ha in 2006 (Table 3).

The top three districts in Tamil Nadu for shrimp aquaculture are Nagapattinam, Cuddalore and Thanjavur. The Pichavaram Mangroves are located in Cuddalore district and Muthupet Mangroves are located in Thanjavur and Nagapattinam districts. Assessment of changes in the land classes in these three districts due to shrimp aquaculture reveals the trend of land use changes due to shrimp aquaculture in Tamil Nadu.

3. IMPACT OF SHRIMP AQUACULTURE ON MANGROVES

3.1 Pichavaram mangroves

The Pichavaram Mangroves near Parangipettai is located in Vellar - Coleroon estuary complex in Cuddalore district of Tamil Nadu, and is situated on the South East Coast of Peninsular India and lies between $79^0$45' - $79^0$50'E and $11^0$20' - $11^0$30'N. It is a vast plain gently sloping towards the Bay of Bengal.

Table 3. Status of shrimp farming in the different districts of Tamil Nadu and Union territory of Puducherry & Karaikal

District	Potential area	Area developed	Area under culture
	(in ha)		
Tiruvallur	12,600	406	143
Kancheepuram	4,500	177	136
Villupurum	3,863	347	130
Cuddalore	3,500	742	410
Nagapattinam	20,000	1,969	1,505
Thiruvarur	3,500	351	385
Thanjavur	5,500	722	448
Puddukottai	400	308	158
Ramanathapuram	1,115	711	274
Toothukudi	850	353	35
Tirunelveli	217	4	-
Kanyakumari	355	5	-
Puduchery & Karaikal	220	143	60
Total	56,000	6248	3684

River Uppanar and Coleroon which are the tributaries of the Cauvery drain the area. It is a well known place for luxuriant growth of mangroves with high productivity and diversity of fauna. *Avicennia marina* and *Rhizophora* are the dominant species of mangroves with a total area of 1358 ha[4]. Pichavaram mangroves (Fig. 2) consists of three reserve forests (RF) *viz.* Killai RF, Pichavaram RF and Pichavaram extension area.

Killai and Pichavaram mangroves have been declared as reserve forests in 1893 and an area of 92 ha was included in reserve forest area in 1897 as Pichavaram extension area. The Pichavaram mangroves is characterized by the presence of 13 exclusive mangrove species (Table.4)[4].

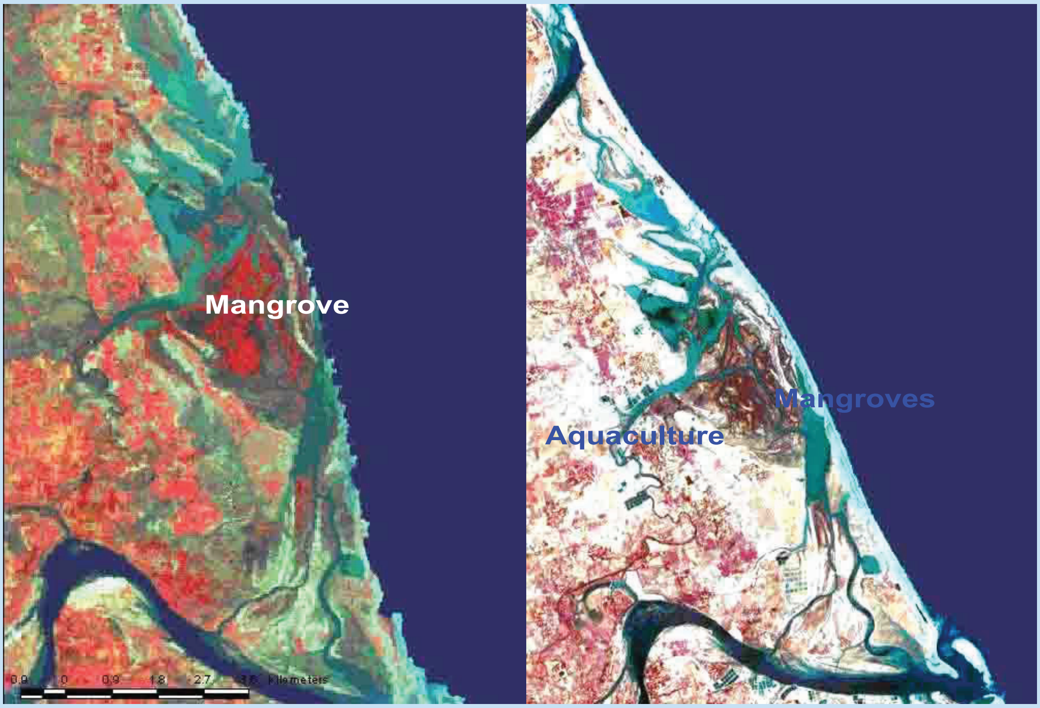
Suaeda martima, Suaeda monica, Salicorinia brachiata are the important associated species of the mangroves. Available literature shows that salinity sensitive mangrove species like *Xylocarpus granatum, Kandelia candel, Bruguieru gymnorrbiza and Sonneratia apetala*, which were present earlier in large numbers have disappeared[14].

Development of commercial aquaculture has taken place around Pichavaram mangroves during late 80's and this development was attributed as one of the main reasons for the destruction of mangroves. To assess the actual picture, temporal remote sensing satellite data was used to derive the impact of aquaculture development on mangroves. The digital images of LANDSAT – Thematic Mapper data of 1987 (Fig. 3a) and IRS 1D - LISS III data of 2004 (Fig. 3b), obtained from National Remote Sensing Agency, India were used for the study.

Fig. 2. Pichavaram Mangroves

Table 4. Mangroves species present in Pichavaram

S.No.	Species name	Family
1.	*Acanthus ilicifolius* L.	Acanthaceae
2.	*Aegiceras corniculatum* (L) Blanco	Myrsinaceae
3.	*Avicennia marina* (Forsk) Vierh.	Avicenniaceae
4.	*Avicennia officinalis* L.	Avicenniaceae
5.	*Bruguiera cylindrica* (L.) Blume	Rhizophoraceae
6.	*Ceriops decandra* (Griff.) Ding Hou.	Rhizophoraceae
7.	*Excoecaria agalloacha* L.	Euphorbiaceae
8.	*Lumnitzera racemosa* Wild	Combretaceae
9.	*Rhizophora apiculata* Blume	Rhizophoraceae
10.	*Rhizophora mucronata* Lam.	Rhizophoraceae
11.	*Rhizophora lamarckii*	Rhizophoraceae
12.	*Xylocarpus mekongensis* (Prain) Pierre	Melicaea
13	*Sonneratia apetala* Buch-Ham	Meliaceae



(a) (b)

Fig. 3. Remote Sensing Imagery of Pichavaram mangroves (a) LANDSAT–TM data of 1987 (b) IRS I C LISS III view of 2004

In the images (Fig. 3a and 3b), the smooth red indicates the dense mangroves. The variation in the mangrove appearance is due to the variation in the sensor capability. Regular square or rectangular shaped dark blue or bluish grey indicate aquaculture farms.

