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Restoration of Mangroves in Kerala and Karnataka States

A Special Study

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Sri. M.Y. Ajayakumar
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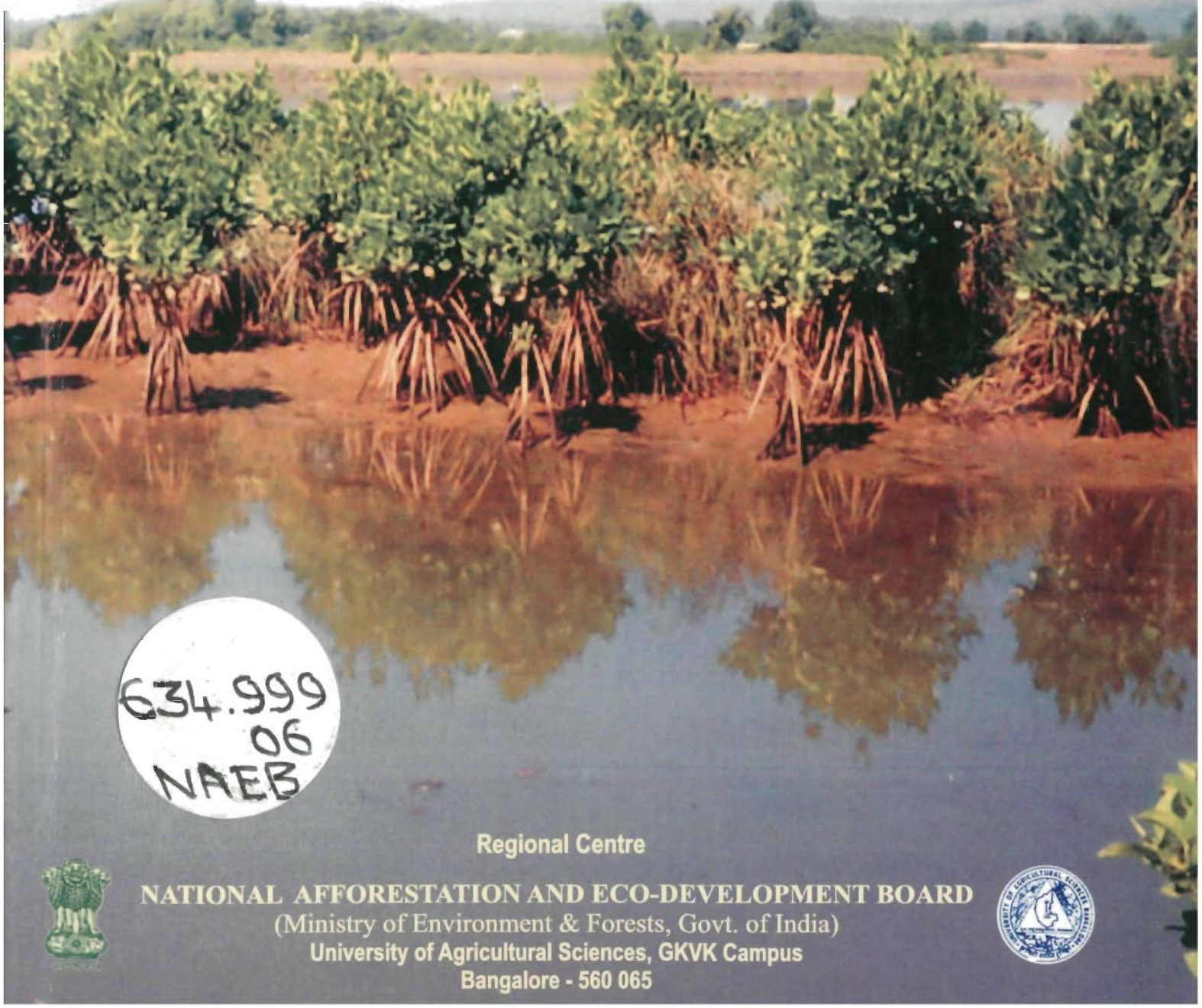

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NATIONAL AFFORESTATION AND ECO-DEVELOPMENT BOARD
(Ministry of Environment & Forests, Govt. of India)
University of Agricultural Sciences, GKVK Campus
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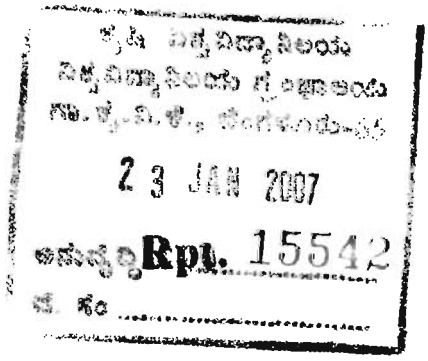

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V. BHASKAR
(Coordinator)

CONTENTS

EXECUTIVE SUMMARY

The present study was undertaken by RC, NAEB, Bangalore during 2005-06 to know the extent of Mangrove restoration work carried out in Kerala and Karantaka States. A total of 74 plantation sites were sampled in Karnataka and Kerala, 62 plantation sites in Karnataka and 12 plantation sites in Kerala. Visits were made to the plantation sites to collect relevant data on mangrove restoration work in four Territorial Costal Divisions of Karnataka (Honnavar, Karwar, Mangalore and Kundapur) and on Coastal Territorial Division of Kerala (Kannur).

