PROGRESS REPORT

Project Title	Integrating conservation with Development in Mangrove ecosystems in Tamil Nadu (File No.38-7-122-5)
Institution	M.S.Swaminathan Research Foundation Madras, India
Principal Investigators	Dr.V.Selvam Miss G.Uma and Dr.M.S.Swaminathan, M.S.Swaminathan Research Foundation
Duration of the Project	2 years (May 1993 -April 1993)
Period of progress report	January 1994 to June 1994

Contents

A.Conservation

A.Conservation

1. Ecological studies in relation to restoration and conservation of Pichavaram mangroves

1.1. Introduction

Information on spatial distribution and community structure of mangrove plant species in relation to local geomorphology, topography and frequency and extent of tidal inundation is a prerequisite in developing conservation strategies for a specific mangrove ecosystem since the above factors play a crucial role in creating favourable condition for the establishment, survival, growth and regeneration of mangrove species. In addition, a detailed study on natural and human-induced stresses on mangrove ecosystem structure and function is also indispensable in developing a reliable restoration and conservation plan. Apart from these, information on changes in coastline configuration over a period of time and their impacts on dynamics of mangrove plant communities is also necessary since the future of the mangrove ecosystem is dependent on such changes. With these views, the following studies were conducted in the Pichavaram Reserve Mangrove Forest:

1. changes in mangrove forest cover between 1897 and 1993
2. spatial distribution and structural properties of the plant communities in relation to topography and tidal inundation
3. coastline changes between 1930 and 1992 and their impact on mangrove ecosystem and
4. impacts of natural and human-induced stresses on mangroves

1.2. Materials and methods

1.2.1. Changes in the forest cover between 1897 and 1993

Data on the area of Pichavaram mangrove froest cover in 1987 when it was declared as Reserve Forest, were collected from the records of the Forest

estimate the changes in the forest cover and the present area of the forest is also not known. An attempt was made to estimate the reduction or increase in the wooded area of this forest since 1987 with the help of toposheets published in 1930 and 1970 but changes could not be dedected accurately due to poor demarcation of the mangrove forest in the toposheets. However, area of the Pichavaram mangrove forest in 1986 and 1993 was estimated by Krishnamoorthy (Personal communication, Institute of Ocean Management, Anna University) using high resolution satellite data (Landsat TM for 1986 and IRS.LISS-II for 1993) and these data were used in the present study to estimate the changes in the actual forest cover between 1897 and 1993.

1.2.2. Spatial distribution and structural properties of the plant communities in relation to topography and tidal inundation

For systematic survey on spatial distribution and collection of data for the computation of community structure indices as well as for the measurement of topographical features and frequency and extend of tidal inundation, Pichavaram mangrove was divided into three areas: **Area I** is the northern portion of the mangrove ecosystem including 10 islands with dense mangroves; **Area II** is the middle portion including a large wooded area called Bunglowthittu and **Area III** is the southernmost part including "Periaguda" area where mangrove communities are relatively undisturbed (Fig 1). The present study was conducted only in Area I and II. In these two areas microtopography was measured (in cm) in 10 randomly selected quadrats (7 in Area I and 3 in Area II). The transects were laid perpendicular to the water course and the length of the transect varied from 95 to 245m depending on the size of the sites investigated. The method described by Emery (1961) was followed for the microtopographical measurement. A bench mark was established at the edge of the high tide level (considered as 0 amplitute), from there readings were taken at 2m interval along the entire length of the transect. Frequency and extent of tidal inundation of different portions of the transect was measured during the day-time high tide covering the period between neap and spring tide.

Distribution pattern of different species along the transect was studied by visual observation. A zone was demarcated clearly on the basis of a resident species which was dominant in it and the zone was named after that dominat

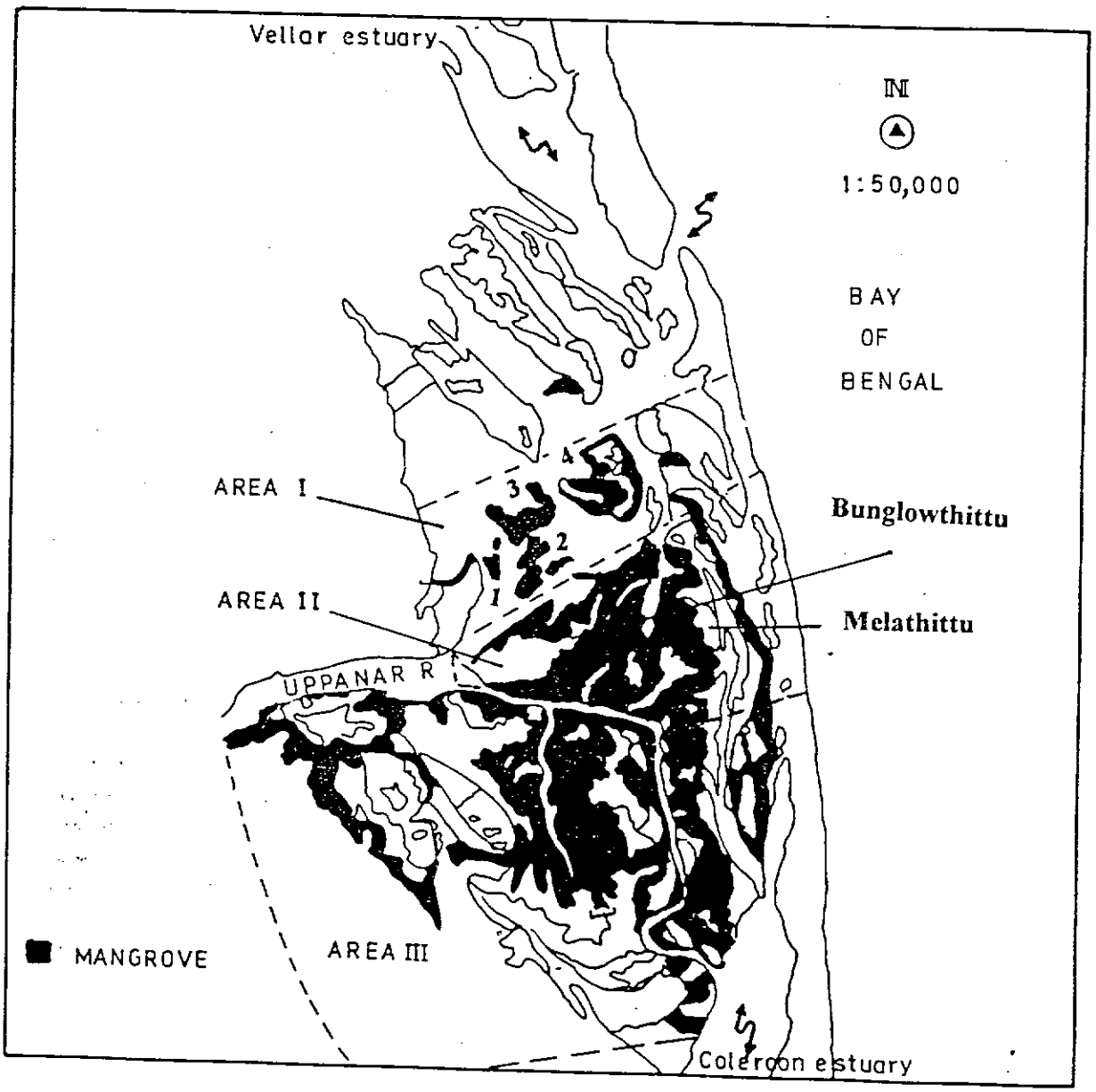


Fig.1. **Map of the Pichavaram mangroves and location of the study sites (Areas covered in the present are Islands 1 to 4 of Area I and Bunglowthittu and Melathittu regions of Area II)**

species. Data for community structure analysis were collected from a series of quadrats of 5x5 m^2 laid along the length of the belt transect at 5m interval. From each quadrat data on i) number of species, ii) number of individuals of each species and iii) circumference of each individuals at breast height were collected. Stems below 10cm in circumference (less than 3cm in diameter) were omitted since the basal area of these individuals would be negligible. The circumference readings were later converted into diameter and the diameter readings were used to compute the basal area. Community structure indices like relative density, relative frequency, relative dominance and importance value were computed using standardised formulae (Cintron and Novelli, 1984).

1.2.3. Impact of natural and human-induced stresses

1.2.3.1. Impact of coastline changes between 1930 to 1992

Changes in coastline configuration and their impact was studied using toposheets published in 1930 and 1970 and 1992 map prepared on the basis of Landstat TM False Colour Composite imagery. The 1930 toposheet was in 1:63,000 scale whereas 1975 and 1992 maps were in 1:50,000 scale. For comparison the 1930 map was converted into 1:50,000 scale using planvariograph and all these maps were traced on transparency sheets and overlaid on each other to mark the changes.

1.2.3.2 Other impacts

Field studies were conducted to understand the human induced stresses like non-conventional method of fishing, cattle grazing and illegal felling. To analyse the impact of non-conventional method of fishing, data on the height of the mud embankments constructed within the mangrove forest was measured at randomly selected sites. The distance at which the mud embankments are constructed from the shoreline was also measured and the impact on tidal flow was assessed during high tide periods. To analyse the total area degraded by cattle grazing, Area I and II were systematically surveyed and the location and extent of the grazing grounds were marked on the map and the area was measured using a planimeter.

1.3 Results

1.3.1 Changes in the forest cover between 1897 and 1993.

The records of the Forest Department indicate that the Pichavaram mangrove was declared as Reserve Forest on 11th February 1893 under the notification B.P.No.98. The total area of mangroves in 1893, according to the notification, was 1007.26ha. Later under the notification B.P No.430 dated 15th December 1897 an area of 92.27ha was also included in the Pichavaram Reserve Forest as extension area. Thus the actual area of the Pichavaram mangrove ecosystem in 1897 was 1099.53ha. This includes both the forest cover as well as the water body present within the forest boundry. For comparison of the forest cover between 1897 and subsequent years, it is necessary to find the actual forest cover excluding areas of the water body and other landforms. This was accomplished with the help of the Reserve Forest Map prepared in 1897 (Fig.2). Using a planimeter forest and water cover were estimated separately. According to this estimation the forest cover of the Pichavaram mangrove in 1897 was 731.31ha and the area under water was 366.33ha. The above estmation may not be very accurate because of the fact that landforms like barren mudflats, stranded ridges etc, if they were present, were not excluded from the forest cover estimation since they were not clearly demarcated in the toposheets. However, in the absence of any reliable data on the forest cover of 1897 the present estimation may be considered as the baseline area.

After 1897 no survey was conducted to detect any changes in the forest cover and the present actual forest area is also not known. Diffculties involved in surveying this wetland which is criss-crossed by a number of small creeks and channels might be the reason for the above fact. However, with the help of remotely sensed data it is possible to estimate very accurately the area covered by mangrove plants in a given locality. Krishnamoorthy (Personal Communication) analysed the supervised classification data of Landsat-TM of 1986 and IRS-LISS-II of 1993 of Pichavaram area using VAX-11/780 image processing system to estimate the changes in mangrove plant cover. According to him the number of pixels pertaining to actual mangrove plant cover were 2063 in Landsat-TM (1986)

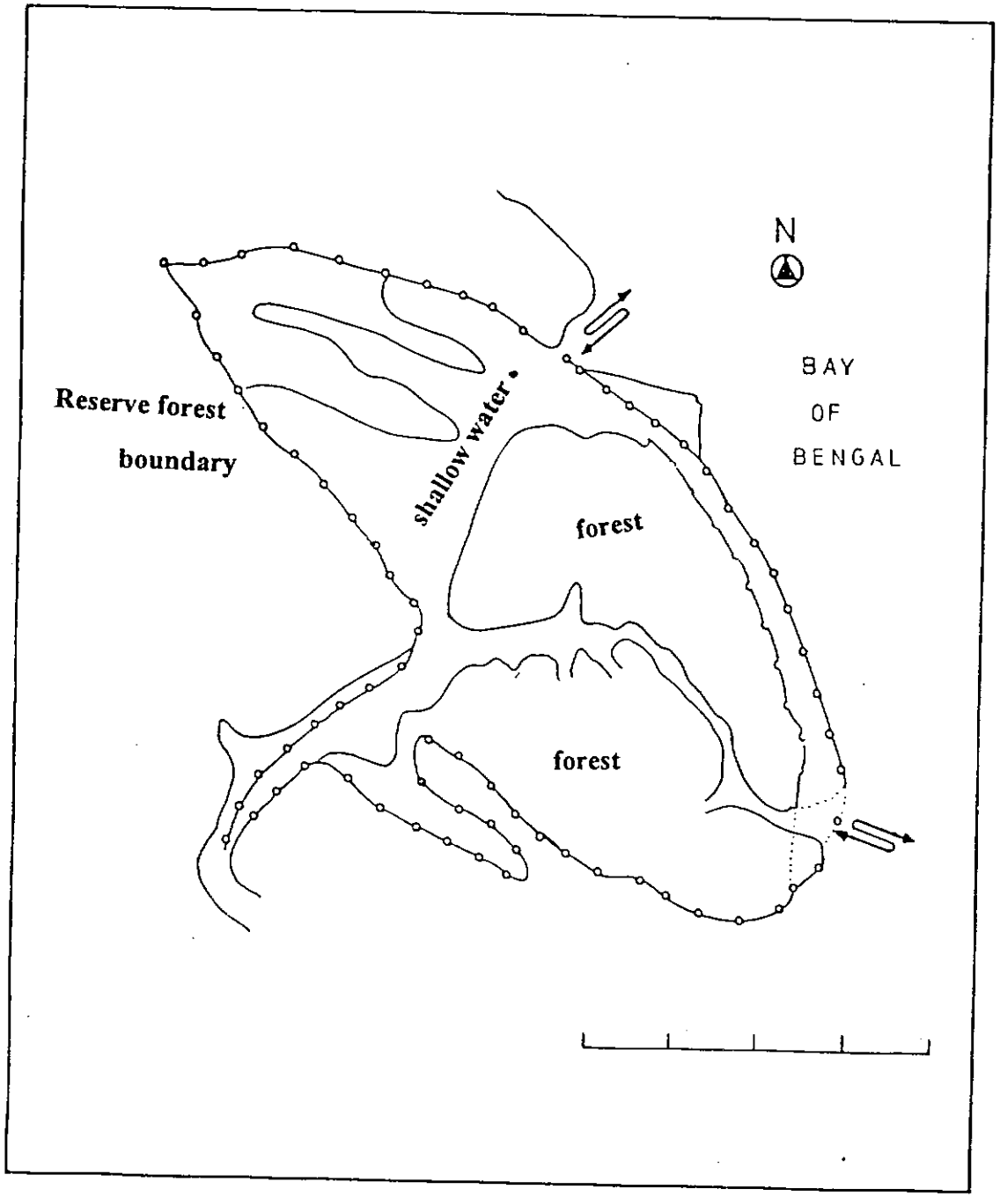


Fig.2 1987 map of the Pichavaram Mangrove Reserve Forest (source: Forest Department, Government of Tamil Nadu)

Table 1.Changes in the forest cover of Pichavaram mangroves between 1893-1993

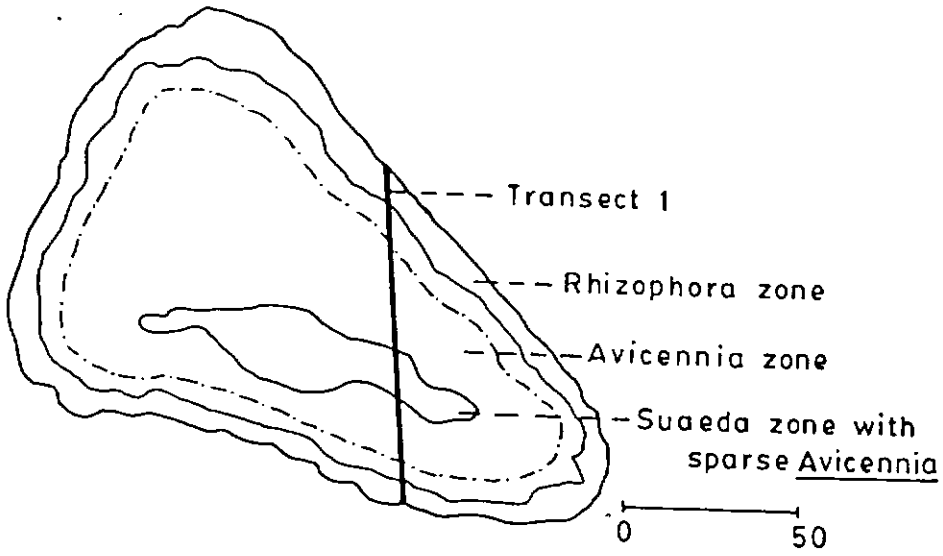
Year	Area (ha)	Reduction (ha)
1897*	731.31	
1986	185.67	Between 1897-1993 545.64 ha (74.61%)
1993	149.43	Between 1986-1993 36.24 ha (19.51)
		Between1893-1993 581.88 ha (79.57%)

and 1153 in IRS-LISS-II (1993).On the basis of the above data the area actually covered by mangrove plants in 1986 and 1993 was calculated and it was 185.67ha in 1986 and 149.43ha in 1993. The classified picture of the Landsat TM of 1986 and IRS-LISS-II of 1993 are shown in Fig.3 and 4 (coutesy Krishnamoorthy). The above area calculation is used for the present comparative study and Table 1 shows the acutual forest area in different years as well as changes over a period of 100 years. Nearly 545.64ha (74.61% of the area in 1897) of the forest was lost between the years 1897 to 1986 and the loss between the years 1986 and 1993 was 36.24ha. The total area lost bewteen 1897 to 1993 was 581.88ha (79.57%) and the rate of loss per year is approximately 6ha.