The topographic map of 58 M/15 from Survey of India, covering the study area was used for the delineation of basic features like rivers, reserve forest boundary, railway and road network, which serves as ground control points for rectification.

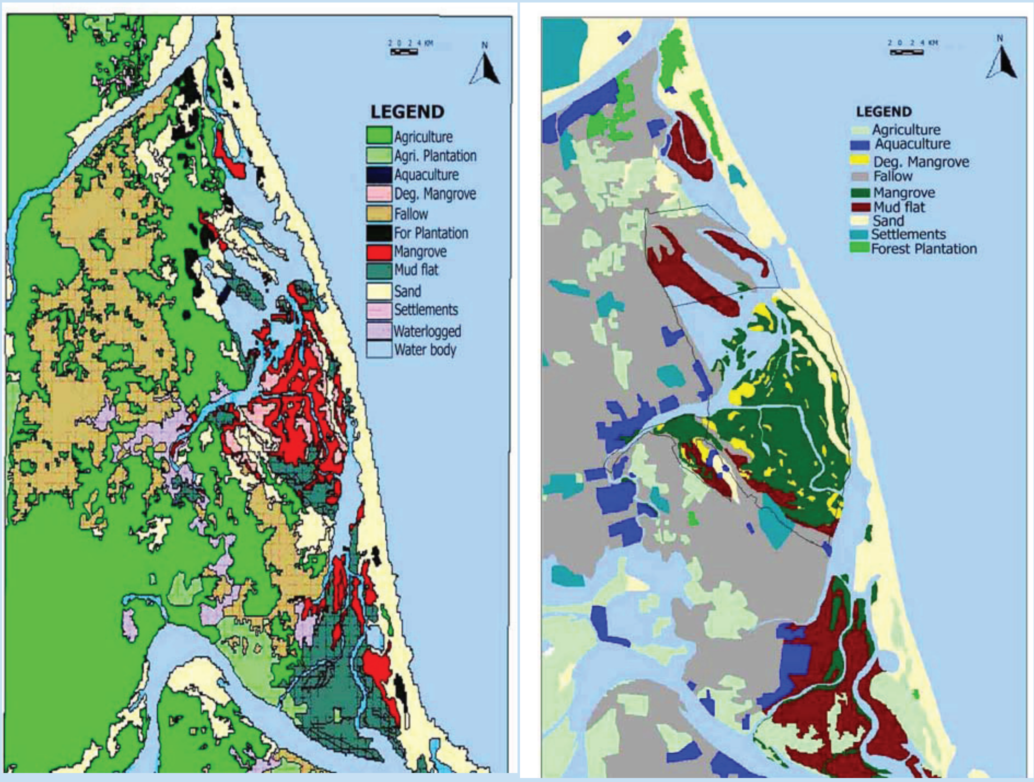


Fig. 4. Pichavaram mangroves and its surroundings (a) Land use pattern in 1987 (b) Land use pattern in 2004

The land resource maps derived from the satellite data consisted of major land use classes such as agriculture, aquaculture, mangroves, degraded mangroves, fallow, forest plantation, mudflat, sand, settlements and water bodies (Fig. 4a and 4b).

The land resources map of 1987 indicates that mangroves and degraded mangroves were present to an extent of 462 ha and 153 ha respectively. The land resources map of 2004 indicates that mangrove forests have increased to 641 ha in 2004 while the degraded mangroves (Fig. 5) have reduced to 82 ha in 2004. The developed aquaculture area in the year 1987 was 7 ha, and it increased to 386 ha in 2004. The areal extent of other land use classes is given in Table 3. The major land use class was agriculture with an areal extent of 2,735 ha and 1,145 ha in 1987 and 2004, respectively. Consequently the fallow area has increased by 1,528 ha between 1987 and 2004.

The overlay analysis was carried out using 1987 and 2004 maps to assess the extent of conversion from different land resources to aquaculture. The resultant map derived from the intersected land use maps of 1987 and 2004 indicated that the total mangrove area has increased by 179 ha. Shrimp farms have been developed out side the mangrove reserve forest area boundary (Fig. 6). The land use classes such as sparse mangroves (6 ha), agriculture field (162 ha), fallow land (145 ha), forest area (2 ha), sandy area (43 ha), water bodies (11 ha) and mud flats (24 ha) were converted to shrimp culture ponds. Major shrimp farm development occurred in erstwhile agricultural lands. Overlay of land use maps of 2004 and 1987 indicated that 6 ha of mangroves located outside the forest boundary were converted to aquaculture.

Earlier studies indicated that mangroves have decreased from 640 ha to 372 ha between 1970 and 1987[4]. This was mainly due to changes in the topography due to coupe felling system of management followed by various government agencies since 1911. In this system, healthy mangrove forests were clear felled for revenue generation in 15 and 20 years rotation. This caused various topographical changes in the biophysical condition of the mangrove wetlands leading to development of hyper saline condition, which prevented natural regeneration of mangroves[4]. In areas covered by coupe felling, the topography becomes trough shaped, tidal water enters and become stagnant leading to the development of hyper saline condition[4].