As per the study findings, in Kannur Division, totally 134.78 ha area has been raised under mangroves in Kottiyoor, Thaliparamba, Kasargod and Kannavam Ranges, during 1997-98 to 2004-05. In Honnavar Division of Karnataka, totally 665.50 ha has been restored under mangroves, covering Kumta, Hiregutti, Katgal, Honnavar and Bhatkal Ranges during 2000-01 to 2005-06. In Karwar Division, totally 190 ha area has been planted under mangroves covering Karwar and Gopshitta Ranges during 2002-03 and 2004-05. The total area of mangrove plantations raised by Mangalore Division is 227 ha during the years 1992-93, 1993-94 and 2002-03. In Kundapur Division, totally 160 ha area has been restored under mangrove plantation in Kundapur, Byndoor, Udupi and Moodbidri Ranges.

In Kannur Division of Kerala, the major species planted are *Rhizophora apiculata Kandelia candel, Avicennia officinalis, Bruguiera cylindrica, Avicennia marina* and *Aeqeras corniculatum.* Among these, *Rhizophora apiculata* and *Kandelia candel* are the major species under restoration. The major species used for plantation in four Divisions of Karnataka are *Rhizophora mucronata, R. apiculata, Avicennia alba, A. officinalis, Kandelia candel, Bruguiera cylndrica, A. gymmorrhiza, A. marina* and *Sonneratia alba.* Among these, *Rhizophora mucronata* and *R. apiculata* are the major species used for raising plantations. Use of tall seedlings of height 0.5 to 1.0 m for planting is unique in Kerala and Karnataka.

The planting techniques adopted in Karnataka are crowbar technique and planting in pits of 30cm x 30cm x 30cm size. Planting is also done by scooping the mud flats and planting seedlings. In few cases the propagules are collected from the older plantations or

from natural mangrove forests and are directly dibbled in the field. In Kerala, the main planting method followed was by pit planting method in pits of 30cm x 30cm x 30cm size. The planted seedlings were tied to the bamboo stick as staking which were inserted in the mud flats. Even though the mangrove restoration work has been a success in Karnataka and Kerala, improved planting methods such as trench or channel method as done in Andhra Pradesh and Tamil Nadu can be adopted for better drainage of tidal water and further better survival rate of mangrove plantations. Such improved methods of planting like trench method and herring bone channel method enable flushing of water in and out of the trenches and thereby avoiding stagnation of tidal water or drying up of mud blanks and also resulting in better growth of mangroves.

Most striking feature in Kerala is 90 per cent of mangrove plantation areas were protected with bamboo fencing @ of Rs. 116/- per running metre and appointing full time watchers. Whereas in Karnataka, barbed wire fencing was done in a few plantation sites and appointed full time watchers for protecting mangrove plantations.

JFMCs are not formed in both Kerala and Karnataka to protect the mangrove plantations. However, the staff of both the states have convinced the people about the importance of mangrove forests. On the contrary, in Andhra Pradesh, Forest Department adopted Joint Forest Management concept to reduce the local people's dependency on mangroves. They have taken up welfare measures along with alternate income generating activities in the fringe villages. Vana Samrakshana Samithies and Mangrove Management units have been formed to ensure people's participation which has led to the successful restoration of mangroves. In Tamil Nadu, Forest Department and M.S. Swaminathan Research Foundation (MSSRF) have implemented Joint Mangrove Management (JMM) programme in the villages located around Picahavaram and Muthupet. Similar joint management committees should be formed in Kerala and Karnataka also.