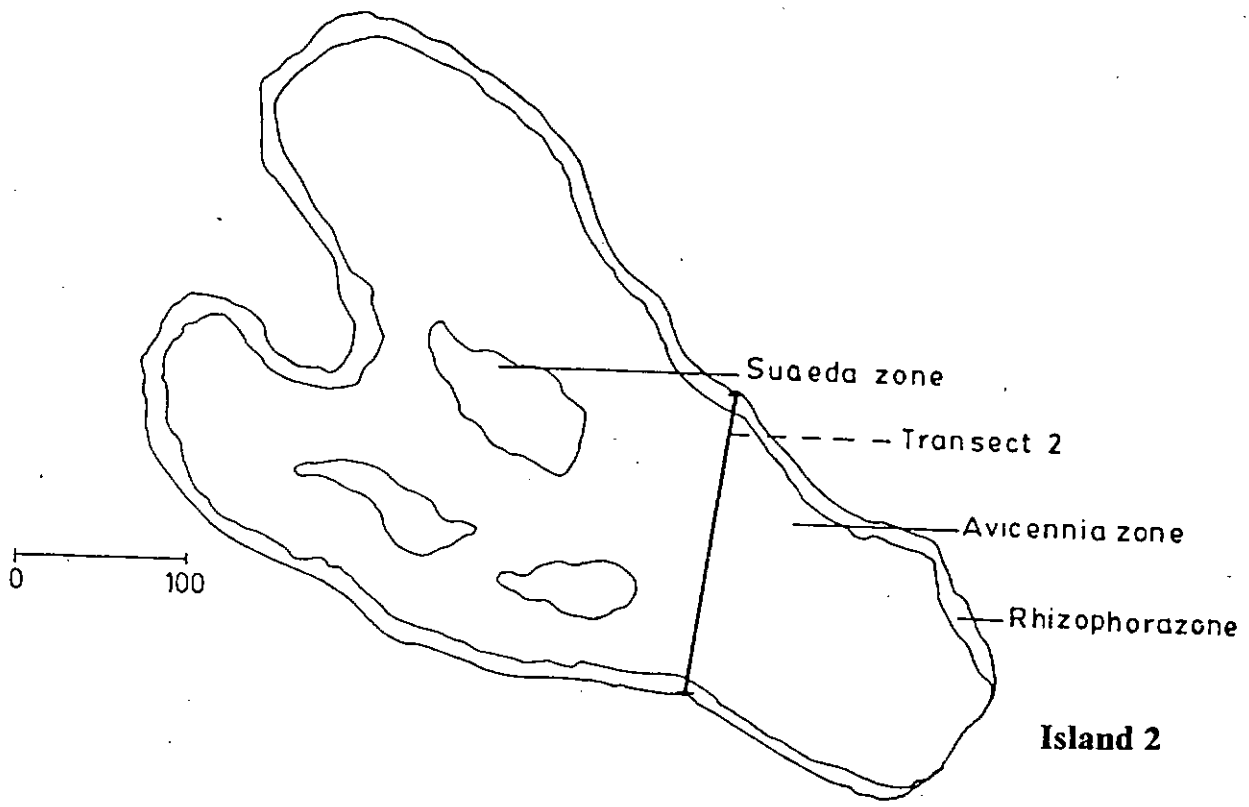
1.3.2. Spatial distribution and community structure of the mangrove plants in relation to topography and tidal inundation

1.3.2.1 Spatial distribution of the flora

Spatial distribution of different mangrove species in the study sites is shown in Fig 5 to 7. On the basis of the pattern of floral distribution three zones namely, **Rhizophora zone, Avicennia zone** and **Suaeda zone** were identified in the study sites. In all the sites Rhizophora zone occurred as a narrow strip along the tidal creeks and channels. In the inner estuarine region the breadth of this zone was only around 4m whereas it was around 10m in the seaward or outer margin. Species like *Rhizophora apiculata* Blume, and *R. mucronata* Lam, were the dominant species of this zone; *R. x. lamarckii* Montrouz was also recorded in some localities. In sites like Bunglowthittu island species like *Bruguiera cylindrica* (L.) Blume and *Ceriops decandra* (Griff) Ding Hou were present in the Rhizophora zone as understory species. The number of individuals of these two species when compared to *R. apiculata* and *R. mucronata* was very less. In all the sites Rhizophora zone was immediately followed by Avicennia zone and the breadth of this zone varied from 20 to 90m depending on the size and topography of the study site. *Avicennia marina* (Fork) Vierh was the dominant species in this zone. Wherever the conditions were favourable Avicennia zone was followed by the Suaeda zone with *Suaeda maritima* (L) Dum as the dominant species; *Suaeda monica* Forst was also occassionaly recorded in this zone. The above observations indicate that

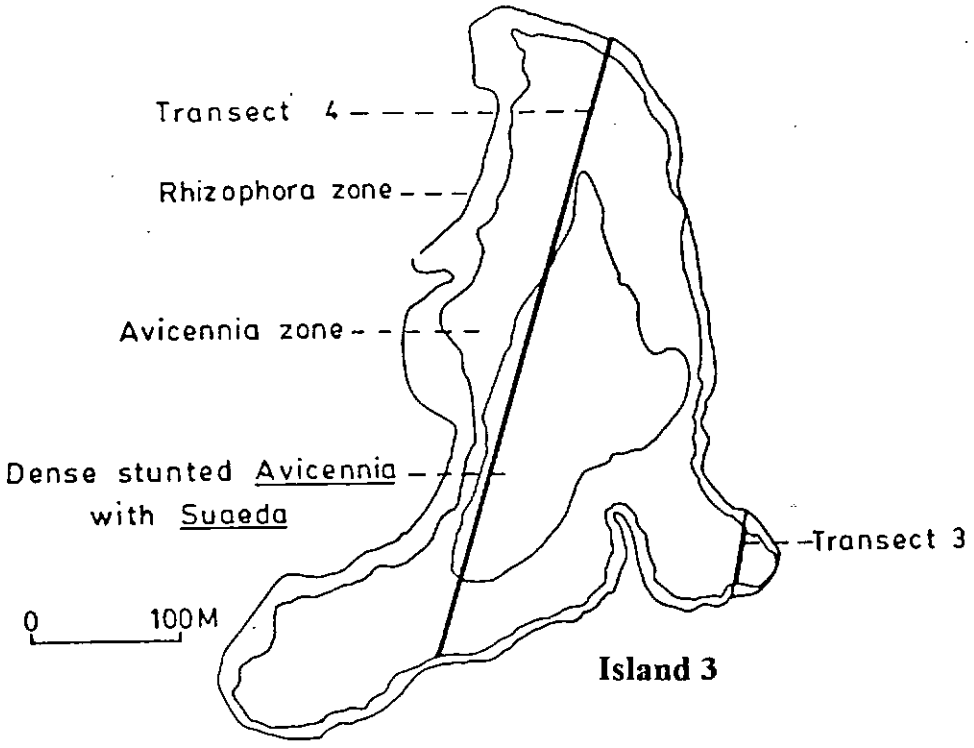


Island 1



Island 2

Fig. 5. Distribution pattern of flora in Islands 1 and 2



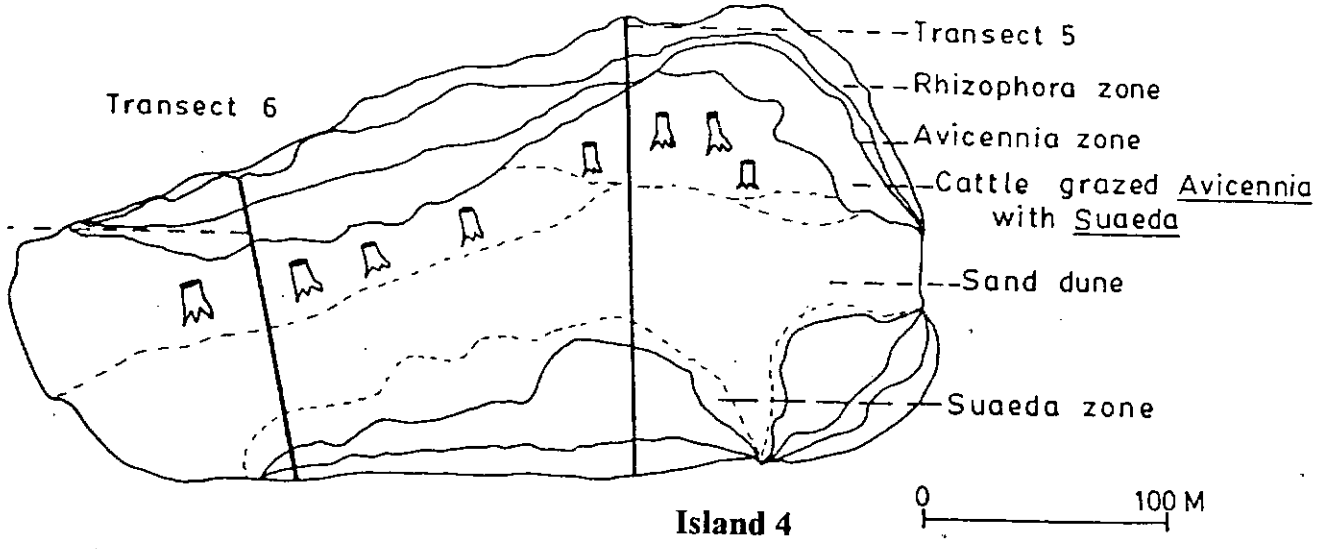


Fig. 6 Distribution pattern of flora in Islands 3 and 4

Fig.7 Distribution pattern of flora of Pichavaram mangroves

Rz - **Rhizophora zone - occupied by** ***Rhizophora apiculata R.mucronata, R.x.lamarckii, Bruguiera cylindrica*** **and** ***Ceriops decandra***

Az - **Avicennia zone - dominated by** ***Avicennia marina***

Sz - **Sueada zone - dominated by** ***Suaeda maritima***

Table 2 Density and diameter class of mangrove and associated plant species of Pichavaram

Location	Transect length (m)	No.of Quadrates (5X5 m^2)	Species & No. of individuals	Diameter class (cm)					
				〈3	3-10	10-30	30-40	40-50	>60
Area I *Island 1*	135m	14 Total area 350m^2	*R.mucronata* 7 (3.63)	-	6 (85.71)	1 (14.29)	-	-	-
			R.apiculata. 7 (3.63)	-	5 (71.43)	2 (28.57)	-	-	-
			A.marina 109 (56.47)	64 (58.72)	39 (35.78)	6 (5.50)	-	-	-
			S.maritima 70 (36.27)	70	-	-		-	-
			Total 193/350m^2						
Area I *Island 2*	95m	9 Toal area 225m^2	*R.mucronata* 3 (2.83)	2 (66.67)	-	1 (33.33)	-	-	-
			R.apiculata 13 (12.26)	1 (7.69)	3 (23.08)	5 (38.46)	4 (30.3)	-	-
			A.marina 90 (84.91)	32 (35.56)	45 (50.00)	13 (14.44)	-	-	-
			Total 106/225m^2						
Area I *Island 3*	245m	25 Total area 625m^2	*R.mucronata* 14 (0.74)	1 (7.14)	9 (64.29)	4 (28.57)	-	-	-
			R.apiculata 1 (0.05)	-	1 (100)	-	-	-	-
			A.officinalis 1 (0.05)	-	-	-	-	1 (100)	-
			A.marina **1839** (97.57)	1739 (94.56)	63 (3.43)	37 (2.01)	-	-	-
			S.maritima 30 (1.59)	30 (100)	-	-	-	-	-
			Total 1885/625m^2						

Area I *Island 4*	145	15 Total Area 375m^2	*R.mucronata* 6 (1.59)	1 (16.67)	5 (83.33)	-	-	-	-
			R.apiculata 4 (1.06)	-	3 (75)	1 (25)	-	-	-
			A.marina 149 (39.52)	129 (86.58)	14 (9.40)	6 (4.02)	-	-	-
			A.corniculatum 2 (0.53)	2 (100)	-	-	-	-	-
			C.decandra 11 (2.92)	11 (100)	-	-	-	-	-
			S.maritima 201 (53.85)	201 (100)	-	-	-	-	-
			S.monica 4 (1.06)	4 (100)	-	-	-	-	-
			Total 377/375m^2						
Area II Bungalow thittu *Island 1*	95	9 Total area 225m^2	*R.mucronata* 8 (5.10)	-	8 (100)	-	-	-	-
			R.apiculata 6 (3.82)	-	3 (50)	3 (50)	-	-	-
			B.cylindrica 12 (7.64)	12 (100)	-	-	-	-	-
			C.decandra 2 (1.27)	2 (100)	-	-	-	-	-
			A.marina 129 (82.17)	92 (71.32)	25 (13.38)	14 (10.85)	-	-	-
			Total 157/225m^2						
Area II Bungalow thittu *Middle*	155	15 375m^2	*R.x lamarckii* 1 (0.36)	-	-	-	-	1 (100)	-
			R.mucronata 3 (1.08)	-	-	3 (100)	-	-	-
			A.marina 275 (98.56)	228 (82.91)	33 (12)	14	-	-	-
			Total 279/375m^2						