Table 5. Land use pattern before and after aquaculture development

Category	Area in 1987 (ha)	%	Area in 2004 (ha)	%
Agriculture	2,736	20.1	1,144	8.4
Aquaculture	7	0.1	386	2.8
Degraded mangroves	153	1.1	82	0.6
Fallow	1,324	9.7	2,850	20.9
Forest Land Plantation	125	0.9	99	0.7
Mangroves	462	3.4	641	4.7
Mudflats	782	5.7	647	4.7
Sand	1,699	12.4	819	6.0
Settlements	31	0.2	313	2.3
Water	6,286	46.1	6,624	48.6
Total	13,605	100.0	13,605	100.0

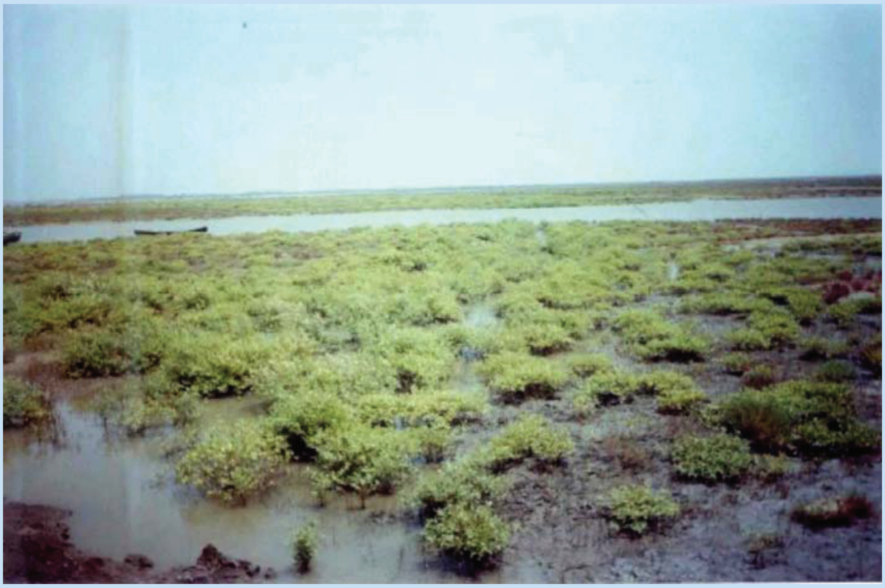


Fig. 5. Degraded mangroves at Pichavaram

This hyper saline condition was the major reason for the degradation of mangroves, which happend much before the commercial aquaculture development took place in this area.

The results indicate that after introduction of aquaculture in 1987, the area under mangroves has, in fact, increased. This increase under healthy mangroves was due to the various conservation techniques adopted under participatory mangrove forest management programmes involving local communities, Government agencies such as Department of Forests, Government of Tamil Nadu and NGOs such as M.S.Swaminathan Research Foundation. This signifies the positive role due to people's participation and is contradictory to common belief that no regeneration has taken place. It also indicates that mangroves in

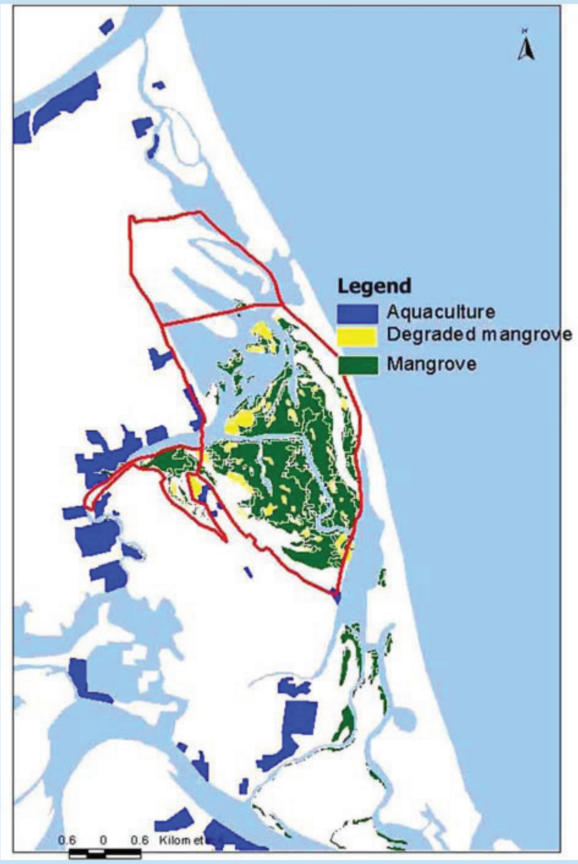


Fig. 6. Aquaculture development outside reserve forest boundary (indicated by red line) in Pichavaram mangroves

Pichavaram were neither converted nor affected due to the development of shrimp culture.

3.2 Muthupet mangroves

Muthupet mangroves swamp (Fig. 7) is the biggest mangrove forest in Tamil Nadu and located in the southernmost end of the Cauvery delta in the districts of Nagapattinam, Thanjavur and Thiruvarur. Muthupet mangroves was declared as reserve forest in 1911 and the total wetland area is about 11,885 ha. The mangrove wetlands are a combination of *Avicennia marina* forest, creeks, lagoon, mudflats and man made fishing canals. The wetland consists of seven reserve forests and has a long history of management by different government agencies, starting from the year 1740 by the Maratha rulers to the State Forest Department, Government of Tamil Nadu.

The mangrove zone of the forest is restricted to the edges of the brackishwater lagoon where the true mangrove species are distributed in varying degree of abundance. River Cauvery supplies freshwater to Muthupet mangroves and the flow of fresh water is very much reduced now a days due to construction of dams in the upstream of Cauvery. Spatial zonation of mangrove species is not much evident in Muthupet due to near total dominance by *Avicennia*. However three distinct zones exist namely *Avicennia* zone, *Suaeda* zone and degraded area. The soil salinity in the degraded area was high (45-125 ppt) compared to *Avicennia* zone (20-25 ppt) and *Sueada* zone (12.5 - 95 ppt). The mangrove species present in the Muthupet wetlands are depicted in Table 6[4].

Table 6. Mangrove species present in Muthupet wetlands[4]

S.No.	Species name	Family
1.	*Acanthus ilicifolius* L.	Acanthaceae
2.	*Aegiceras corniculatum* (L.) Blanco	Myrsinaceae
3.	*Avicennia marina* (Forsk.) Vierh.	Avicenniaceae
4.	*Excoecaria agalloacha* L.	Euphorbiaceae
5.	*Rhizophora mucronata* Lam.	Rhizophoraceae
6.	*Lumnitzera racemosa* Wild	Combretaceae

Fig. 7. Muthupet Mangroves

Avicennia marina is the most common and abundant species, followed by *Aegiceras corrniculatum* and *Excocaeria agallocha*. The Point Calimere wildlife and bird sanctuary including Muthupet Mangroves was designated as Ramsar site, (No. 1210), on 19 August 2002, which gives it the status as a wetland of international importance under the international Ramsar Convention.