I. INTRODUCTION

The mangroves are coastal tropical plant formations found along the border of the sea and lagoons, reaching up to the edge of the rivers to the point where the water is saline, growing in swampy soils and covered by the sea during high tides. Frequently, 'tidal forest' or "coastal wood lands" are used as synonyms to denote mangrove. Mangrove forests are salt tolerant eco-systems of tropical and sub-tropical intertidal regions like estuaries, lagoons, coastal mud flats etc of the world. The mangroves that occur in India have the constitution similar to Malaysia type and so are called Indo-Malaysia type. According to an estimation, mangroves occupy 1,98,82,000 ha extent of area in the world of which 6,99,000 ha are well protected. India occupies 14th place in the world. As per the Forest Survey of India Report (2003), the total mangrove cover in India is 4,461sq km, which is 0.14 per cent of the country's total geographical. In South India, Andhra Pradesh is having more mangrove cover (329 sq. km) followed by Tamil Nadu (35 sq. km), Kerala (8 sq. km) and Karnataka (3 sq. km).

The natural mangrove cover in Karnataka is 3 sq.km which is confined to North Canara district (2 sq.km) and Udupi district (1 sq. km). In Kerala, the natural mangrove cover is 8 sq. km which is confined to Kannur district (7 sq. km) and Ernakulam district (1 sq. km). In Karnataka, the change with respect to 2001 assessment, there is an increase in the mangrove cover by 1 sq. km. The natural mangrove cover in Kerala consisting of small and scattered patches, has been assessed for the first time by FSI.

Mangroves are notable for their plant diversity, biomass and productivity. Among the 70 mangrove species which occur all over the world, 30 species are present in India. The mangrove species show convergent evolution as they live in the same habitat. The destruction of mangrove eco-system is happening at a time when there are invisible threats from potential changes in temperature and increase in sea levels. It will be a tragedy if we lose the mangroves, which are the last frontiers in our defence against the adverse consequences of changes in sea level. Besides, conservation of mangroves with genetic material conferring tolerance to sea water intrusion is important for meeting the long term need. Their role as "buffer zones" between the land and the sea, effectively checking cyclonic storms, tidal waves, soil erosion and intrusion of salinity on land surface is well recognised.

Mangrove forests act as a habitat for a variety of wild life such as migratory birds, crocodiles and other sea animals. Mangroves are self maintaining, renewable and are considered as potential land builders. They are the source of timber, firewood and fodder to local people and are known to sustain apiculture. Mangrove eco-systems support both commercial and recreational fisheries, boating, bird watching and photography. They also attract tourists, nature lovers and researchers.

The concept of mitigating the harsh effect of cyclones through mangrove forests is age old. It needs no introduction for the people who live on the coastal tracks. The people living in the coastal region are well aware of the beneficial role of mangrove forests in mitigating the harsh effects of cyclone. People are fully aware that mangrove forests have reduced wind velocity, sand drift, salt spray, erosion of sea bank and stabilized sand dunes.

One of the most disastrous thing that occurred on 26th December 2004 was tsunami which affected the lives of millions in Asia. But as per a few reports, wherever mangroves were intact they had actually reduced the harsh effects of tsunami. Hence, several afforestation measures were undertaken to mitigate such disasters. One such was scheme undertaken by Tamil Nadu Forest Department sanctioned by the Government of Tamil Nadu at an outlay of Rs. 7 crores. The Department has started building a bio-shelter on 2000 hectares of land along the coastline of 13 districts of Tamil Nadu. The project is aimed at weaning away people from deforestation activities such as cattle grazing and cutting down of trees by providing alternative employment and involving them in planting trees. This is followed by a World Bank assisted scheme that aims to continue with the same goals in other areas of the State (Anon, 2005).

The livelihood security of major coastal communities in terms of food, fuel wood and shelter is traditionally derived from this ecosystem. As a consequence of *anthropogenic pressure, huge blanks are formed in mangrove forests along the coastal* areas of Kerala and Karnataka States. The Forest Departments of both states have taken up restoration works including afforestation, protection and conservation. Mangrove restoration work has been done very well in Andhra Pradesh and Tamil Nadu and this Centre conducted a detailed survey and documented its findings [Mangrove restoration work in Tamil Nadu State (RC, NAEB, Publ. 90) and Afforestation of mangrove blanks in

East Godavari and Krishna Districts of Andhra Pradesh (RC, NAEB Publ. 108)]. Subsequently, it was thought desirable to study and document on the various afforestation and restoration techniques adopted in Kerala and Karnataka states with the following objectives.

Objectives :

1. To document the status of mangrove forests in Karnataka and Kerala.
2. To document the mangrove restoration work taken up by the Forest Departments in Karnataka and Kerala.
3. To study the impact of mangrove restoration work in Karnataka and Kerala.
4. To document the factors responsible for success of mangrove restoration and conservation.
5. To develop the future strategies for successful afforestation and conservation of mangrove forests in Karnataka and Kerala.