Area II Bungalow thittu *West end*	245	25 $625m^2$	*R.mucronata* 5 (0.17)	-	-	5 (100)	-	-	-
			R.apiculata 1 (0.16)	-	-	1 (100)	-	-	-
			B.cylindrica 76 (11.82)	64 (84.21)	12 (15.70)	-	-	-	-
			C.decandra 56 (8.71)	56 (100)	-	-	-	-	-
			A.officinalis 1 (0.16)	-	-	-	-	-	1 (100)
			A.marina 135 (20.99)	92 (68.15)	33 (24.44)	10 (7.41)	-	-	-
			A.corniculatum 1.(o.16)	1 (100)	-	-	-	-	-
			S.maritima 368 (57.23)	368 (100)	-	-	-	-	-
			Total 643/$625m^2$						

i. distribution of *Rhizophora apiculata, R. mucronata, R. x.lamarckii, Bruguiera cylindrica* and *Ceriops decandra*, all are members of the Family Rhizophoraceae is similar, restricted to the fringe area of 4 to 10m wide along the water course ,

ii. distribution pattern of *Avicennia marina* and *A. officinalis* L both belonging to the Family Avicenniaceae is different; distribution of *A. officinalis* is restricted near the tidal creeks and channels whereas *A. marina* is widely distributed even 20 to 60m away from the water course and

iii. in most of the places individuals of *Rhizophora* spp occurr only in single rows which is usually followed by several rows of *A.marina*

1.3.2.2 Community structure

The absolute density of both the exclusive mangrove species and their associates along with diameter of the individuals are given in Table 2. In Island 1 nearly 56% of the individuals belonged to *Avicennia marina* whereas *Rhizophora apiculata* and *R. mucronata* contributed only 3.63% to the total population. In Island 2 and 3 population density of *A.marina* was 84.91 and 97.57% respectively. In these islands density of *R. apiculata* and *R. mucronata* was between 0.05 and 12.26% of the total population. In Island 4 and Bungalowthittu west end population desnity of *Suaeda maritima* was higher than the exclusive mangrove species. In general in most of the sites, the density of *A. marina* was much higher than other exclusive mangrove species like *R.apiculata, R.mucronata, R. x.lamarckii, B. cylindrica, C. decandra* and *Aegiceras corniculatum.* Regarding diameter at breast height (dbh), most of the individuals *R. apiculata* and *R. mucronata* belong to 3-10cm diameter class. In the case of *A. marina* in some sites nearly 80% of the individuals had diameter less than 3 cm. In some other sites like Island 1 and 2, Bunglowthittu island and Bunglowthittu west end considerable percentage of the individuals had a dimaeter between 3 and 10 cm the diameter of the individuals of *R. x lamarckii* and *A. officinalis* was the highest, ranged between 40 and 60cm. The diameter of almost all the individuals of *Ceriops decandra, Aegiceras corniculatum* and *Suaeda maritima* was less than 3cm.

Table 3.Basal area (m^2). relative density(%), relative frequency(%), relative dominance(%) and Importance Value of floral components of Pichavaram mangroves

Location	Species	Basal Area (m^2)	Relative. Density	Relative. Frequency	Relative Dominance	Importance Value
Area I *Island 1*	*R. mucronata*	0.02121	3.66	8.33	8.14	20.13
	R. apiculata	0.04495	3.66	8.33	13.14	25.40
	A. marina	0.02628	56.03	58.34	78.45	192.82
	S. maritima	-	36.65	25.00	-	-
Area I *Island 2*	*R. mucronata*	0.01536	12.26	16.67	31.00	59.93
	R. apiculata	0.09629	2.83	8.33	4.95	16.11
	A. marina	0.19895	84.91	75.00	64.05	223.96
Area I *Island 3*	*R. mucronata*	0.06498	0.74	7.89	8.60	17.23
	R. apiculata	0.00897	0.05	2.63	1.19	3.87
	A. officinalis	0.02953	0.05	2.63	3.91	6.59
	A. marina	0.06518	97.61	65.79	86.30	249.97
	S. maritima	-	1.55	21.06	-	-

Area I *Island 4*	*R. mucronata*	0.03765	1.59	9.09	20.32	31.00
	R. apiculata	0.00096	1.06	9.09	0.52	10.67
	A. marina	0.14670	39.52	36.36	79.12	155.00
	A. corniculatum	-	0.53	4.55	-	-
	C. decandra	-	2.92	4.55	-	-
	S. maritima	-	53.32	31.81	-	-
	S. monica	-	1.06	4.55	-	-
Area II Bungalow thittu *Island 1*	*R. mucronata*	0.02096	5.37	11.76	6.01	23.14
	R. apiculata	0.03433	4.03	11.76	9.84	25.63
	A. marina	0.29355	8.05	11.76	84.15	218.32
	B. cylindrica	-	1.34	11.76	-	-
	C. decandra	-	81.21	52.96	-	-
Area II Bungalow thittu *West end*	*R. mucronata*	0.02951	0.80	3.85	9.54	14.19
	R. apiculata	0.00385	0.16	3.85	1.24	5.25
	A. marina	0.16349	18.20	23.07	52.85	94.12
	A. officinalis	0.08919	0.16	3.85	28.83	32.83
	B. cylindrica	0.02331	12.24	11.54	7.54	31.32
	C. decandra	-	9.02	11.54	-	-
	A. corniculatum	-	0.16	3.85	-	-
	S. maritima	-	59.26	38.45	-	-

The community structure indices such as relative density, relative frequency, relative dominance and Importance Value of different species are given in Table 3. In all the sites, expect Bunglowthittu west end, *A. marina* showed the highest relative dominace and the co-dominat species were *R. apiculata* and *R. mucronata.* Regarding relative density, *Suaeda maritima* showed the highest value in Island 4 and Buglowthittu westend whereas in the remaining sites the relative density of *A. marina* was the highest. Regarding Importance Value *A. marina* showed the highest value in all the sites followed by *R. apiculata* and *R. mucronata*. In Island 3 and Bunglowthittu Island though the relative density of *A. officnalis* was very less its relative dominace and Importance Value were high due to their high basal area. The above results indicate that

i. though the density and dominance of *Avicennia marina* is much higher than any other exclusive mangrove species nowhere it showed monospecific dominace
ii. *Rhizophora apiculata.*and *R mucronata* are the co-dominant species but their relative density, frequency and dominance are very low
iii. in some sites obligatory halophytes like *Suaeda. maritima* is dominant indicating that these sites are less favourable for facultative halophytes like exclusive mangrove species
iv. most of the individuals of mangrove species have a diameter between 0-10 cm indicatiing that this mangrove forest is of bushy type

1.3.2.3. Topography and vegetation profile

The topographical features of the study sites along with horizontal and vertical profile of the vegetation are shown in Fig 8 to 13. In Island 1 (Transect 1) upto 5m from the western side the elevation of the ground from the low tidal level was around 18cm, from 5 to 13m it was around 35cm: from 13 to 42m the level of the ground found to be undulating with small mounds and depressions; from around 45 to 75m the shape of the floor was like a "cup" and the height of the edges was app.28cm. The elevation of the forest floor on eastern margin was a little lesser that the western margin. Both the west (inner) and east(outer) margins were occuppied by *Rhizophora* spp, undulating portion was occuppied by *Suaeda maritima* and the area bteween 40 to 75m was dominated by *Avicennia marina* (Fig.8). In all other sites also the topography along the margins was more less

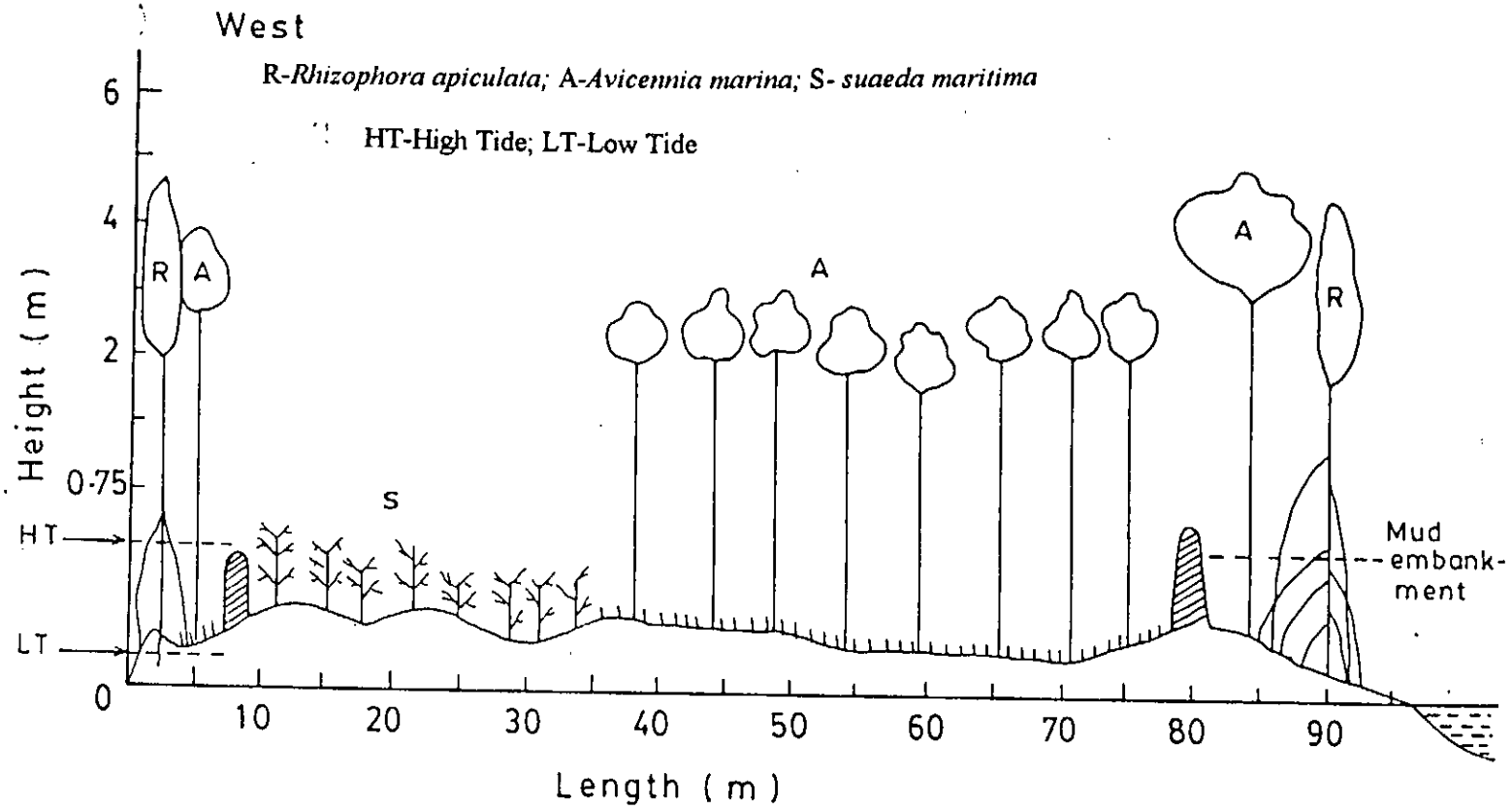


Fig .8 Topography and vegetation profile along Transect. 1 (island 1)

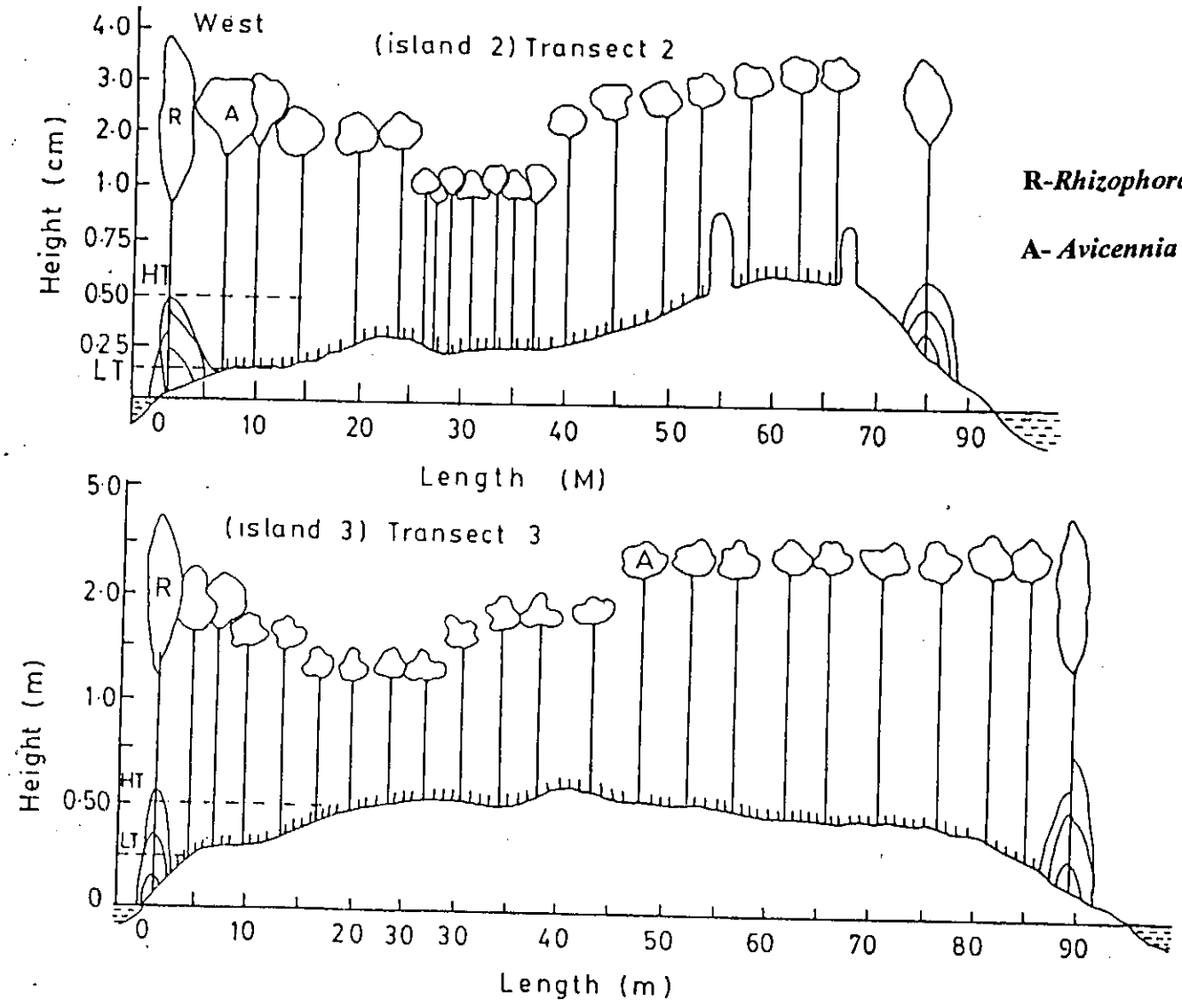


Fig. 9 Topography and vegetation profile along Transect 2 (Island 2) and Transect 3 (Island 3)