The Muthupet mangroves is divided into six reserve forests *viz*, Palanijur RF, Thamarankottai RF, Maravakkadu RF, Thurukkadau RF, Thambikottai RF, Vadakadu RF and Muthupet RF. Besides these six reserve forest areas within the mangrove areas (Table 7)[4] one more additional reserve forest area, Kodikkadu Reserve Forest covering an area of 1,729 ha has been declared.

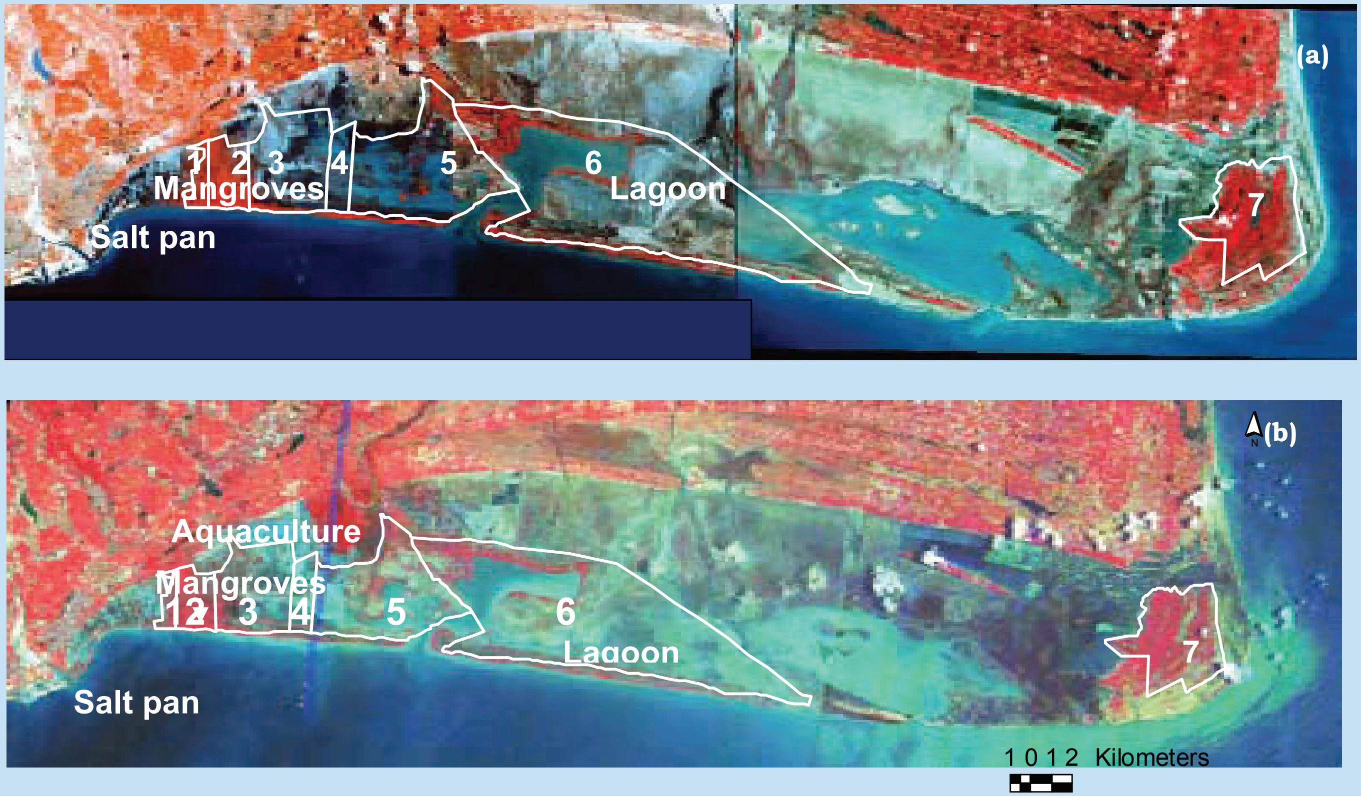
Table 7. Reserve forests and its areal extent

Reserve forest	Area (ha)
Muthupet	6,802
Thuraikkadu	2,502
Tamarankottai	530
Thambikottai Vadakadu	372
Maravakkadu	1490
Palanjur	189
Total	11,885

Among the reserve forests, Muthupet is the major mangrove area and has been declared as reserve forest since 1937. This is the largest reserve forest accounting for the half of the total forest area. Vadakadu and Tamarankottai were brought under reserve forest in 1972. The Maravakkadu, Palanjar and Thuraikadu forests were declared as reserve forests in the years 1979, 1989 and 1995 respectively[4].

In the present study, LANDSAT TM data of 6th February 1988 with Path 142, Row 53; IRS 1D - LISS III data with Path 102 and 103, Row 66 of 1st July 2005 and Survey of India Topographic maps Nos. 58N 7, 11, 15 were used as basic inputs. Updated Reserve Forest map received from Department of Forests, Tamil Nadu was georeferenced using reserve forest boundaries from topographic maps.

In the satellite data, the mangroves can be identified in dark red colour with smooth texture while the degraded area and mud flats are represented by dark to light colour with rough to moderate texture. Area covered by *Prosopis* trees can be identified in bright red colour. The satellite data indicated the absence of shrimp farms in 1988 (Fig. 8a) and its development in the western side on mangroves in 2005 (Fig. 8b). The land resource maps (Fig. 12) derived from the satellite data indicated the presence of major land use classes such as lagoon, mangroves, degraded mangroves, *Prosopis*, reserve forest, degraded forest, agriculture, salt pan, aquaculture, scrub land, sand dunes, river, muddy land, canals and rivers.



1- Palanjur RF, 2- Tamaran kottai RF, 3-Maravakkadu RF, 4- Vadakadu RF, 5-Thuralikadu RF, 6- Muthupet RF, 7- Kodikkadu RF.