II. METHODOLOGY

The Regional Centre, National Afforestation and Eco-development Board, Bangalore conducted a special study to document the mangrove restoration works carried out in Karnataka and Kerala States. The Regional Centre obtained the information regarding list of mangrove plantations raised in Karnataka and Kerala from Conservators of Forests, Canara and Mangalore Circles, Karnataka, Deputy Conservators of Forests of Honnavar, Karwar, Mangalore and Kundapur Divisions of Karnataka, Conservator of Forests (Northern Circle), Kannur, Kerala, and Divisional Forest Officer of Kannur Division, Kerala. In each Division, the mangrove restoration sites were visited. Wherever mangrove restoration works were taken up, the plantation sites were randomly selected. The list of mangrove plantation sites sampled is given below :

Mangrove plantations sites sampled in Karnataka and Kerala

Division	Range	Year of planting	Area (ha)	Location
Honnavar	Honnavar	2001-02	18.50	Kasarkod
		2005-06	22.50	Kasarkod
	Kumta	2000-01	30-00	Aghanashini-Masur-Lukkeri
		2001-02	27.00	Masur-Lukkeri-Baad-Kagal
		2002-03	68.00	Masur-Lukkeri
		2003-04	6.50	Alwekodi
		2003-04	60.00	Kagal-Lukkeri-Masur-Hegde
		2003-04	17.50	Kumta-Alwekodi-Kalbag
		2004-05	25.00	Masur-Lukkeri-Baad
		2005-06	10.00	Kumta-Alwekodi-Kalbag
	Hireguti	2001-02	23.00	Gangavalli riverbed
		2003-04	15.00	Bargi Gazniland-Morba
		2003-04	15.00	Juga-Ulware
		2003-04	15.00	Moralli-Mogta-Andle
		2004-05	35.00	Nushikote gazniland
		2005-06	90.00	Morba-Nushikote gazniland
	Katgal	2003-04	17.00	Paduvani riverbed
		2005-06	22.00	Mirzan (Paduvani Riverbed)
	Bhatkal	2001-02	9.00	Shirali (Venkatapur riverbed)

Contd...

Division	Range	Year of planting	Area (ha)	Location
Mangalore	Mangalore	1992-93	10.00	Joppinamogalru-I
			10.00	Joppinamogalru-II
			10.00	Thinnirubhavi-I
			15.00	Thannirubhavi-II
			15.00	Bangra-Kuluru-I
			10.00	Bangra-Kuluru-II
		1993-94	12.00	Ullala-I
			13.00	Ullala-II
			5.00	Joppinamogaru
		2002-03	10.00	Sampukuduru
			10.00	Bengre
			10.00	Thannirubhavi
Kundapur	Kundapur	1995-96	15.00	Kodi
		2002-03	10.00	Uppinakuduru
			10.00	Halkady-I
			10.00	Halkady-II
			10.00	Hemmadi-I
			10.00	Hemmadi-II
			5.00	Hosadu
			10.00	Tallur
	Byndoor	1995-96	10.00	Padavary
		2002-03	10.00	Uppunda
	Udupi	1995-96	10.00	Kothathattu
		2002-03	10.00	Udyavara
Karwar	Karwar	2002-03	20.00	Kodibag
			20.00	Sunkeri
			20.00	Halgejug
		2004-05	8.00	Kadawada
			7.00	Boviwada
			25.00	Amdalli
	Gopshitta	2002-03	20.00	Devbag
			10.00	Mavinhde
		2004-05	2.00	Kanasageri
			2.00	Hotegali

Contd...

Division	Range	Year of planting	Area (ha)	Location
Kannur	Kottiyoor	1997-98	3.00	Koduvally
			3.00	Mathikovu
		1998-99	6.00	Palayad dist
			2.50	Palayad East
			3.00	Palayad East
			4.00	Maidupalem Bridge
		2000-01	2.00	Maidupalem Bridge
			2.00	Palayad East
		2001-02	2.50	Mazhappilangad
	Thaliparamba	2000-01	7.50	Madakkara South
		2001-02	2.50	Madakkara-I
			2.80	Madakkara-II
			3.50	Madakkara-III
		2002-03	1.50	Madakkara West
		2003-04	1.00	Muttil - I
			1.50	Muttil – II
			0.75	Muttil – III
	Kasargod	2003-04	I3.40	Thalangara-I
			4.15	Thalangara-II
		2004-05	9.43	Arikkady
			6.25	Mogral

III. STATUS OF MAN-MADE MANGROVE PLANTATIONS AND SILVICULTURAL TECHNIQUES ADOPTED IN KERALA

As per the information provided by Kerala Forest Department, about 134.78 ha area is planted with mangroves in Kannur Division. Kannur Division is a Costal Division where most of the mangrove restoration work has been undertaken compared to other coastal divisions of Kerala.