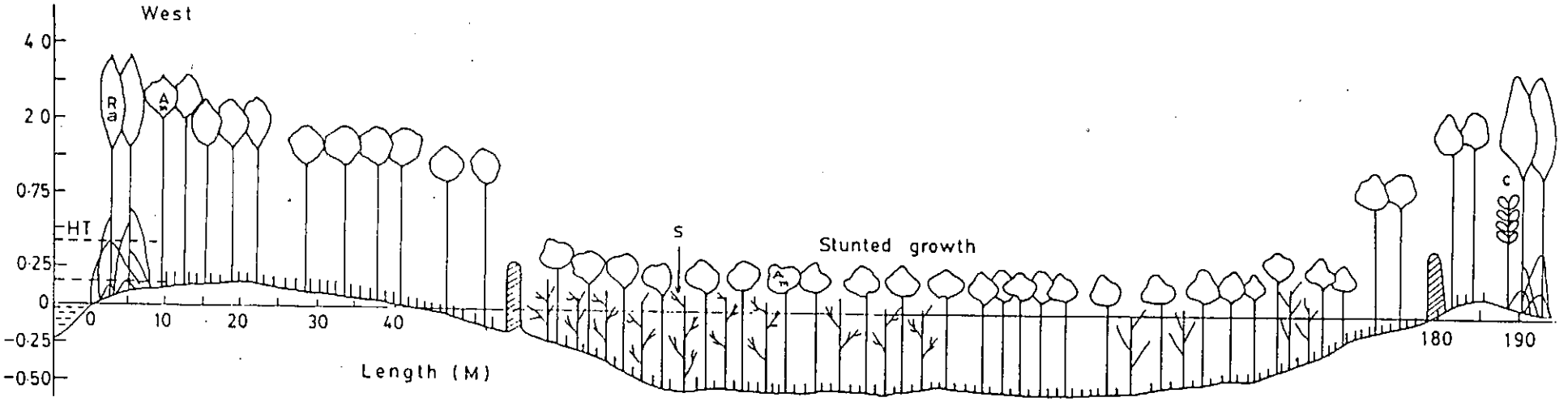
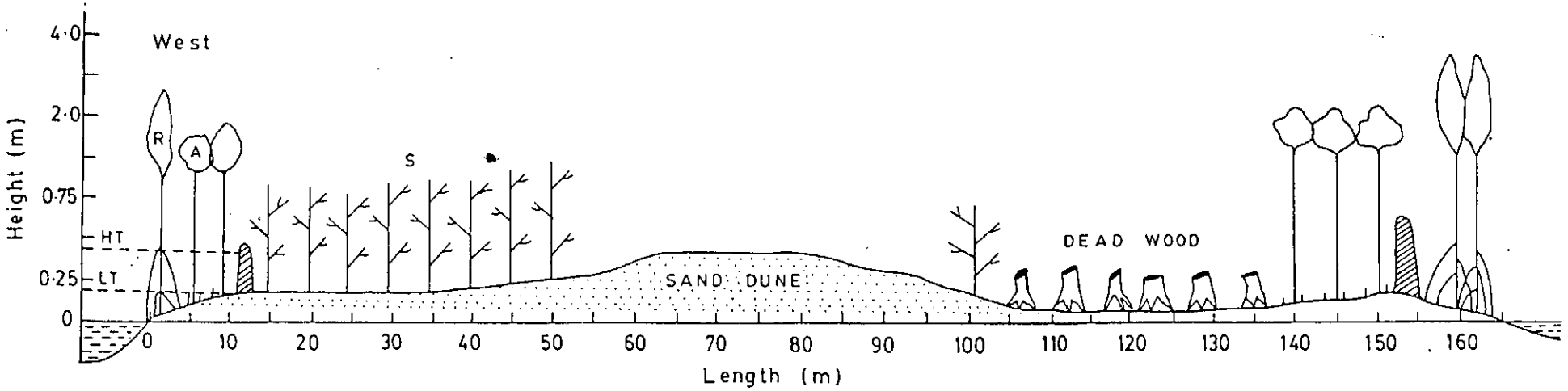
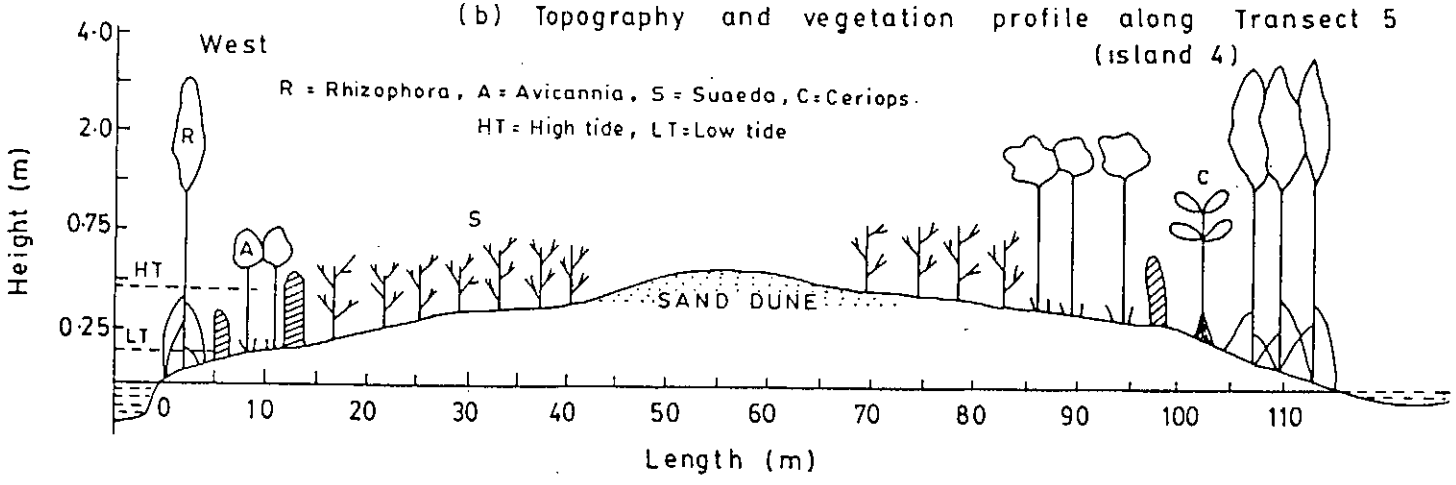


Fig.10 Topography and vegetation profile along Transect 4 (island 3)

R-*Rhizophora mucronata;* A-*Avicennia marina;* S-*Suaeda maritima;* C-*Ceriops decandra*



(b) Topography and vegetation profile along Transect 5 (island 4)



R-*Rhizophora apiculata*
A-*Avicennia marina*
S-*Suaeda maritima*
C-*Ceriops decandra*

Fig. 11 Topography and vegetation profile along Transect 6 (island 4)

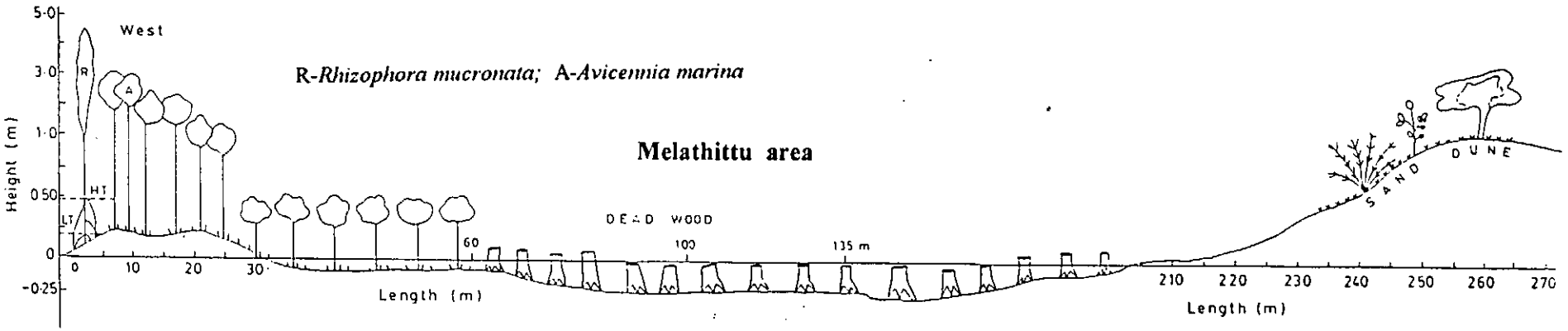


Fig.12. Topography and vegetation profile along Transect 7

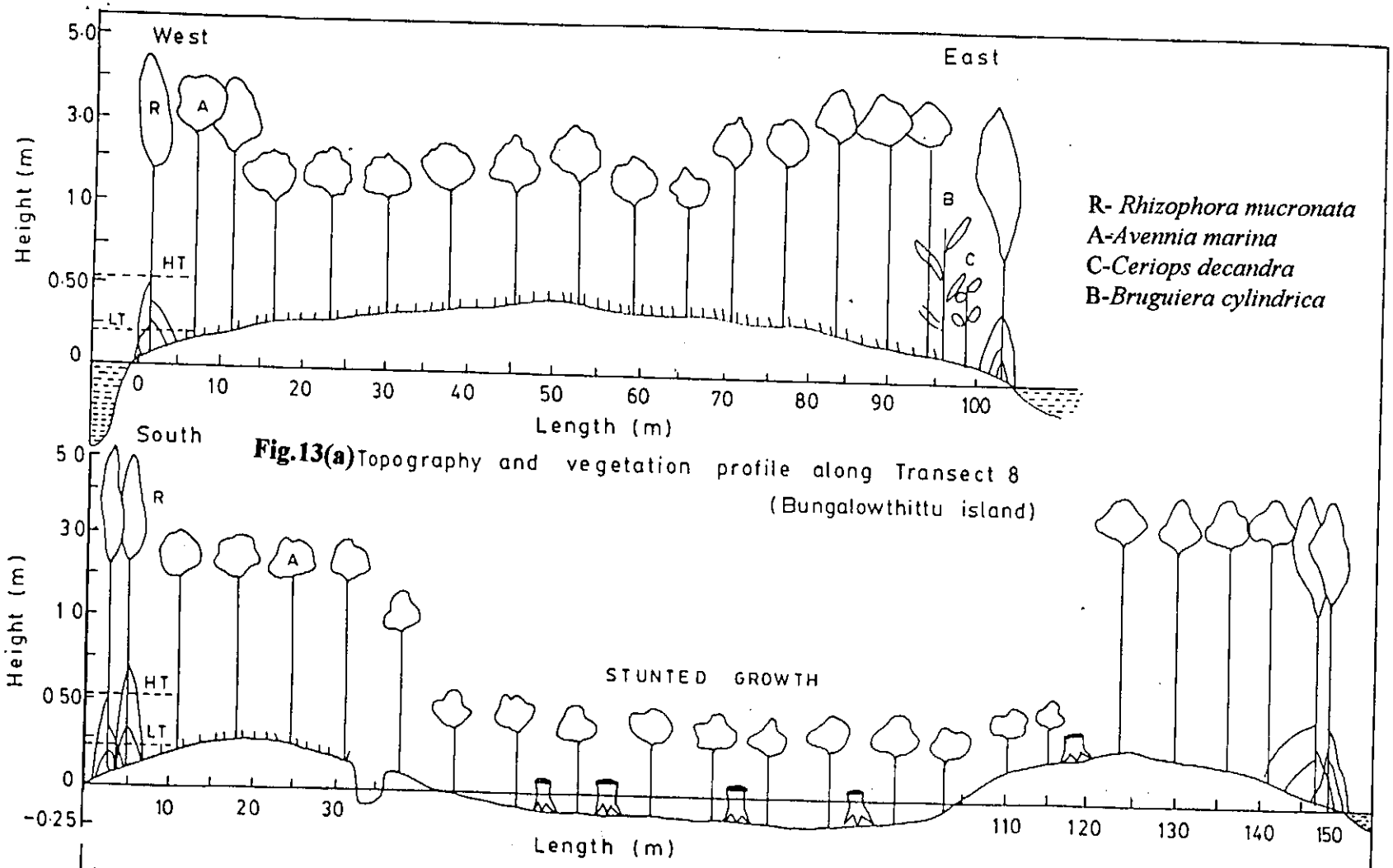


Fig.13(a) Topography and vegetation profile along Transect 8 (Bungalowthittu island)

Fig. 13(b) Topography and vegetation profile along Transect 9 (Bungalowthittu middle)

similar to that of Island 1, the elevation upto 5 to 10m from the low tide level was around 12 to 20cm. However, the ground level beyond the margins varied from site to site. In Island 2 (Transect 2) a small mound with an approximate height of 65 cm was present around 50 to 70m from the western side. In Island 3 (Transect), the level of the ground showed gradual elevation from both west and east margins and reached the peak at about 50m from the eastern side (Fig 9). In the same Island an interesting topographical feature was observed along Transect 4 where the relief of the ground between 40 to 180m from the western side was below the low tide level (0 altitute) and the depth of this "trough" was around 38cm (Fig.10). This area was occuppied by poorly grown but dense *A. marina* trees of less than 1.5m height; in this site *S. maritima* was also present in small numbers. In contrast to this feature, in Island 4 (Transect 5) the elevation was gradual from 0 to upto 50m from the shoreline and between 50 to 100m a small "sand dune" (strananded ridges ?) with sparse vegetation was present; from around 100 to 140m the floor was "trough shaped" but the relief was not below the low tide level (Fig.11). In this portion large number of dead trees whose stems were removed were seen. In the Melathittu area also (Transect 7) the ground level was "trough like" between around 30 and 210m and the depth of this trough varied from 8 to 23cm. All the trees present in this area were dead and cut stumps of these trees were abundant (Fig) In the case of Bunglowthittu Island 1 (Transect 8) the level of the forest floor was smooth, raising gently from the margins, and,the area between around 20 to 85m was more or less flat (Fig 13). In Bunglowthittu middle portion (Transect 9) the level of the ground around 30 to 110m was -15cm below the level of the low tide and this area was mostly occuppied by poorly grown *A. marina* trees

It can be inferred from the above results that

i. topographical gradients along the margins of the tidal water course is more or less similar in all the areas studied but beyond this smooth fringe area topographical features show wide range of variation and

ii. distribution pattern of floral components and structural properties of the palnt community seem to be largely determined by the variations in topography.