Fig. 8. Muthupet mangroves (a). Landsat TM view in 1988 (b). IRS 1D view in 2005

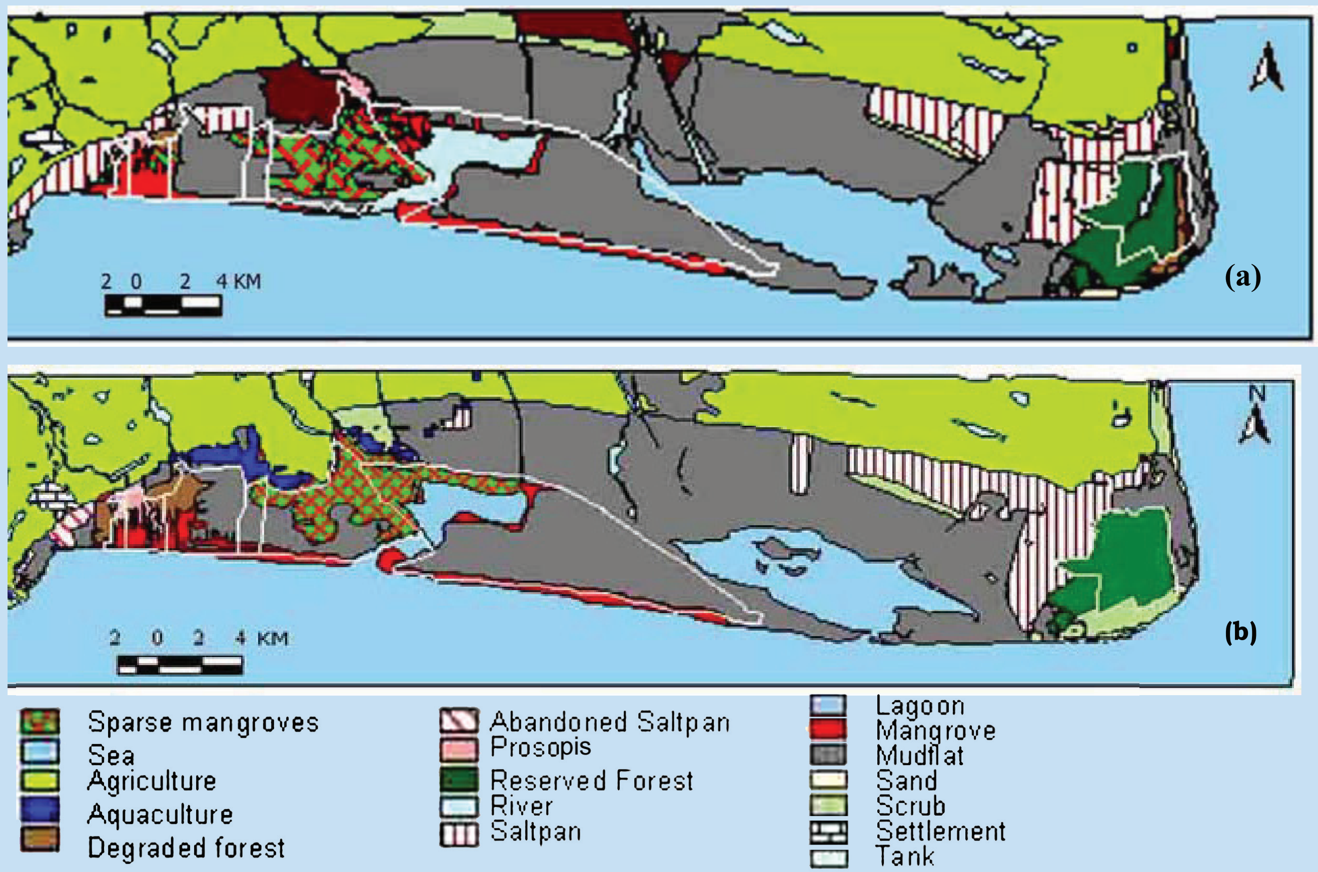


Fig. 9. Land resources map in and around Muthupet mangroves
a. Land use in 1988 b. Land use in 2005

The analysis of IRC 1D remote sensing data covering an area of 59,009 ha, shows that the dense mangroves and degraded mangroves have occupied an area of 2,374 and 1410 ha respectively in 1988 (Fig. 9a). The dense mangroves have reduced to 2,016 ha and degraded mangroves have increased (Fig. 9b) to 2,264 ha in the year 2006. This indicates that dense mangrove of 358 ha areas was reduced to degraded mangroves. There were no shrimp farms in 1,988 and it was developed to an extent of 948 ha in 2005 (Table 8).

Agriculture was the major activity and paddy was cultivated once a year as this area was located at the tail end of the Cauvery River. The area under agriculture increased from 17,739 ha to 18,355 ha between 1988 and 2005. Saltpans were present in the western part of the mangrove wetlands and 13 of them were owned by Salt Corporation of the Government of India. Salt production was discontinued from 1997 on the directions of the Supreme Court. The salt pan located in the landward margin of the Muthupet (Fig. 10) drew water from the Palk Strait and produce salt for industrial chemicals. Intrusion of high saline water into the mangrove areas and forest plantation would be detrimental to growth and regeneration of mangroves. Hence, there is a need for maintenance of a buffer zone between the saltpan and the forest area.

Muthupet wetlands receive freshwater mostly during the north east monsoon from October to November. The dry season is long, extending from February to September and corresponding to it, the average salinity in the mangrove area is also high ranging from 35 to 45 ppt. In some pockets of Muthupet mangroves, water salinity in dry season was as high as 75 ppt. Increasing salinity has been identified as one of the reasons responsible for disappearance of *Rhizophora* and *Sonneratia* about 150 years ago from Muthupet[15]. Lack of freshwater flow has resulted in loss of biodiversity and led to near total dominance by the salinity resistant *Avicennia marina.* Due to low tidal amplitude, tidal inundation is limited to the areas immediately abutting the water bodies, that led to high soil salinity varying between 12.5 -125 ppt[12].

The trough shaped portion of the mangrove wetlands, permits the water to move laterally to the dense mangroves areas. Due to lack of sufficient outlets and draining channels, floodwater stagnates in the degraded areas and interior areas and then evaporation over the years led to hyper saline conditions, preventing fresh regeneration. Therefore we could conclude that the reduction in mangroves is due to a variety of topological changes occurring over the years and is linked to increased salinisation.