Kannur Division

Kannur Division falls between $11^0$32' to $12^0$52' North latitude and $74^0$52' to $75^0$42' East longitude. The whole division lies within Kannur, Thaliparamba and Thalassery Taluks of Kannur Revenue District, Kasaragod and Hosadurg Taluks of Kasaragod District. Kannur Division has boundaries starting from Arabian Sea along the interstate boundary between Kerala and Karnataka states in the north, Kozhikode District in the south, tri-junction of Kannur, Wayanad and Coorg District in the East and Arabian Sea in the West. Kannur Division has a total forest area of 29,503.83 ha including 20,638.84 ha of Reserve Forests and 8864.99 ha of vested forests. Approximately, forests comprise 6 per cent of the total geographical area of the Division. There are five ranges in the Division viz., Kanhangad, Kannavam, Kasaragod, Kottiyoor and Thaliparamba Ranges.

Mangrove plantations are raised in Kannur Division at Chandragiri and Mahe riverbeds. The mangrove restoration work was done by Kannur Territorial Forest Division, Kerala Forest Department. The total area of mangrove plantations in Kannur Territorial Division is 134.78 ha raised during the years 1997-98 to 2004-05 (**Table-1**).

3.1 Extent of mangrove plantation

In Kannur Division, totally 134.78 ha area has been raised under mangroves in Kottiyoor, Thaliparamba, Kasargod and Kannavam Ranges. During 1997-98 to 2004-05 mangrove plantations were taken up in an area of 50.00 ha in Kottiyoor Range, 49.55 ha in Thaliparmba Range, 33.23 ha in Kasargood Range and 2.00 ha in Kannavam Range (**Table-1**).

3.2 Species planted

There are 6 main species planted in Kannur Division. They are *Rhizophora apiculata, Kandelia candel, Avecinnia officinalis, Brugueira cylindrica, Avecinnia marina* and *Aeqiceras corniculatum.* Among these, *Rhizophora apiculata* and *Kandellia kandel* are the major species under restoration. However, *Avecinnia officinalis* and *Sonneratia alba* are the major natural dominant species found in Kannur Division.

3.3 Soil type

The mangrove species are planted in very specific type of soils. The soils of mangrove species should have high saline in nature and coupled with regular flushing of tidal water. Regular flushing of tidal water results in regulating salinity of the terrain, to facilitate maintenance and improvement of true mangrove vegetation. The mangrove species thrive well in water of 20 ppt (parts per thousand) salinity that is in inter tidal regions including estuaries. As per the information obtained from Kannur Forest Division of Kerala, the soils along the estuary beds are best suited for mangrove restoration as they contain more clay content which are slushy in nature.

3.4 Silvicultural operations

3.4.1 Nursery practices

For raising nursery, the viviparously pre-germinated seedlings are collected during low tides and transplanted into the polythene bags of 8" x 12" size. These polythene bags are filled with slushy silt collected from the adjacent creek beds at the time of low tides. In Kerala, the mangrove nurseries are located in the creek beds where the availability of slushy silt is abundant and the chances of survival of seedlings is more. The polybagged seedlings are maintained in the nurseries for 6 months to 1 year period.

The polybagged seedlings are arranged in the sunken beds and water is pumped into these beds for a day or two and then released to facilitate the planting of seedlings. Later, the sunken beds are inundated by pumping tidal waters to maintain water level of 2" to 3" above the top of the bags. Casualties are heavy in the nursery during early stages and these are replaced continuously. Simultaneously, in order to replace casualties, seedling beds are formed separately by puddling the soil and collected seedlings are

planted in these beds at 2" to 3" apart. These seedlings will be used to replace casualties in the polybags. The nursery will be maintained by pumping water daily once till planting i.e. up to October-November. The seedlings will grow to a height of 60cm – 1m with pencil thickness at the bottom by end of October-November and planting will be started during January.

3.4.2 Selection of site for mangrove plantation

Mangrove blanks which are barren with only a few shrubs and herbs are usually chosen for raising plantations. Mud flats are slushy in nature which were formed due to improper exchange of fresh water, insufficient tidal mixing in dry seasons resulting in high salinity conditions. In Kannur Divisions of Kerala, the selected sites for mangrove restoration were found to be free from any trees, herbs and shrubs.

3.4.3 Planting

The seedlings of height 60cm - 1m with pencil thickness are planted on the shoulders of the mud flats by the end of November/December. In Kerala, 30 cm x 30 cm x 30 cm pits were dug out and along with the seedlings one bamboo stick of 1m height was inserted and tied as a stake. This facilitates the seedlings to remain intact during flooding. In few cases the propagules are collected from the older plantations or from natural mangrove forests and are directly dibbled in the plantation areas. Wherever there is more slope which is more than high tide area, the plantation area is leveled to facilitate the flushing for plantation during high tide.