1.3.2.4. Frequency and extent of tidal inundation

The tidal amplitude recorded in the study area from 14-6-94 to 23-4-94 covering the periods between neap and spring tides is shown in Fig 14. The tidal amplitude during the neap tide was only 20cm whereas during the spring it was around 50cm indicating that the tide of the Pichavaram mangrove ecosystem is of microtidal type. Observation on frequency and extent of tidal inundation of the forest floor showed that Rhizophora zone was submerged in tidal water during most of the high tides, whereas Avicennia zone was frequented by tidal water only during the spring tide i.e. once in 15 days and some portions of the Avicennia zone was flushed by tidal water during spring high tide and high tides of 1 or 2 days before and after the spring tides. Wherever the forest floor was "trough or basin shaped" the tidal water entering into this area during the spring tide become stagnant. In some localities like the southern portion of Island 3 and Bunglowthittu Island the entire portion of the forest floor was flushed during the spring tide due to smooth topography. The results clearly indicate that

i. the tide of the Pichavaram mangrove water is of microtide type with very low tidal amplitude, consequently only the Rhizophora zone situated along the margins of the water course are inundated by daily high tides
ii. Avicennia zone is flushed only during the spring tide and
iii. tidal water becomes stagnant wherever the topography is "trough shaped" and the trees present in this area are either dead or poorly grown

1.3.4 Impacts of natural and human-induced stresses on Pichavarm mangroves

1.3.4.1 Impact of variations in topography and tidal inundation

As described in the earlier section different portions of the mangrove forest floor are inundated during different tidal regimes like daily high tides, spring tides or during high tides of 1 or 2 days before and after the spring tide. This variation in frequency and extent of tidal variation in relation to topography cause variation in factors such as pH, Eh,. oxyen potential, abundance and range of anions and cations and sediment flux which in turn direcly control the distribution, biomass and regeneration of individual species or a species group. In Pichavaram mangroves, the topography of the fringe area favour daily tidal inundation and

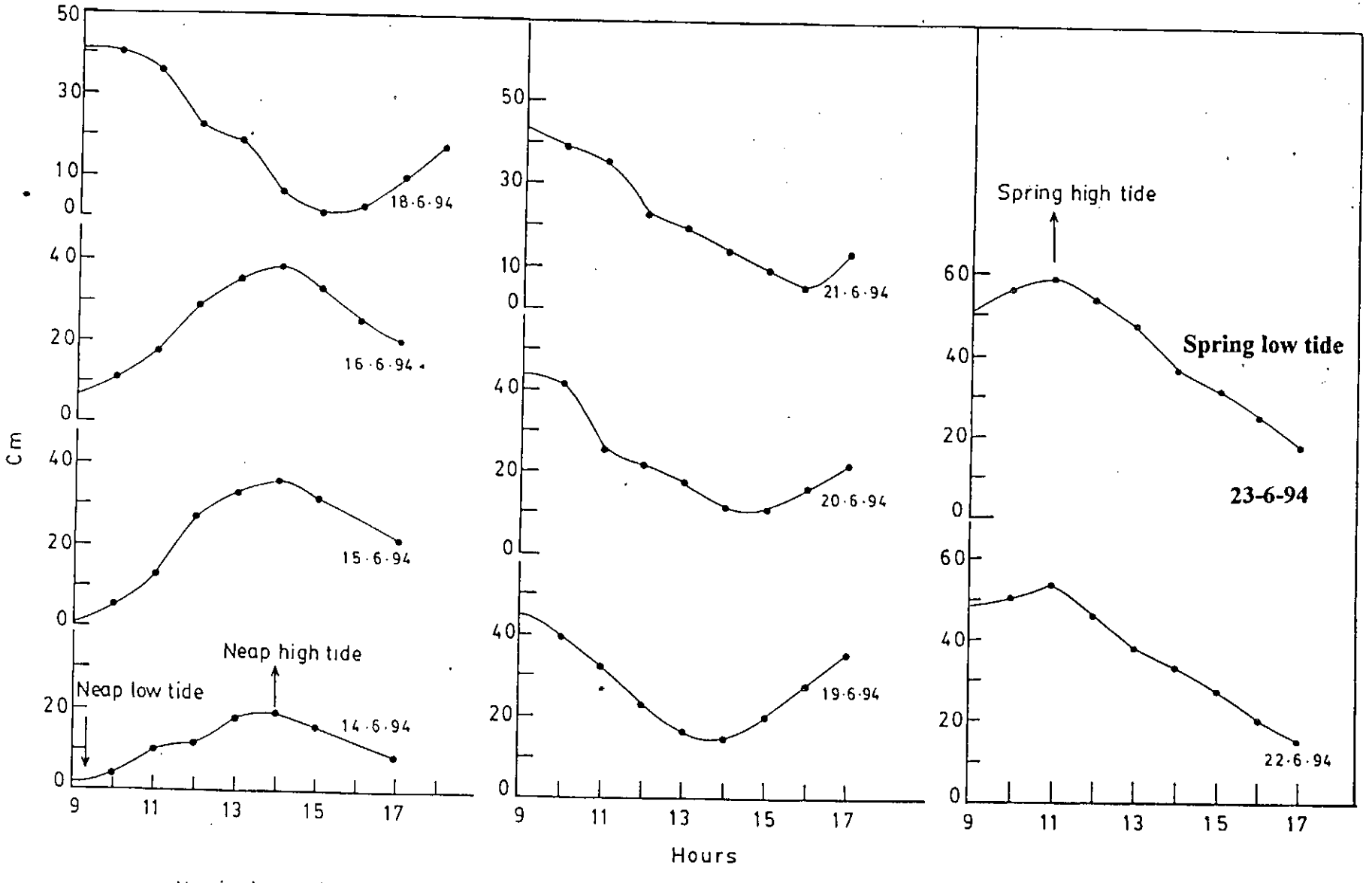


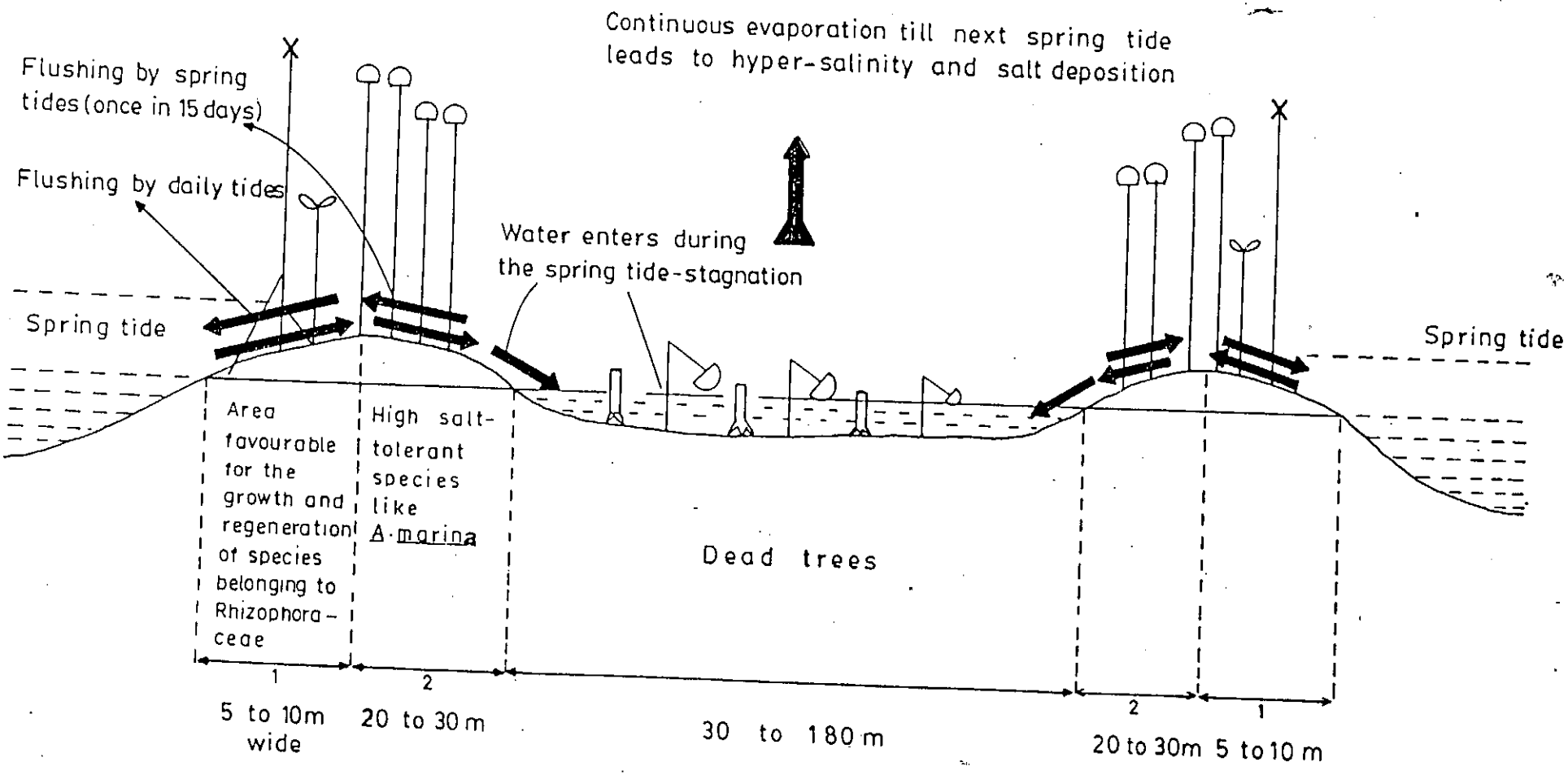
Fig. 14 Variations in tidal level between 14-6-94 to 22-6-94 observed from 09·00 hrs to 17·00 hrs.

thereby create condition favourable for the species like *Rhizophora apiculata, R. mucronata, R.x. lamarckii, Bruguiera cylindrica, Ceriops decandra and Agiceras corniculatum* . Since only the margins of the tidal water course are inundated by daily tides the distribution of the above species are restricted only to this area and hence the population density of the above mentioned species are very low. On the other hand the area behind the margins of the forest is flushed only during the spring tide and thereby create a condition favourable for species like *Avicennia marina.* Since the tidal amplitude during the spring tide is large the area flushed by this tide is wide and so the breadth of the Avicennia zone and this might be one of the reasons for the high population density of *A.marina* in the Pichavaram mangroves.

In contrast to the above situation, wherever the topographical features favour stagnation of tidal water the pore water and soil conditions gradually become unsuitable to support any mangrove species. For example, in the Melathittu area large number of dead trees (stems removed) are present in the "trough shaped" middle portion. In this area extend and frequency of tidal inundation was observed between 9-5-94 to 17-594. As shown in Fig 15 tidal water begun to tickle into this area during the initial hours of the hightide on 9-5-94, a day before the spring tide; after 3 hours most of the area was inundated by tidal water. After 4 days the site was revisited and found the entire area was under water with an average depth of 28cm. The salinity of the stagnant water measured at 12 points using a hand held refractometer showed values ranging from 88 ppt to 112 ppt (grams per litre). When the site was visited again after 10 days it was found that the water was completely evoparated and salt was deposited on the entire area. Such a hypersaline condition might give severe physiological stress which may lead to death of trees in this area. The above condition was also oberved in the central portion of most of the localities of the study area. The general features of the relationship between topography, tidal inundation and species distribution is diagramatically represented in Fig.16.The above degraded areas can be restored if proper facility for regular tidal flushing is provided.

Fig.15 Inundation and stagnation of tidal water into the 'trough shaped' centred portion of the Melathittu area

Fig.16 **Digramatic representation of the general topographic features, frequency and extent of tidal flushing and species distribution in Pichavaram mangroves**



1.3.4.2.Impact of changes in coastline configuration and sedimentaion

The changes in coastline configuration between 1930 and 1992 are shown in Fig 17 to 18. It is clear from the figures that the shoreline boardering the Pichavaram mangrove undergo severe erosion. Between the years 1930 and 1970 approximately 550m breadth of the beach was eroded and the rate of erosion was around 14m per year. Between the years 1970 and 1992 the rate of erosion was around 12m per year. All these indicates that the rate of erosion of coastline in the Pichavaram area is severe. The impact of such changes on mangrove ecosystem is being studied; preliminary results indicate that considerable portion of a lagoon which is connected to the Coleron estuary in the south and mangroves in the north west is lost and this might have severe impact on the hydrodynamics of the Pichavarm mangroves

From Fig 17 to 18 it is clear that within the Pichavaram mangroves erosion and sedimentation occur simultaneously. The rate of sedimentation seems to be high due to supply of sediments by external source like fresh water discharge and internal source like erosion of the banks of some tidal creeks and canals. High rate of sedimentation is indicated by the enlargement in size of some of the islands as well as joining of 2 or more islands due to silting up of the spaces in between the islands. In one case, an island located near to the mainland in 1970 is now joined to the mainland due to filling up of the space between this island and the mainland by sediment. It is clear from the Fig 19 to 20 that some of the canals are also completely silted up and in some cases a portion of the canal is filled with sediment. The impact of such changes on the mangrove plant community and hydrodynamics is not clear and a thorough study on this line is necessary to develope a reliable conservation plan for this mangrove ecosystem.

1.3.4.3.Impact of non-conventional method of fishing

The fishing method followed by a group of fishermen called "Vedars" (Hunters) affect the normal flow of tidal water into the mangrove forest. Since fishing is not the traditional occupation of these fishermen they do not know how to use net or other fishing gear; their fishing is restricted to shallow water and hand-picking is the common method followed. Some of them follow an innovative

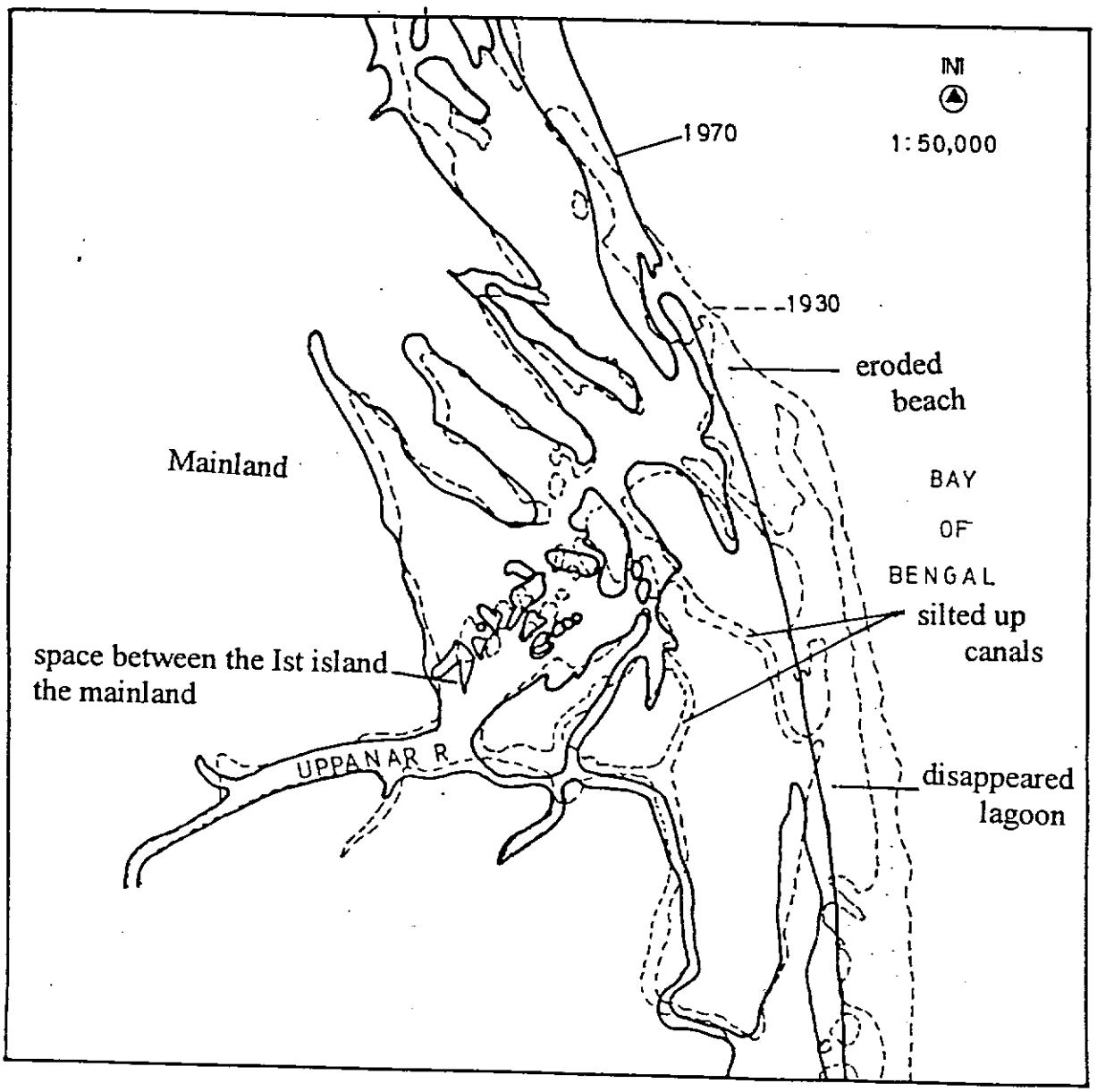


Fig.17 Changes in coastline configuration between 1930 and 1970
Note the space between the Ist island and the mainland