Table 8 Land use pattern in and around Muthupet mangroves

S.No	Land use class	Area in 1988 (ha)	Area in 2005 (ha)
1.	Dense mangroves	2,374	2,016
2.	Sparse mangroves	1,410	2,264
3.	Agriculture	17,739	18,755
4.	Aquaculture	0	948
5.	Mudflat	25,852	24,163
6.	Abandoned salt pan	0	312
7.	*Prosopis* trees	361	374
8.	Forest plantation	2,185	2,165
9.	Saltpan	4,254	4,234
10.	Sand	342	252
11.	Scrub land	3,204	1,743
12.	Settlement	262	490
13.	Tank	583	583
14.	Degraded forest	437	613

Overlaying the reserve forest boundary on the aquaculture land use (Fig. 10) indicated that dense mangroves are not converted for aquaculture. Mudflats (688 ha), scrub land (83 ha), salt pan (41 ha) and sparse mangrove (2 ha) have been utilized for the development of shrimp farms in which improved/modified extensive farming is being practiced. The shrimp farms have been developed mainly from the erstwhile flood-prone mudflats, agricultural lands and salt pans.

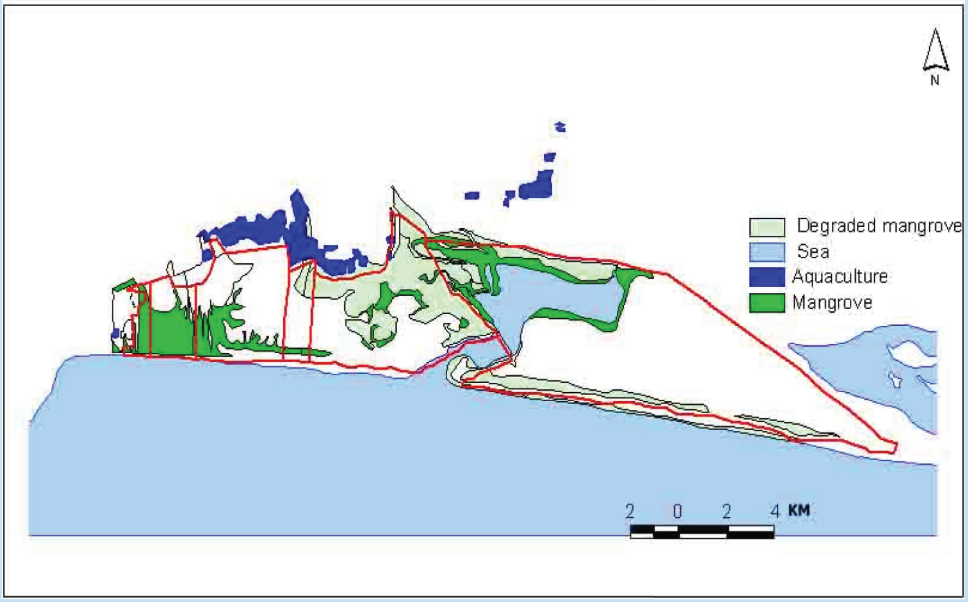


Fig. 10. Reserve forest boundary (red line) of Muthupet mangroves overlaid on mangroves and aquaculture land use

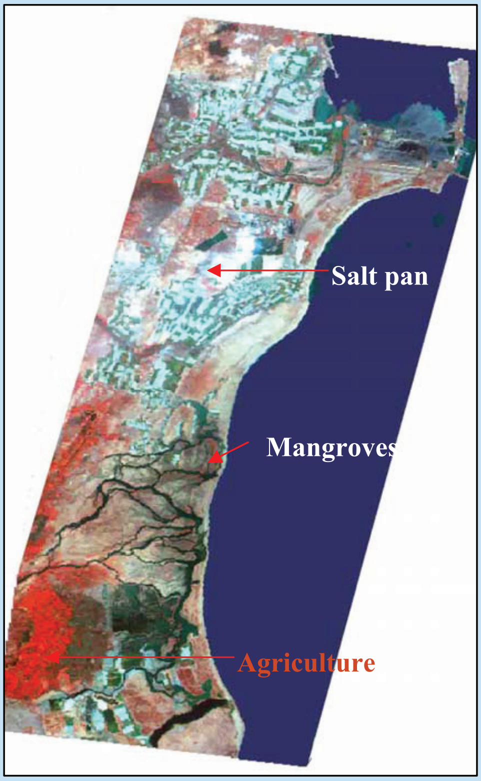
In the six reserve forests, shrimp farms have not been found near the dense mangroves. They are closely located to the degraded mangrove areas. The sparse mangrove areas of 1.75 ha have been converted for shrimp culture. Though the conversion of sparse mangroves for aquaculture farms (0.002 %) was negligible, future development should be based on the site selection guide lines issued by Coastal Aquaculture Authority, Government of India, to promote long term sustainability of the aquaculture sector.

Agricultural land of 134 ha has been converted to aquaculture and the main reasons given by stakeholders are non availability of good water, decreased profit in agriculture and ever increasing demand for shrimp. Aquafarming activities were initially started in the coastal fallow lands close to suitable water resources but it gradually moved towards the interior and neighbouring paddy fields. Though agriculture land has been converted for aquaculture and habitation, the over all agriculture area has increased by 1,016 ha due to the development of agriculture in earlier scrub land. However, the conversion of agricultural lands into shrimp farms is not permitted now and shrimp farms are not eligible to get license for their operation if located in agricultural lands, as per the Coastal Aquaculture Authority Act, 2005 and its guidelines.

3.3 Impact on Punnakayal mangroves

Punnakayal mangroves is located in Gulf of Mannar region in southern Tamil Nadu. The area described as the Dhanskodi-to-South of Tuticorin barrier reef was declared a National Park in 1986 and later converted into a Biosphere Reserve in 1989. The district has about 400 ha of mangroves, which are in a highly degraded state. River Tamirabarani is the main source of freshwater flow. This mangrove area (Fig. 11) is yet to be declared as a reserve forest. The major mangrove species present in the Punnakayal Mangroves are *Avicennia* species and the other associated mangrove species are *Salicornia* and *Suaeda*.