3.4.4 Espacement

In Kerala, the espacement followed was little wider. The espacements followed were 1.5m x 1.5m, 2.0m x 2.0m and 2.5m x 2.5m. The casualities were less since the seedlings are tied with the bamboo stick and the seedlings are intact with slushy mud and also resulted in better survival.

3.4.5 Age of the seedlings

Age of the seedlings planted varied from 6 months to 1 year old. In most of the cases 1 year old seedlings were used for planting. Better survival rate was recorded wherever the restoration work was undertaken with 9 months to 1 year old seedlings.

No soil working and fertilizer application were done for mangrove plantations in Kannur Division of Kerala state. However, in few plantations sites weeding was done to remove algae to facilitate good growth. No irrigation was given in any of the plantation sites. *Generally mangrove species are relatively free from pests. However, mulluscan* snails were found building their shells on the stem of growing mangrove seedlings that is believed to hamper the growth of the seedlings. Casuality replacement of 10 – 20 per cent was done twice in 1st and 2nd year after planting in Kannur Division of Kerala state.

3.5 Protection

In Kerala, almost 90% of the plantation sites were protected with bamboo fencing. This fencing was provided so as to prevent the cattle and fisherman's boats. The cost incurred for bamboo fencing was Rs.116/- per running metre. In addition to these, strict monitoring and supervision by the departmental staff has resulted in better restoration of mangrove plantations in Kannur Division. Generally, all plantations are protected by appointing full time watchers. In Kerala, the watchers were paid with Rs.104/- per day + Rs.20/- as variable daily allowance (VDA). This provision of appointing watchers will be there up to 3 years after planting. During this maintenance period, the plantations were protected well and resulted in higher survival percentage.

3.6 Survival rate

In Kannur Division, most of the plantations are raised in Kottiyoor and Thaliparamba Ranges. The survival rate of the mangrove plantations in Kannur Division ranged from 50-85 per cent. Higher survival rate of plantation (> 80 %) was recorded in the plantation sites of Kasaragod Range where plantations were raised during 2003-04 and 2004-05. Lower survival rate (52 %) was recorded in Palayad East of Kottiyoor Range raised during 1998-99 and other older plantations raised during 1997-98 and 1998-99 However, these plantations have attained good growth (**Table-2**).

3.7 GBH / Collar girth and Height

The girth and height of mangrove plants in Kannur Division ranged from 9cm (collar girth)- 35 cm (GBH) and 1.4 - 5.8 m, respectively. Higher GBH (35 cm) and height (5.8 m) were recorded in Mathikavu plantation site of Kottoyoor Range raised

during 1997-98. Lower collar girth (9cm) and height (14 cm) were recorded in Muttil-III plantation of Thaliparamba Range raised during 2003-04 (**Table-2**).

3.8 *JFM activities*

No JFMCs are formed for the protection and restoration of mangroves in Kerala. In most of the sites, there was a non-cooperation from local people or local fishermen thinking that the restoration work hampers their fishing activities. Forest Department has to motivate them about the importance of mangroves and form JFMCs. Whereas in Andhra Pradesh, Forest Department adopted Joint Forest Management concept to reduce the local people's dependency on mangroves. They have taken up welfare measures along with alternate income generating activities in the fringe villages. Vana Samrakshana Samithies and Mangrove Management units were formed to ensure people's participation which led to the successful restoration of mangroves. In Tamil Nadu also Forest Department and M.S. Swaminathan Research Foundation (MSSRF) have implemented Joint Mangrove Management (JMM) programme in the villages located around Pichavaram and Muthupet.

Table-1 : Mangrove plantations raised in Kannur Division (Kerala) during 1997-98 to 2004-05

Range	Year of planting	Location	Area (ha)	Species
Kottiyoor	1997-98	Koduvally	3.00	*Rhizophora apiculata*
		Eranholi	3.00	*Rhizophora apiculata* *Kandelia candel*
		Mathikavu	3.00	*Rhizophora apiculata* *Kandelia candel*
	1998-99	Kuyyali nettur	3.00	*Rhizophora apiculata* *Kandelia candel*
		Palayd diet	6.00	*Rhizophora apiculata* *Kandelia candel*
		Palayad East	2.50	*Rhizophora apiculata* *Kandelia candel*
	1999-2000	Palayad University	3.00	*Rhizophora apiculata* *Kandelia candel*
		Palayad East	3.00	*Rhizophora apiculata* *Kandelia candel* *Avicennia officinalis* *Sonneratia alba*
		Moidupalem Bridge	4.00	*Rhizophora apiculata* *Kandelia candel*
	2000-2001	Andallukavu Kadavu	3.00	*Rhizophora apiculata* *Kandelia candel* *Avicennia officinalis* *Sonneratia alba*
		Maidupalem Bridge	2.00	*Rhizophora apiculata* *Kandelia candel* *Avicennia officinalis* *Sonneratia alba*
		Palayad East	2.00	*Rhizophora apiculata* *Kandelia candel* *Avicennia officinalis* *Sonneratia alba*
	2001-02	Muzhappilangad	2.50	*Rhizophora apiculata* *Kandelia candel* *Avicennia officinalis* *Sonneratia alba*
	2004-05	Palayad East	8.00	*Rhizophora apiculata* *Kandelia candel*
		Kuyyali	2.00	*Rhizophora apiculata* *Kandelia candel*
		Subtotal	**50.00**	