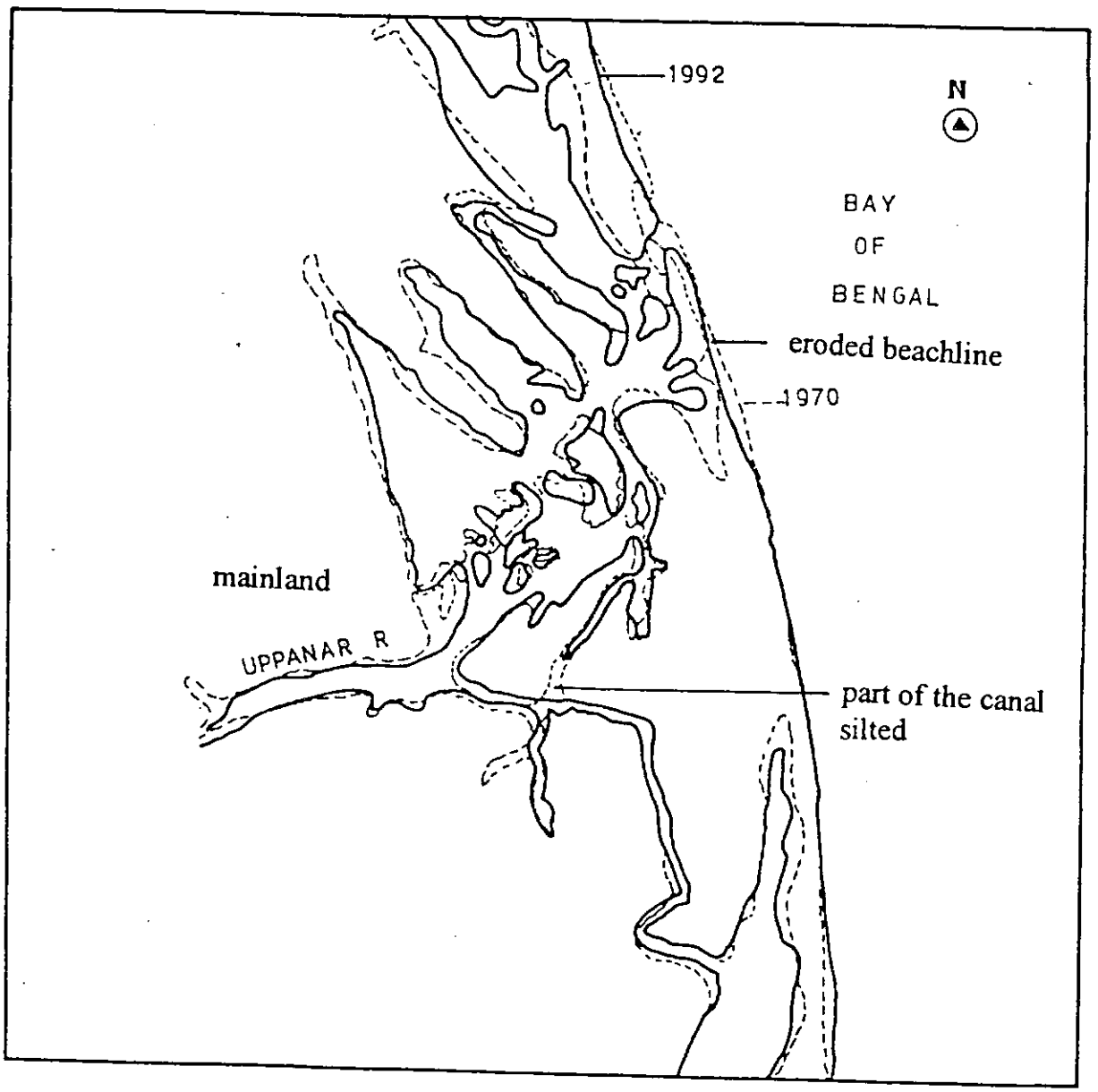


Fig. 18 Changes in coastline configuration between 1970 and 1992
Note the Ist island joined to the mainland due to sedimentation

method in which mud embankments of 30 to 35cm height is constructed 6 to 8m inside from the edge of the forest (Fig. 19) and are opened at 3 to 4 places with narrow opening to allow the tidal water enter into the forest during the spring tide. When the water begin to recede during the low tide the openings are closed with net which allow only water to pass through. All the prawns and fish entered along with tidal water is retained within the forest and are later collected.

The mud embankments are usually constructed at an elevation of 25 to 30 cm from the low tide level and hence the total of the mud embankment exceeds the level of spring high tide which is only around 50cm. and hence the normal flow of the tidal water is very much affected which in turn affect the soil condition. Secondly, the mud for the construction of these embankments is dug out in the site itself and these pits act as trap for mangrove litter. This may affect the nutrient cycling in the mangrove and adjacent coastal water.

1.3.4.4.Impact of cattle grazing and illegal felling

Nearly 200 cattle from the villages situated in the north and northwest of Pichavaram mangroves graze in the forest. Enquiries with the villagers revealed that cattle grazing is heavy only during the monsoon season (October to December) when there is cultivation in the agricultural lands; Secondly, only the peripheral areas of the forest are used as grazing ground since deep mud and wall like root system of *Rhizophora* spp prevent the entry of cattle into inner mangroves. Field studies showed that cattle relished mostly on the leaves of *Avicennia marina* and its seedlings. *Rhizophora* spp were not grazed probably due to high amount of tannin in their leaves. During the field study it was also noticed that the height of the *A. marina* trees grazed by the cattle was very short and natural regeneration was totally absent.(Fig.20a and b). The above stress can be overcome by providing an alternative source of fodder, at least during the monsoon season.

Regarding illegal felling species are seem to be selectively felled. Previously *Xylocarpus granatum* and *Sonneratia apetala* were selectively felled for their timber and now only a very few individuals of them are present. In recent times, *A. officinalis* is selected for felling because a single tree alone yield 2 to 3 headload of firewood which is clandenstiouslly sold to teashops and small hotels.

clandestinely

Fig 19. Mud bank constructed within the forest for non-traditional method of fishing

Fig.20. Cattle grazing

Though it seems selective felling alone is responsible for the above 3 species becoming locally endangered other factors like reduction in freshwater flow might have also contributed in reducing the population density of the above species since they require freshthewater or very low salinity condition for longer period of time.

1.3.4.5 Impact of other stresses

Apart form the above stresses, the mangroves of Pichavaram is also affected by other stresses like using of 'bombs' during film shooting (Fig. 21) etc. In recent times large scale prawn farms are being constructed near the mangroves (Fig. 22). Key ecological processes like nutrient cycling, cation excahnge capacity pH, redox potential etc of mangrove ecosystem will be affected if the spent water from these intensive culture ponds is drained in the mangrove water.

1.4. Conclusion

1. In Pichavaram mangroves dynamics of plant communities such as changes in species composition, reduction or increase in population density and biomass of a species, dominance of single or group of species etc., are related to habitat changes induced primarily by geomorphic processes. This is clearly indicated in the relationship between distribution pattern, horizontal and verticle profile and structural properties of the plant communities and topographic gradients and tidal hydroperiods and exposure. The concept of plant succession which involves replacement of one community by another overtime due to changes in the habitat condition induced by previous community seems to be not applicable in explaining vegetational changes in Pichavaram mangroves. Hence, the conservation plan for this mangroves ecosystem should be based on geomorphic evolution rather than on plant succession.

2. Areas of mangroves which are degraded due to stagnation of tidal water can be easily restored if facilities for proper tidal flushing are provided; this can be achieved by cutting channels across the elevated border of the mangroves. The number of channels and their dimensions required for regular tidal flushing should be determined on the basis of microlevel variations in ground relief, tidal amplitude and depth of the canal which supply tidal water.

Fig.21 Rhizophora sp destroyed by firing' during a film shooting

Fig. 22 Construction of large scale prawn farms near Pichavaram mangroves

3. Pure stands of species like *Rhizophora apiculata, R. mucronata, R. x.lamarckii, Bruguiera cylindrica* and *Ceriops decandra* can be created for future by planting them in places which are inundated by daily tides. Such environmental condition exists in all the newly formed, non-vegetated mud flats. Based on the depth of the mud in the top layer either propagules or seedlings of the above species can be used for planting.

4. Internal supply of sediments due to erosion of tidal creeks and channels should be stopped to avoid accretion of the margins of the forest by planting *Rhizophora* spp which induce active sedimention on the bank. These species may also limit water agitation at high tide because their damping effect inhibits reflection of waves. Thus, they could favour sedimentation on eroding bank or at least limit subsequent erosion.

5. Mud banks constructed within the mangrove forest for non-conventional method of fishing should be immdeiately removed to pave way normal tidal flushing; the fishermen dependent on such method of fishing can be given training in using cast net which is simple to operate but effective in prawn fishing in shallow water.

6. Cattle grazing, a common chronic stressor in the Pichavaram forest should be removed to allow *Avicennia marina* to grow and regenerate normally in these areas; this can be achieved by providing alterntive source of fodder.l

7. Selective felling of *Avicennia offcinalis* whose population is at the verge of local extinction (shown by the absence of seedlings and non-graded individuals) should be stopped by providing employment oppurtunities to the people (whose number is only a few) engaed in illegal felling.

8. A through study on hydrodynamics such as changes in quantity and period of freshwater flow, tidal circulation, tidal flushing time scale, tidal mixing and trapping and rate and pattern of sedimantation is urgently needed to predict the future of this mangrove ecosystem. It is also suggessted that the mouth which connect the mangrove and coastal waters may be widened and deepened to facilitate more quantity of tidal water to come in and go out which will not only

enhance flushing rate and thereby avoid sedimentation but also increase fisheries yield by the improving quality and quantity of the resident mangrove water.

2. Restoration

2.1 Reintroduction of *Rhizophora mucronata* into Muthupet mangrove ecosystem

2.1.1 Introduction

As described in the Ist report, Muthupet mangrove ecosystem is characterised by the presence of only 4 exclusive species of mangroves namely *Avicennia marina, Exoecaria agallocha, Aegiceros corniculatum* and *Acanthus ilicifolius*. However, species belonging to *Rhizophora, Bruguiera* and *Ceriops* were present in this mangroves till recently (French Institute, Pondichery). Combined effect of unscientific management policies followed by various authorities and development of hypersaline conditon (around 40 t0 45ppt) particularly during the summer months are considered as responsible for the disappearence of the above species in this mangrove ecosystem. Hence, it was decided to a conduct trial plantation of *Rhizophora mucronata* (which tolerate salinity above 35 ppt) in the Muthupet mangroves to find out the weather the present habaitat condition can support species belonging to *Rhizophora*

2.1.2 Materials methods

Literature as well as our own observations indicate that areas inundated by daily tides are the best suitable place for the plantation of *Rhizophora* species. So the Muthupet mangroves was thoroughly surveyed in June 1993 to identify such areas and an area of approximately 6ha distributed in small pockets along the northern boarder of Muthupet mangrove was found to have the above mentioned environmental condition. In August 1993, a total number of 500 propagules of *Rhizophora mucronata* collected from Goa were planted in one site which is localled called "Kachankarai. Propagules were planted in 15 rows, paralles to the shore extending from the low tide to high tide level. Longer propagules are planted in the water-front and shorter one were in the landward-side to avoid the

propagules completely immersed in tidal water. Nearly 1/4 of a propagule was direcly embeded in the mud at an interval of 1m.

2.1.3 Results

The percentage survival, average net growth, number of internodes. and their length and other morphometric data collected from the reintroduced indiividuals after a period of 10 months are given in Table 4.

Table 4. Morphometric data of Rizophora mucronata reintroduced into Muthupet mangrove ecosystem

Growth parameter	Average	Range
Net growth (cm)	37.13	22.2 to 56
No. of internodes	6	5 to 7
No.of leaves	7	6 to 10
Leaf area (cm^2)	48.2	10.8 to 80.6

After 10 months nearly 61% of the individulas palnted survived and their average growth was 37.13cm. The average internode was 6 and in all the individulas the height of the first internode was very shorter than the others The average number of leaves per seedlings was 7 and the leaf area showed a mean value of 42.3 cm^2 Fig 23 and 24 show the *R.mucronata* growing in the Muthupet mangroves.

2.1.4 Conclusions

1. Nearly 60% of the survival of the reintroduced *Rhizophora mucronata* seedlings indicate the habitat conditon in the Muthupet mangrove ecosystem is suitable to support the above species and hence large scale plantation can be taken up.

2. the growth rate compared to the R.mucronata grown in the nursery condition under freshwater irrigation was low; this may be due to existence of high salinity condition in the Muthupet mangroves.

Fig. 23 *Rhizophora mucronata* reintroduced into Muthupet mangrove ecosystem

Fig.24 A reintroduced indivvidual of *R. mucronata* grown to a maximum height of 56 cm in 10 months

seaseon). Now the seedlings collected from the west coast are growing in the Muthpet mangroves which is located on the east coast and it will be of great interest in the future to study the period of propagule production in the R. *murcronata* growing in the Muthupet mangroves

B.Development

Contents

B. DEVELOPMENT

1.0 Introduction

Pichavaram Mangroves as described in the earlier section has conceded to natural as well as anthropogenic stresses which is directly associated with the growing population and their ever increasing demands. Hence it has been selected for intensive **development-oriented programmes**, apart from the steps taken to conserve and restore it.

2.0 Objectives

As part of the project, major objective is to establish a model for demonstrating sustainable management of mangrove resources and replicate the same in other areas, by the following development-oriented interventions .

1) Analysis of economically viable on-farm and off-farm employment
2) Promotion of coastal agro-forestry involving raising of
   - Casuarina, Cashew, etc
   - Poultry and small ruminants
3) Establishment of fodder and feed banks based on the locally available biomass and crops, and introduction of suitable indigenous species for supporting the poultry and small ruminants

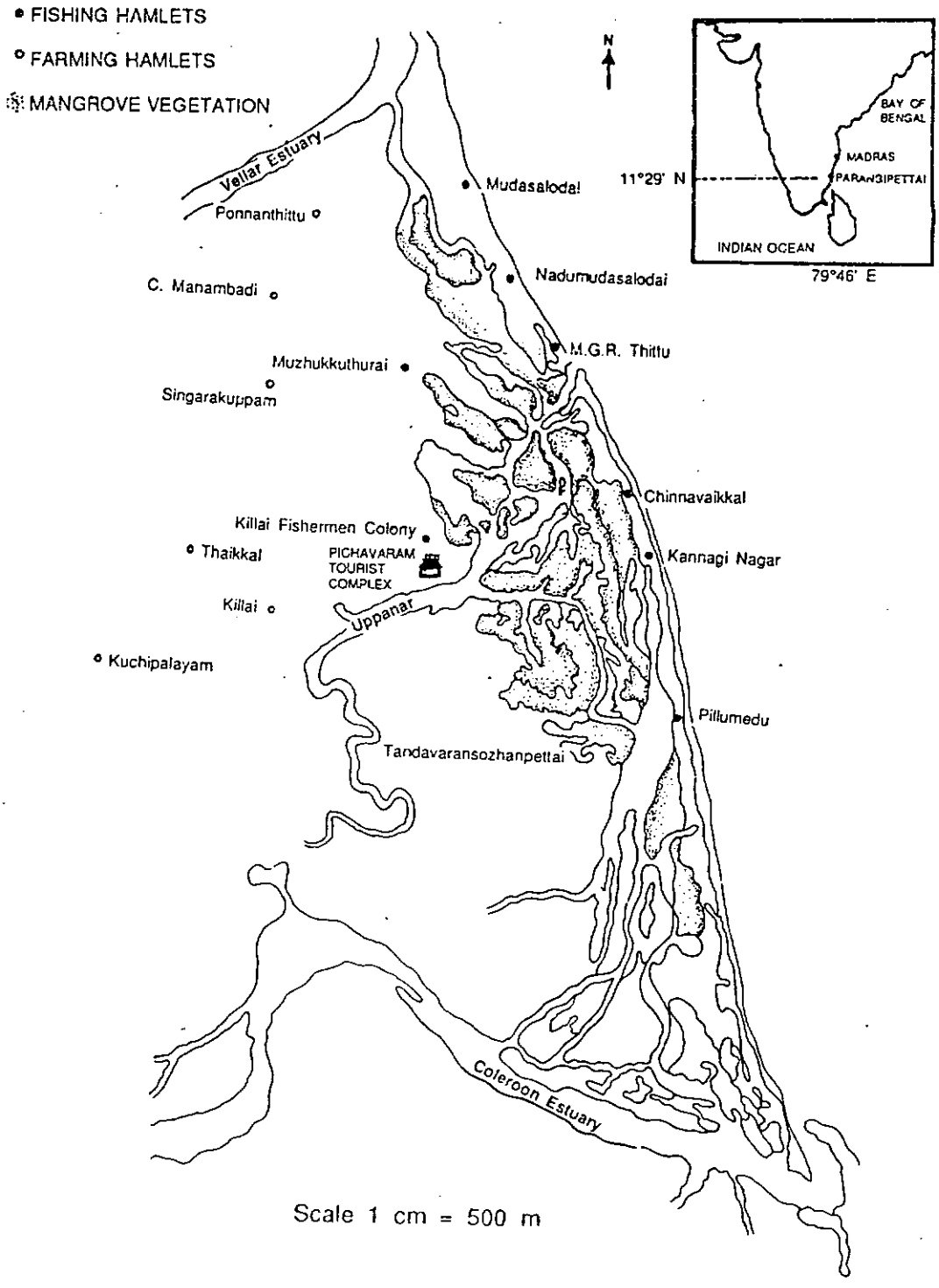
However, in order to utilise the available resources sustainably and implement development programmes effectively it is necessary to first study the **socio-economic** conditions of the user communities before prescribing any management practices.