Fig. 11. Punnakayal Mangroves



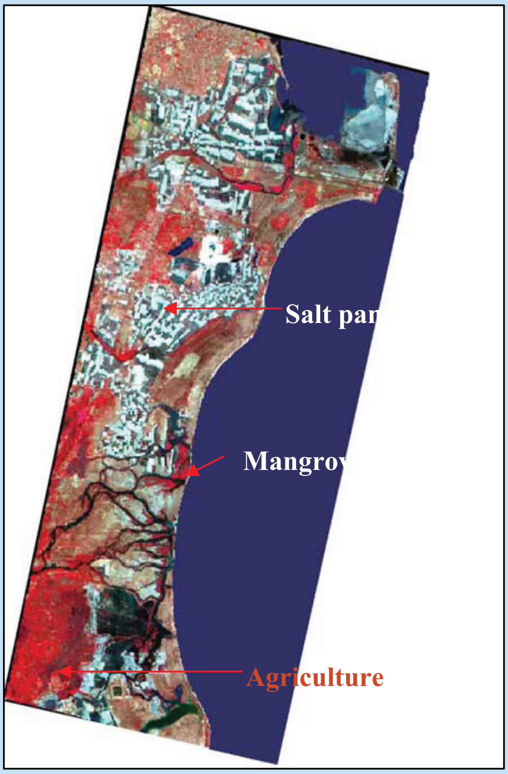


Fig 12. Punnakayal mangroves
(a) TM sensor view In 1987 (b) LISS III view in 2005

To assess the changes in the mangroves, satellite images covering the area with geographic coordinates 80 38' – 8048 N' and 78 04' – 78 012' E were used in the study. To map the status of mangroves before aquaculture development and the present condition, Landsat TM satellite data of the year 1987 (Fig. 12a) and IRS P6 data of year 2005 (Fig. 12b) were used. The ground control points for the image processing were derived from the topographic maps 58L1 and L2. The land resources maps were prepared using ERDAS Imagine and Arc GIS 9.1. The land resource map (Fig. 13) derived from the satellite data of 1987 indicated the presence of major land use classes such as saltpan, agriculture, mangroves, industries, agriculture, saltpan, scrub land, canals and rivers. The mangrove area in 2005 was 244 ha, which was 37 ha less than that in 1987 (281 ha).

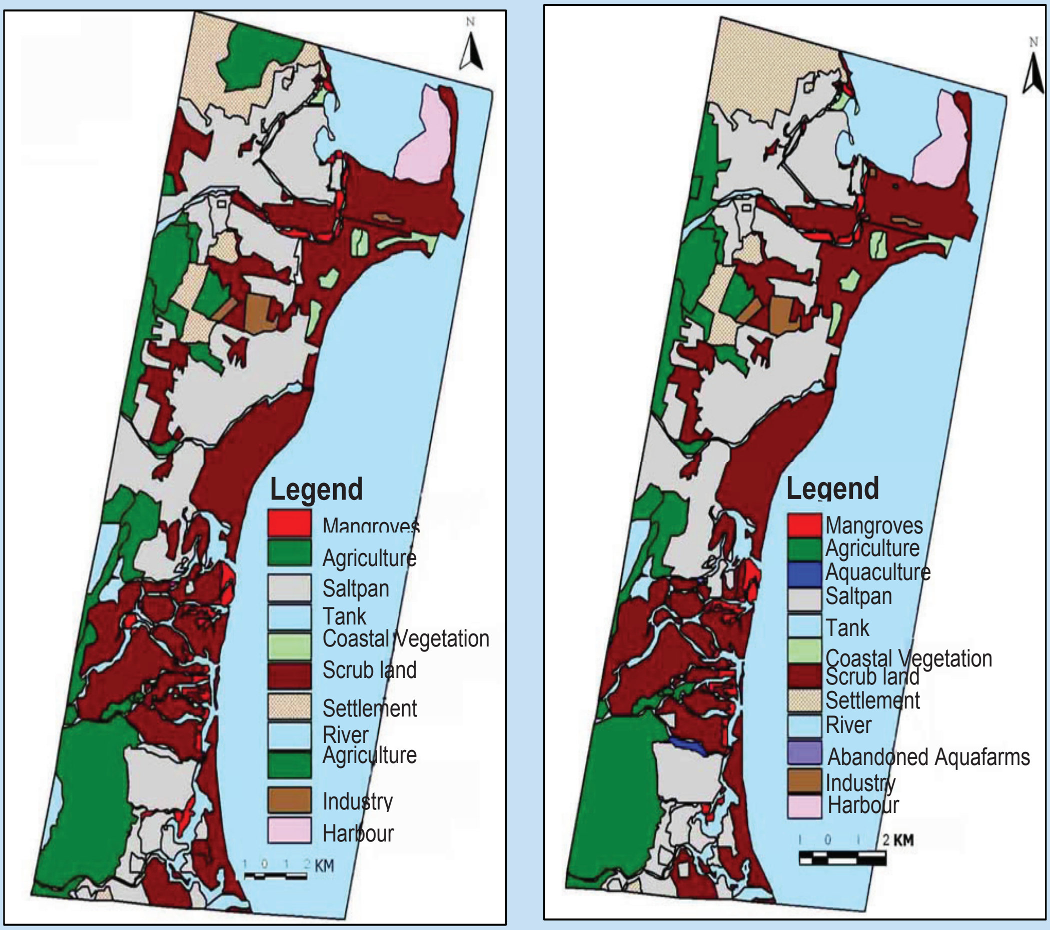


Fig. 13 . Land use pattern in and around Punnakayal mangroves
(a) Land use in 1987 (b) Land use in 2005

There were no shrimp farms located around mangroves. Crab farms were developed to an extent of 28 ha. Scrub land (4,239 ha) occupied a major portion of the area followed by salt pans (4,159 ha) and agriculture (2,392 ha). The agriculture area was reduced from 2,483 ha to 2,392 ha.

The change detection analysis revealed that the presence of salt pan nearer to mangrove areas was the main reason for degradation. The overlay analysis using 1987 and 2005 maps indicated that the mangroves (Fig. 14) had degraded to scrub land (29.4 ha) and were converted to saltpans (7.9 ha). The electrical conductivity of water nearer to mangroves was 110ds/m due to the saltpan activities. This high salinity nearer to mangrove areas may be the main reason for mangrove degradation and retardation of growth in mangrove tree; the mangrove trees appear as bushes and do not grow above 1.5 m. The sewage water also enters some parts of mangroves and could negatively impact mangrove growth.