Table-1 : Contd...

Range	Year of planting	Location	Area (ha)	Species
Thaliparamba	2001-01	Madakkara North	2.50	*Rhizophora apiculata* *Kandelia candel* *Avicennia officinalis* *Sonneratia alba*
		Madakkara South	7.50	*Rhizophora apiculata* *Kandelia candel* *Avicennia officinalis* *Sonneratia alba*
		Madakkara-I	2.50	*Rhizophora apiculata* *Kandelia candel* *Avicennia marina* *Sonneratia alba* *Aeqiceras corniculatum*
		Madakkara-II	2.80	*Rhizophora apiculata* *Kandelia candel* *Avicennia marina* *Sonneratia alba* *Aeqiceras corniculatum*
		Madakkara-III	3.50	*Rhizophora apiculata* *Kandelia candel* *Avicennia marina* *Sonneratia alba* *Aeqiceras corniculatum*
	2002-03	Madakkara West	1.50	*Rhizophora apiculata* *Kandelia candel* *Avicennia marina* *Sonneratia alba* *Aeqiceras corniculatum*
	2003-04	Muttil-I	1.00	*Rhizophora apiculata* *Kandelia candel*
		Muttil-II	1.50	*Rhizophora apiculata* *Kandelia candel*
		Muttil-III	0.75	*Rhizophora apiculata* *Kandelia candel*
		Dhalil-I	10.00	*Kandelia candel*
		Dhalil-II	8.00	*Rhizophora apiculata* *Kandelia candel*
		Dhalil-III	8.00	*Rhizophora apiculata* *Kandelia candel*
		Subtotal	**49.55**	

Table-1 : Contd...

Range	Year of planting	Location	Area (ha)	Species
Kasaragod	2003-04	Talangara-I	13.40	*Rhizophora apiculata*
				Kandelia candel
	2004-05	Talangara-II	4.15	*Rhizophora apiculata*
				Kandellia kandel
				Aeqiceras corniculatum
		Arikkady	9.43	*Rhizophora apiculata*
				Kandellia kandel
		Mogral	6.25	*Rhizophora apiculata*
				Kandellia kandel
Kannavam	2004-05	Mahe riverbed	2.00	*Rhizophora apiculata*
		Subtotal	**2.00**	
		Grand total	**134.78**	

Table-2 : Growth Parameters and survival rate of Mangrove Plantations sampled in Kannur Division

Sl. No.	Range	Year of planting	Area (ha)	Location	Av height (m)	Av GBH/ collar girth (cm)	Survival rate (%)
1.	Kottiyoor	1997-98	3.00	Koduvally	5.5	33 (gbh)	68%
			3.00	Mathikavu	5.8	35 (gbh)	60%
		1998-99	6.00	Palayad diet	5.0	33 (gbh)	58%
			2.50	Palayad east	5.3	34 (gbh)	52%
		1999-00	3.00	Palayad University	4.2	30 (gbh)	56%
			3.00	Palayad east	4.0	31 (gbh)	55%
			4.00	Maidupalem Bridge	4.3	32 (gbh)	60%
		2000-01	2.00	Maidupalem Bridge	3.6	23 (cg)	65%
			2.00	Palayad east	3.2	20 (cg)	64%
		2001-02	2.50	Mazhappilangad	3.8	26 (cg)	64%
2.	Thaliparamba	2000-01	7.50	Madakkara South	3.5	22 (cg)	55%
		2001-02	2.50	Madakkara I	2.0	15 (cg)	60%
			2.80	Madakkara II	1.8	16 (cg)	58%
			3.50	Madakkara III	2.0	16 (cg)	62%
		2002-03	1.50	Madakkara West	2.0	14 (cg)	58%
		2003-04	1.00	Muttil I	1.30	12 (cg)	60%
			1.50	Muttil II	1.35	12 (cg)	62%
			0.75	Muttil III	1.4	9 (cg)	65%
3.	Kasargod	2003-04	13.40	Thalangara I	2.7	14 (cg)	80%
			4.15	Thalangara II	2.8	15 (cg)	80%
		2004-05	9.43	Arikkady	1.8	13 (cg)	83%
			6.25	Mogral	2.2	10 (cg)	85%