3.0 Socio-economic survey

3.1 Study area

The area chosen for conducting the socio-economic study were the 15 hamlets (Figure 1) surrounding the Pichavaram Mangrove Forest. Survey was conducted in all the fishing hamlets, while in the case of farming hamlets only

Figure.1. Map showing the 15 hamlets around Pichavaram Mangroves



those falling within the radius of 9 km and which were thought to have an impact on the mangroves were selected. The area occupied by all the hamlets is about 15.36 sq km. The hamlets fall under the three major sub-divisions namely, North Pichavaram, South Pichavaram and Elanthaimodu. The 1991 census shows a population of 9436. There are about 7 Panchayat Union Schools, 1 Government High school and a Harijan Welfare School and about 9 rural feeding centres. Water is supplied by means of 53 hand pumps with only one pump house at Killai Thirunalthoppu situated 2 km away from Pichavaram. Water comes from a village (Anthambakkam) from a bore well which is more than 600' deep. Apart from these there are 20 open wells and 8 ring wells. There are 3 daily markets apart from small tea stalls and provision shops.

3.2 Methodology for data collection

Fifteen hamlets/ villages in and around Pichavaram mangrove forest were surveyed during the period July '91 to February '93. Initially, preliminary surveys were carried out in seven hamlets with the major aim of developing a suitable questionnaire. Later, regular surveys were carried out on a house-to-house basis. A total of 733 households distributed over 15 hamlets were surveyed. The questionnaire provided information on family structure, educational status, particulars of the dwelling units, energy consumption, time activity budget, food consumption, domestic budget, occupational details, asset ownership and value and finally the impact of the local communities on the mangrove forest. The survey covered 100% of the households in the case of smaller hamlets and 20-45% in larger hamlets on a random basis where the number of households exceeded 75 (Table 1.)

3.3 Socio-economic characteristics of the hamlets surrounding Pichavaram Mangroves

Owing to high congregation of population along the coasts, the utilisation of coastal resources is also very high. The study conducted in Pichavaram helped in determining the trends of the socio-economic status of the inhabitants, and understanding the occupational pressures on the estuarine habitats, and their impact on the mangroves. The results of the study are as follows :

Table.1. Number of households surveyed in each hamlet/ village

S. no.	Name of the hamlet/ village	Total no. of households	No. of households surveyed
	FISHING HAMLETS		
1	Killai Fishermen colony (KFC)	260	70
2	Mudasalodai (MUD)	134	60
3	Muzhukkuthurai (MUZ)	110	50
4	Pillumedu (PDU)	22	22
5	Nadumudasalodai (NDM)	44	44
6	M.G.R thittu (MGRT)	160	50
7	Chinnavaikkal (CV)	72	72
8	Kannaginagar (KN)	23	23
	FARMING HAMLETS		
9	Singarakuppam (SKPM)	200	50
10	Killai Thirunalthoppu (KT)*	250	50
11	Thaikkal (TKL)	210	41
12	T.S. Pettai (TSP)	240	50
13	Kucchipalayam (KPM)	120	50
14	Ponnanthittu (PT)	200	50
15	C. Manambadi (CM)*	200	51
	Total	3694	733

( ) indicates the codes for villages * Revenue villages

3.3.1 *Socio-demographic Profile*

The population density per sq.km is found to be 547.4. In most hamlets the male population is slightly higher than the female population. A major percentage of the households (76 - 100%) have own houses, while a small percentage (1.4 - 20%) live in rented or leased houses. Courtyard facility, space for kitchen gardens and poultry, and sanitation facility is nil in most hamlets excepting KFC and KT (See Graph 1.)

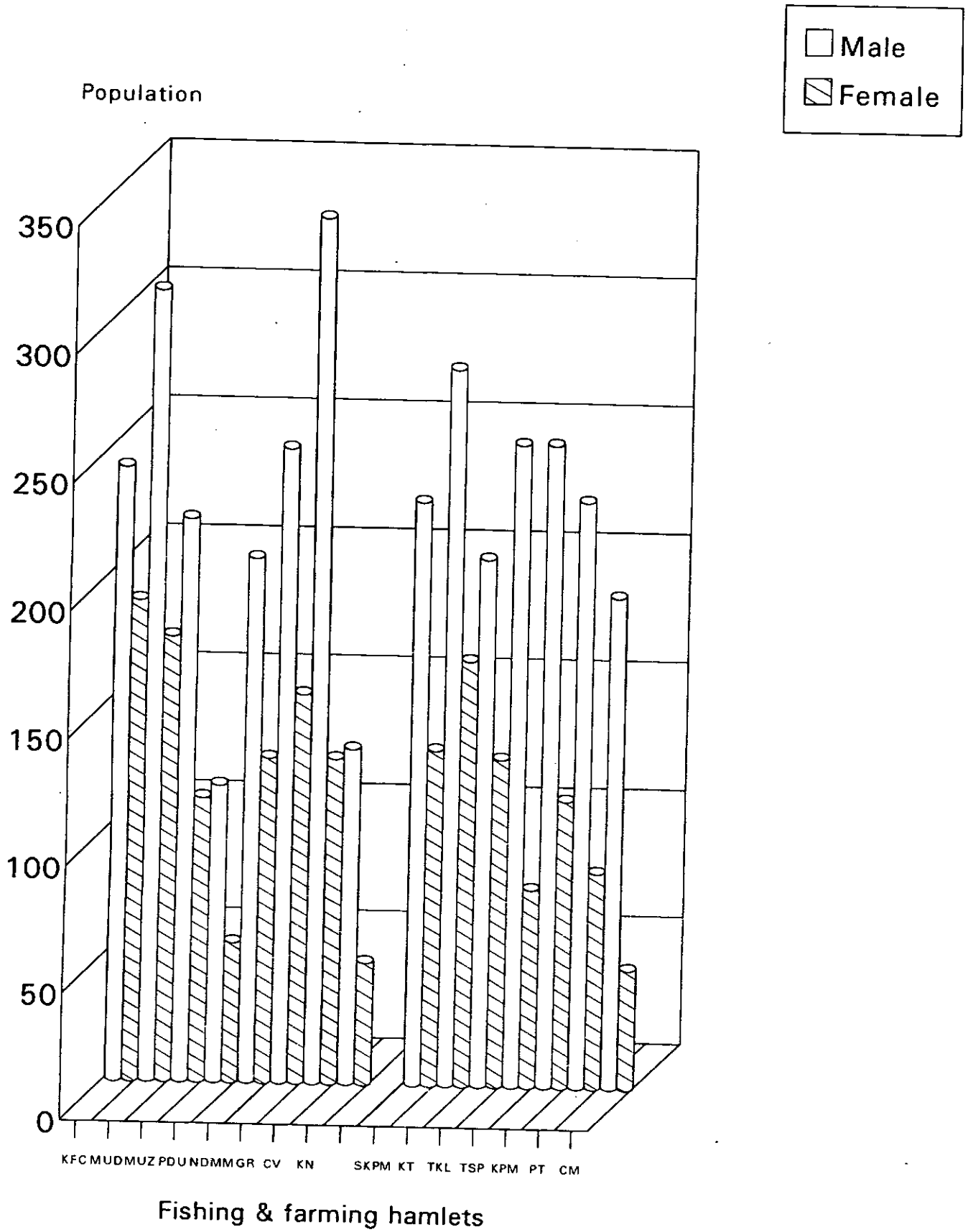
3.3.2 *Status of dwelling units : Utilisation of natural resources*

Demand for housing construction also imposes heavy strains on the natural resources. For all hamlets the major roof material was found to be palm/ coconut leaves (74-100%). Major wall and material was found to be mud (44%-100%). A small percentage of the population owned concrete buildings. MGRT and TSP belonging to the fishing and farming hamlets respectively have the highest record of concrete buildings (18 and 64% respectively).

3.3.3 *Land ownership*

With land as the major usable and needful asset for most rural communities, its distribution could be considered as an indicator of rural poverty. Among the fishing community the highest record for land ownership is in the order of KFC > PDU & NDM > MGRT > CV > MUZ > MUD > KN. Among the farming community KPM has the highest record for land ownership as well as highest average yield. The order is as follows - KPM > SKPM > TKL > KT > PT > TSP > CM. Paddy and Groundnut are the major crops. The most common and notable feature in all the hamlets is a higher percentage of land under groundnut cultivation, when compared to paddy. Also the present trend is conversion of paddy lands to groundnut cultivation. Choice of this crop is attributable to the saline conditions and aridity. This crop is also rain dependent and reduces the cost of pumping water. Water shortage is prevalent among the hamlets and drinking water is brought from a distance of 1.5-2 km. Water form local pumps if any, is

Socio-demographic profile of the 15 hamlets



available only for restricted hours in the morning and in the evening and is mainly utilised for other purposes.

For pumping water in the fields animal energy is used by a majority of land owners, while only a small percentage of them could afford to use diesel energy.

3.3.4 *Occupation*

As is mentioned earlier, the major occupation is either farming or fishing. Occupation in general is divisible into primary and secondary occupation (engaged in other activities other than the main occupation). Among the fishing community, greater percentage of the heads of the household (HOH) were found to be engaged in fishing activities than non-fishing activities, while women and children were found to be engaged in non-fishing activities. In the fishing hamlets closer to the Pichavaram Tourist Complex the HOH readily accept to take the tourists/ visitors around the mangrove forest.

Among the farming community a high proportion of younger generation are engaged in non-agricultural activities, thereby helping to increase the total household income, which is represented in Graphs 2 & 3.

3.3.5 *Domestic budget as indicators of living standards*

Indicators of the living standards of a household also depend on the disposable income relative to family size and accessibility to public services and amenities. Food accounts for a major portion of the average annual budget while the rest of the budget goes for house repairs, clothing, medical care etc. (Table 2.) The very low values obtained for the average savings is because most of the households had such low income that scope for saving did not exist.

3.3.6 *Energy Consumption*

As is obvious from Table 3. firewood and biomass represent a household's major fuel material. The average consumption ranges from 3.18 - 6.41 kg and 0.22 - 4.5 kg/ day, respectively. Average consumption of kerosene ranges from

Table 2. Average annual expenditure (Rs.)

	Food	House repairs	Tax	Rent	Health care	Clothing	Education	Festival/ Entertainment	Social events	Savings	Loans
FISHING COMMUNITY											
KFC	9271	1150	28	104	797	2081	725	1823	1453	1426	8350
MUD	15998	1048	12	1000	420	1615	233	1374	1242	133.3	1500
MUZ	17554	954	7	21	522	1994	186	1394	1070	660	4000
PDU	17600	848	0.46	0	391	1582	132	1509	1004	525	1000
NDM	18536	989	7	0	299	1736	309	1575	991	578	0
MGRT	21163	955	8.4	7.1	539	1831	276	1762	1034	1431	0
CV	19685	986	0	0	449	1809	325	1145	309	0	0
KN	18779	1866	0	0.22	813	3458	679	2442	554	232	0
FARMING COMMUNITY											
SKPM	14562	1110	8	0	472	1890	400	1230	880	713	4500
KT	12592	973	14	18	610	1591	506	1401	933	915	4000
TKL	12327	1141	15	24	661	1532	557	1119	1257	993	7000
TSP	19380	1070	45	30	387	1549	2206	1610	542	94	0
KPM	19880	981	0	0.06	440	1871	308	1188	321	0	0
PT	42260	1036	13	85	327	1687	214	1460	263	572	0
CM	18592	990	0	0.43	452	1488	98	1067	199	82	0

Table 3. Average energy consumption per day

Hamlet	Firewood (kg)	Value (Rs.)	Biomass (kg)	Value (Rs.)	Kerosene (ml)	Value (Rs.)	Electricity (units)	Value (Rs.)
FISHING COMMUNITY								
KFC	5.2	4.5	2.6	1.4	527	3-5	1.9	1.05
MUD	4.5	2.7	2.6	0.9	380	3-5	2.5	1.4
MUZ	3.6	2.1	2.6	0.8	289	3-5	0.9	0.5
PDU	4.7	2.8	3.3	1.1	345	3-5/ 10	0	0
NDM	4.5	2.7	3.7	1.2	268	3-5/ 10	2.2	1.2
MGRT	4.6	2.8	4.1	1.3	350	3-5	2.6	1.4
CV	3.8	2.3	1.3	2.5	332	5-10	0	0
KN	3.8	2.3	1.4	2.8	305	5-10	0	0
FARMING COMMUNITY								
SKPM	5.6	3.5	2.7	1.4	293	3-5	1.3	0.7
KT	6.4	3.8	3.2	1.2	426	3-5	0.5	0.3
TKL	5.9	3.5	2.6	0.8	312	3-5	0.8	0.4
TSP	4.0	2.5	4.5	1.5	345	3-5	1.4	0.7
KPM	4.0	2.7	0.2	0.1	422	3-5	0	0
PT	3.6	2.2	1.3	2.7	325	3-5	0	0
CM	3.1	18	0.9	2.0	475	10	0	0

0.268 - 0.526 litres per day which is mainly used for lighting purposes. Most hamlets do not have electricity facility and the consumption ranges from 0.04 - 2.61 units Percentage dependence on a particular sources of fuel is depicted in Graph 3. Highest percentage of firewood collection from the mangrove forest was recorded for KFC, MUD and MUZ and TSP, which is attributable to the fact that these hamlets are closest to the forest.

4.0 Impact of the local population on the mangrove forest

Rural coastal communities have some characteristics in general. They

(1) are confined to a narrow strip of sea and land
(2) are deprived of adequate fishing range (or) agricultural land
(3) have multitude of related socio-economic characteristics
(4) are faced with a limited set of alternatives, and
(5) are virtually dependent on the local natural resources for their livelihood

In all the hamlets/ villages, a majority (70 - 95.45%) of the households surveyed know about the mangrove forest from their childhood. Various activities in the Pichavaram mangrove forest include collection of firewood, construction materials, fishing, etc. In most of the hamlets cattle is let loose and tend to graze in the mangrove forest, especially on the young seedlings. This has an impact on on the regeneration of the forest. This also is an indication of inability to provide alternative fodder to the cattle and most of them have also become semi-wild.