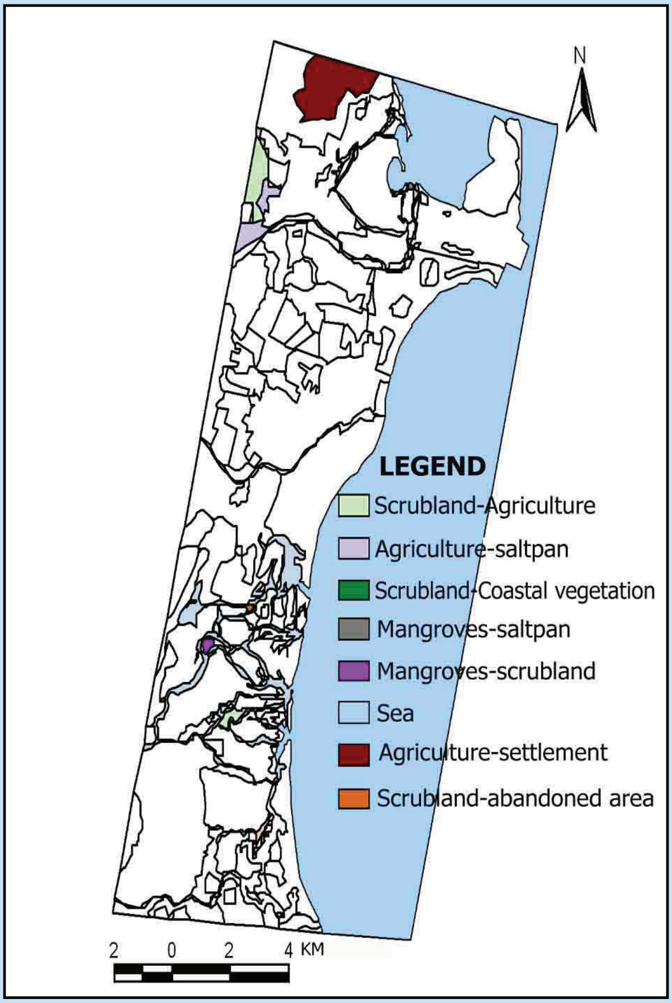


Fig. 14. Changes in different land use classes in and around Punnakayal mangroves between 1987-2005

Fig. 15. Sewage and drainage near Punnakayal mangroves

Gulf of Mannar region and its surroundings of 15 km were declared as bio reserve and shrimp farms were not permitted in 15 km from the Gulf of Mannar Reserve, which is inclusive of Punnakayal mangroves. Hence saltpans, industrial effluent and domestic sewage are the reasons for mangrove degradation (Fig. 15) The Punnakayal mangroves are not yet declared as reserve forest category. It is in a highly degraded state and there has to be immediate action with buffer zone and provision for freshwater flow to save the mangroves.

4. LAWS AND REGULATIONS FOR MANGROVES PROTECTION

Protection of mangroves in India has been taken up as early as 1979 when a National Mangrove Committee was established and which is now superseded by a National Committee on Wetlands, Mangroves and Coral Reefs, as an advisory body to the government. This body has identified 15 key mangrove areas and has drawn up Management Action Plans for all of them, to be administered by the state governments with financial assistance from the Ministry of Environment and Forests. The three mangrove ecosystems studied in Tamil Nadu form a part of these. Small afforestation schemes have been undertaken, notably in the Gulf of Kutch. A number of sites have also been given legal protection, including part of the Gulf of Kutch and the Great Andamans.

Notification on Coastal Regulation Zone (CRZ) was gazetted in 1991 under Environment (Protection) Act 1986 for the protection and improvement of the environment. Under this Notification coastal stretches are classified into four categories such as CRZ I, II,III and IV. Mangroves are classified under CRZ- I, which is strictly a no-development zone, and any construction or development activity in mangrove areas are considered as violation of CRZ Notification.

Tamil Nadu is the first state to bring out a comprehensive legislation on aquaculture in 1995 and the act prohibited the establishment of aquaculture units in ecologically sensitive areas like mangroves and cultivable lands. With the establishment of Aquaculture Authority in 1997 under the Environment Protection Act, 1986, coastal aquaculture especially shrimp farming came under the regulation of Aquaculture Authority. In 2005, the Coastal Aquaculture Authority Act was enacted to regulate the culture of all aquatic organisms in the coastal area. Under this Act, no new aquaculture farm is permitted upto 200 m from the high tide line and 100 m from mangroves. The guidelines are very specific and conversion of mangroves into aquaculture farms is not permitted.

5. CONCLUSION

Mangroves are among the most productive ecosystems of the world. Neglected for long by science and forestry, it never featured significantly in any of the traditional tending and regeneration of forest systems. The world has realized that mangroves provide vital ecological services which support the food and livelihood of millions around the world and play a commendable role in maintaining biodiversity and protection to coastal areas from natural hazards. Mangrove conservation has received worldwide attention after the 26 December 2004 Tsunami in view of their potential as bio-shields.

As mangroves play a vital role in providing major protection in the coastal areas, conversion of mangroves has been focused on identifying major destructive activity in coastal areas. The world has till now lost 5 million ha of mangroves over the last twenty years, or 25 % of the extent found in 1980. Based on the experience in counties like Philippines and Indonesia, shrimp farming was considered as one of the reason for the loss of mangroves in India. Rapid expansion of shrimp farming has led to a public perception that this development had negatively impacted the mangrove environment.

In India, significant loss in the mangroves cover in the coastal belt was reported during the last several years. Temporal satellite data from pre-aquaculture times till the present revealed that the development of shrimp culture was not at the expense of mangroves as often perceived. Within the area developed for shrimp culture (6248 ha) in Tamil Nadu, sparse mangroves covering a small area (7.75 ha) which translates to a miniscule 0.001% only was converted for shrimp aquaculture. This indicated that there was no major destruction of mangroves for shrimp culture development in Tamil Nadu. The legal instruments available at the Central and State government levels indicate that there exists strict provisions to ensure that aquaculture development does not in any way impact mangroves negatively.

The literature reviewed in this bulletin along with data on different land classes very clearly indicates that the destruction of mangroves in Tamil Nadu is mainly due to topographical changes and reduction in freshwater flow leading to increased salinity. It categorically proves that the destruction of mangroves due to modern scientific shrimp farms is insignificant. The analysis also reveals that the reasons for destruction of different mangrove areas are site specific. Detailed study on each mangrove area with remote sensing data and use of GIS would help in identifying the changing land use classes and based on that further enquiry could identify the reasons for destruction. It is imperative to carry out such studies before any regeneration plans are mooted.

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