A large proportion of the people collect firewood and construction materials from dense forest. *Avicennia*, *Bruguiera* and *Suaeda* spp are mainly used as fuel, while *Rhizophora* stilt roots and stems are used as frames for tatched roofs, especially for temporary dwellings made by fishermen during peak season.

Of all the fishing hamlets, only PDU, MUD, NDM and MGRT collect shell fish and crustaceans apart form fishes, as they are more closer to the sea than the swamp. It is seen that most of the other fishing hamlets confine themselves to fish and prawn collection, and if collected is a rare occasion.

The rural families were given the option of choosing either aqua culture, agroforestry and animal husbandry, by enquiring whether they would participate if resources are made available. It is notable that even in fishing hamlets people seemed to be interested in agroforestry and animal husbandry. Only MUD and PDU seemed to be interested in aqua culture. In most of the farming hamlets, a few people showed interest in initiating and participating in agroforestry and animal husbandry programmes. Their opinion is that the fuel and fodder requirements could be met by such a programme. Money is the only limiting factor for such hamlets/ villages for initiating such programmes.

The extent of dependence on the mangrove forest was also indicated by the responders. A majority of them depend highly on the mangroves, and a very small percentage show low or nil dependence. Table 4-4d shows the various activities and the dependence of the local people on the Pichavaram mangroves.

5. Sustainable Livelihood Security Index (SLSI)

The three main factors of sustainable development namely, Ecology, Economics and Equity are integrated in the Sustainable Livelihood Security Index (SLSI) which can be developed for any given ecosystem/ region. The computation of the SLSI is described in detail in (Annexure I previous Annual Reports under Sub-Programme Areas 102 and 405). Household is considered as the basic unit of analysis. The four essential components required for developing this index at household level are, the (1) Income status, (2) Asset Ownership status (3) Nutritional status, and (4) Educational status. An attempt has been made to apply this index to the data from all the hamlets.

The main aim of the index is to identify hamlets/ villages that are economically and educationally backward, and nutritionally poor. The ranking based on the index scores helps in setting priorities to undertake the developmental programmes for both eco-redevelopment and poverty alleviation.

Table. 4. Activities carried out in Pichavaram (%)

Hamlets	Nil activity	Firewood collection	Construction material collection	Grazing	Fishing	Shell fish collection	Crustacean collection
FISHING COMMUNITY							
KFC	4.3	51.89	21.18	0	22.63	0	0
MUD	38	46	10	0.56	5.44	0	0
MUZ	10	60	0	10	20	0	0
PDU	0	43	30	0	27	0	0
NDM	0	39	11	1	30	10	9
MGRT	71	26	1	0	1	0.5	0.5
CV	70	0	0	0	30	0	0
KN	100	0	0	0	0	0	0
FARMING COMMUNITY							
SKPM	100	0	0	0	0	0	0
KT	100	0	0	0	0	0	0
TKL	73	9	9	0	9	0	0
TSP	0	82.5	0	0	8.5	4.5	4.5
KPM	100	0	0	0	0	0	0
PT	80	0	0	0	0	0	20
CM	15.68	0	0	0	0	0	84.32

Table. 4 a. Localities chosen for firewood collection (%)

Hamlets	Nil collection	Dense forest	Isolated trees	Barren areas
FISHING COMMUNITY				
KFC	100	0	0	0
MUD	19	53	26	2
MUZ	38.33	61.67	0	0
PDU	100	0	0	0
NDM	7	43	30	20
MGRT	100	0	0	0
CV	90	5	5	0
KN	80	10	10	0
FARMING COMMUNITY				
SKPM	4.55	61.36	25	9.09
KT	0	51	37.5	11.5
TKL	0	45	37	18
TSP	0	44	36	20
KPM	100	0	0	0
PT	0	0	0	0
CM	0	0	0	0

Table.4 b. Species preference for domestic purposes (%)

Hamlets	Nil collection	Avicennia	Rhizophora	Bruguiera	Suaeda	Prosopis
FISHING COMMUNITY						
KFC	100	0	0	0	0	0
MUD	6	64	25	0	0	5
MUZ	38	32	30	0	0	0
PDU	0	0	0	0	0	0
NDM	8	43	41	4	4	0
MGRT	0	0	0	0	0	0
CV	0	29.5	60	0	8.5	2
KN	0	57	30	0	10	3
FARMING COMMUNITY						
SKPM	0	50	45	2.5	2.5	0
KT	0	50	27	30	3	0
TKL	0	39	3[illegible]	7	30	0
TSP	0	53	19	1	27	0
KPM	100	0	0	0	0	0
PT	100	0	0	0	0	0
CM	100	0	0	0	0	0

Table.4 c. Degree of dependence (%) on mangrove forest

Hamlets	Nil	Low	Medium	High	Very high
FISHING COMMUNITY					
KFC	100	0	0	0	0
MUD	4.26	7.14	30	54.29	4.29
MUZ	37.2	35.48	16.12	11.2	0
PDU	0	0	0	0	0
NDM	10	4	26	80	0
MGRT	0	0	0	0	0
CV	23	49	19	8	0
KN	4	44	48	4	0
FARMING COMMUNITY					
SKPM	9.1	0	16.16	72.72	0
KT	0	2.27	25	72.73	0
TKL	2	0	32	66	0
TSP	0	0	60	40	0
KPM	100	0	0	0	0
PT	100	0	0	0	0
CM	100	0	0	0	0

Table. 4 d. Programme opted for (%) by the local community

Hamlets	Not interested in any programme	Aquaculture	Animal husbandry	Agroforestry
FISHING COMMUNITY				
KFC	0	38	20	42
MUD	74	25	0	1
MUZ	52	45	0	3
PDU	64	0	16	20
NDM	76	18	0	6
MGRT	82	0	6	12
CV	56	14	20	10
KN	40	10	20	30
FARMING COMMUNITY				
SKPM	40	20	9	31
KT	61	33	6	0
TKL	68	27	4	1
TSP	86	10	4	0
KPM	56	0	13	31
PT	36	0	11	53
CM	66	0	0	34

5.1 Results of the individual component performance of the SLSI worked out for the 15 hamlets

Results of three of the four essential components for all the hamlets are summarised in Table 5. The results indicate that the income status is the highest in C. Manambadi and M.G.R. thittu and lowest in Killai Tirunalthoppu. For asset ownership status, Pillumedu ranks first and C.Manambadi ranks last. Educational status is found to be high in Killai Fishermen Colony and lowest in C. Manambadi. Educational status in the present study indicates a maximum of plus two level. The methodology for assessing the nutritional status is being developed.

6. Landuse pattern in Pichavaram

The present scenario in Pichavaram is, increasing population, a low per capita land availability, and shortage of fuel, forage and fodder. The root cause for the shortages is extensive biomass removal for subsistence by the local people themselves. The pace of forest degradation is causing not only economic distress and shortage of biomass supply but also increased salinity of water and soil. To begin with, the prevailing situation necessitates the selection of fuel and fodder yielding plant species alone so as to reduce the biomass famine.

With a population of density of 547.4 per sq. km, it is seen that the major anthropogenic pressures and impact on the estuarine forests is collection of fuel wood and fodder, the results of which are depicted in Graph 1. Table 6 shows the percentage of land under cultivation and unused land, to the total available land area. These include the mangrove forest land and the lands of the surrounding hamlets which were surveyed.

Agriculture is mostly rainfed with emphasis on food crops. Productivity is generally low. Therefore food production receives the highest priority than any other land use.

Therefore a multiple-use concept has to be introduced for conserving the resources by means of **appropriate development programmes**. Many developmental programmes often have an unintended adverse impact on the

Table. 5. Indices of three of the four variables representing the major components of the SLSI at household level.

S. no.	Name of the hamlet/ village	No.of households surveyed	Income Status/ capita	Ranks	Asset Ownership Status/ capita	Ranks	Educational Status	Ranks
FISHING COMMUNITY								
1	Killai Fishermen colony	70	0.0609	10	0.0122	9	0.0980	1
2	Mudasalodai	60	0.0884	6	0.0093	12	0.0564	7
3	Muzhukkuthurai	50	0.0644	7	0.0120	10	0.0628	5
4	Pillumedu	22	0.0636	8	0.0483	1	0.0470	11
5	Nadumudasalodai	44	0.0564	11	0.0118	11	0.0690	3
6	M.G.R thittu	50	0.1220	2	0.0138	7	0.0768	2
7	Chinnavaikkal	72	0.0533	12	0.0086	13	0.0377	14
8	Kannaginagar	23	0.1049	3	0.0144	6	0.0454	13
FARMING COMMUNITY								
9	Singarakuppam	50	0.0957	4	0.0312	3	0.0640	4
10	Killai Thirunalthoppu	50	0.0446	15	0.0069	14	0.0594	6
11	Thaikkal	41	0.0450	14	0.0198	4	0.0519	9
12	T.S. Pettai	50	0.0519	13	0.0196	5	0.0516	10
13	Kucchipalayam	50	0.0944	5	0.0328	2	0.0498	9
14	Ponnanthittu	50	0.0613	9	0.0136	8	0.0462	12
15	C. Manambadi	50	0.1319	1	0.0059	15	0.0348	15

Table 6. Landuse pattern to the total available land area in and around Pichavaram

		Total available land (ha)	Area under cultivation. (%)	Unused land (%)
REGION				
Killai (North)	Dryland area	360.875	63.93	36.07
	Wetland area	31.355	53.31	46.69
Killai (South)	Dry land area	13.260	73.51	26.49
	Wetland area	299.915	100	-
Unauthorised occupation	Dry land area	304.600	100	-
	Wetland area	-	-	-
T.S. Pettai	Dry land area	206.325	51.16	48.84
	Wetland area	190.170	-	-
Pichavaram	Forest			
	Dense mangroves	241.000		
	Sparse mangroves	593.500		
	Mud flats	262.500		
	Saline area	1238.500		
	Dry land area	365.995	71.21	28.79
	Wetland area	194.375	62.77	37.23

Table 7. Total livestock population of the 15 hamlets under study

Cows	55079
Buffaloes	12500
Sheep	3021
Goats	17774
Pigs	1021
Chicken	61577

ecological and economic security of the local inhabitants. This implies a shift from the traditional commodity-oriented approach to a development pattern based on sustainable utilisation, to protect, conserve and manage the available resources for better ecologic and economic security.

7. Intended interventions

7.1 Agroforestry

Planting of *Casuarina* has already been taken up by the Tamil Nadu Forest Department. *Casuarina* plantations are also common among a sizeable tree ownership population adjacent to the coast as indicated by the socio-economic survey.

Another common feature is that paddy lands are being converted to rainfed groundnut crops by both fishing and farming communities. According to the local sources, as soil is becoming saline and the groundwater is depleting, a shift from irrigated paddy to rainfed groundnut is desirable.

7.2 Animal Husbandry : Significance of livestock and poultry in the rural economy

Integration of livestock with farming assumes special significance in which case compost and FYM can be relied upon increasingly to maintain soil fertility. Mixed farming with livestock and more intensive use of agricultural land through agroforestry for fodder production are possible approaches for tackling the problem of shrinking land : man ratio.

With respect to the present study, livestock includes cattle, buffaloes, sheep, goat, pig and poultry. Table 7. reveals the total livestock population of the 15 hamlets. The agroforestry programme deals with fodder production for ruminant livestock.

It is observed that the cattle population is the highest and therefore emphasis will be on the production of fodder grasses. In a given region, livestock is of special significance in the economy and well being of the people particularly, the landless and small farmers. The benefits are :

1. Food : source of milk and meat

2. Draught power : used for ploughing, lifting water for irrigation, transport of agricultural produce and the residues.

3. Organic manure : contributes FYM which improves soil health. Presently it is noticed that the paddy fields have already been converted to or are being converted to rainfed groundnut. In such a situation, addition of organic manure is of special value.

4. Employment : Unemployment is a major problem. in villages. Stallfed cattle rearing is technically simple though labour intensive .In the hamlets under study, however, stall feeding is yet to be introduced. Scientifically designed mixed farming systems will help to increase both income and nutrition at the household level.

Livestock productivity in the hamlets studied is low. Partly, this arises from inadequate and low quality nutrition. Fodder banks involving grass and legume mixtures will help to raise productivity.

8. Site selected for agroforestry programme

Muzhukkuthurai, a fishing hamlet has been selected for the proposed work. This site falls under the Killai South Zone. The enclosed map depicts a pictorial plan of the proposed work. This site was selected based on the criteria that

1. It is close to the mangrove forest, therefore likely to have more impact

2. It forms one of the routes for the cattle to enter the forest

3. It falls under the 25 ha Casuarina Plantation of the Forest Department, and so the spaces in-between the plantations can be used for raising suitable fodder yielding plants.

4. The relatively barren land areas adjacent to the village can be used
- for raising suitable fuel and fodder species, as well as
- for maintaining a mangrove nursery,

5. Based on the Sustainable Livelihood Security Index (SLSI), this hamlet ranks quite low in income status, literacy and asset ownership status (7, 10 & 5; Rank 1 is considered as best performance).

8.1 Outcome of the meeting held in Muzhukkuthurai in May 1994

An informal meeting was held in the selected site with the Village Headman, few residents and representatives from the Forest Department, Chidambaram Taluk, Killai Panchayat and Village Administrative Office. In the course of discussions it was found that Patta or Porambokku lands are nil and also as per the survey map from the Chidambaram Taluk obtained earlier, the Porambokku lands fall under drainage channels, roadsides, ponds or small groves which is not suitable for the proposed work. A notable feature is that the cattle belonging to the selected site and other nearby hamlets graze in the mangrove forest only during the North-east monsoon periods when there is lot of fresh water supply. With the advent of summer the cattle returns back as the water becomes much saline. Therefore it was decided that it will be ideal to create fodder and feed banks so that the entry of cattle can be arrested.

The outcome of the meeting is as follows :

- Since no other lands are available the work can be initiated in the Killai Reserve Forest Area in collaboration with the Forest Department.
- Once the land is formally approved, there will be full support from the Villagers, local Panachayat and Taluk
- The side branches of Casuarina are not pruned. Pruning will help in
  - broader poles,
  - providing fuelwood, and

- diversion of fresh needles to stall feed the cattle.

• Other fuel and fodder yielding species which will be best suited to the present conditions will also be planted. The fodder material can be sold at market rate to the cattle owners. This was acceptable by the local people.

• The revenue from fuel and fodder sale could go to the Forest Department

8.2 Anticipated benefits

This scheme is an attempt to provide practical information in order to implement soil and water conservation measures which will satisfy the basic as well as other needs of the rural communities. These can be categorised into :

1. Economic security or benefits such as

• Cash income/ earnings through employment , sale of products and substitution of own products for purchased items wherein less cash is spent.

• Increased energy supply (fuel) which will be of better quality, cheaper or more convenient source.

• Increased supply of raw materials for crafts/ cottage industries such as basket making with locally available palm or other suitable species.

2. Ecologic security or benefits such as

• Conservation of water through rain water harvesting technique and other suitable field practices for plant growth and livestock.

• Conservation of soil by protection from erosion, loss of nutrients, restoration of degraded soils, improvement of soil moisture and fertility.

• Conservation of plant resources by maintaining or increasing the diversity of species and habitat, increased yield of useful products and improvement of natural regeneration of most desirable species.

3. Social security or benefits such as :

- New forms of savings and investments (tree crops, products, agro business) for better profitability than the existing savings.
- Increased supply of fuel for domestic use and increased supply of fodder for livestock.
- Increased supply of building materials and shelter / shade.
- Protection from wind and animals.

The programme could be initiated by way of demonstration plots in the selected site **emphasising full participation by local people**. This may be tested and refined formally, after which it can be **extended and adapted** by people belonging to the other hamlets.