IV. STATUS OF MAN-MADE MANGROVE PLANTATIONS AND SILVICULTURAL TECHNIQUES ADOPTED IN KARNATAKA

As per the information provided by the Karnataka Forest Department, altogether about 1242.50 ha area is planted with mangroves (man-made mangrove plantations), out of which, in Honnavar Division 665.50 ha area is planted during 2000-01 to 2005-06, 190 ha in Karwar Division during 2002-03 and 2004-05, 227 ha in Mangalore Division during 1992-93, 1993-94 and 2002-03 and 160 ha in Kundapur Division during 1995-96 and 2002-03.

4.1 Honnavar Division

Honnavar Division lies within $13^0$56' to $14^0$41' North latitude and $74^0$26' to $74^0$46' East longitude. Entire Honnavar Division falls in North Kanara District. Honnavar Division has Karwar Division in the North Kanara District. Honnavar Division has Karwar Diviison in the North, Kundapur Division in the South, Sirsi and Sagar Division in the East and Arabian Sea on the West. The total forest area in the Division in 134082 ha includes 3115 ha of Gangavali valley high forest, 41963 ha of Island coastal forest, 38859 ha of interior high forest, 4648 ha of Soppinahosalli high forest and 45497 ha of minor forest. The Division includes entire Bhatkal, Honnaval, Kumta taluks and parts of Ankola taluk of North Kanara District. There are seven ranges in the Division viz., Hiregutti, Khatgal, Kumta, Honnavar, Manki, Geresoppa and Bhatkal Ranges.

Mangrove plantations are situated in Honnavar Division all along the Gangavalli and Aghanashini river beds in the confluence area with sea. All the mangrove plantations are managed by Honnavar, Territorial Division. The total area of mangrove plantations taken up by Honnavar Territorial Division was 665.50 ha during 2000-01 to 2005-06 (**Table-3**). In recent years, the amount of fresh water discharge into the mangrove wetland is reported to have reduced drastically. This is accompanied with high evaporation from the sea resulting in increase in the area under mangrove blanks in Honnavar Division.

4.1.1 Extent of Mangrove plantation

In Honnavar Division, totally 665.50 ha area has been restored under mangroves, covering in Kumta, Hiregutti, Katgal, Honnavar and Bhatkal Ranges (**Table-3**). In Kumta Range, the mangrove plantations are raised all along the Aghanashini riverbed. In

Hiregutti and Katgal Ranges, the mangrove plantations are raised in Gangavalli riverbed. In Honnavar Range the plantations are raised in left bank of Sharavathi riverbed and in Bhatkal Range, the mangrove plantations are raised in Venkatapur riverbed.

4.1.2 Species planted

As such there are about 10 species reported in the Division but among them *Rhizophora mucronata, Kandelia candel* and *Avicennia alba* are the chief mangrove species planted in Honnavar Division. Among these three species, *Rhizophora mucronata* is the dominant species planted in the entire division (>75% area) and the remaining area is planted with *Kandelia candel* and *Avicennia alba*. The seeds of *Rhizophora mucronata* are collected from older plantations for nursery although they do not occur in the natural mangroves in Honnavar Division. *Sonneratia apetala* and *Avicennia alba* are the major natural species in Honnavar Division.

4.1.3 Survival rate

In Honnavar Division, most of the mangrove restoration work was done in Kumta Range. During 2000-01 to 2005-06, the mangrove plantations have been raised in 328.25 ha (**Table-3**). The other Ranges in Honnavar Division, where the mangrove restoration work has been done are, Hiregutti Range (236.0 ha), Katgal Range (39.00 ha), Honnavar Range (41.00 ha) and Bhatkal Range (20.75 ha) during 2001-02 to 2005-06. The survival rate of the mangrove plantations raised in Honnavar Division ranged from 50-95 per cent. Higher survival rate of the plantations (95 per cent) was recorded in the Mirjan plantation site, Katgal Range raised during 2005-06 (**Table-4**). Lower survival rate was noticed in older plantations. However, due to more spread in crown canopy the older plantations exhibited fast growth in older plantations. It appears, that over a period of time, mortality rate is more which is mostly due to heavy floods, biotic interference, fishing and boating.

4.1.4 GBH / Collar girth and Height

In Honnavar Division, mangrove plants have recorded girth ranging from 5 cm (collar girth) - 41cm (GBH) and height ranged from 0.8 to 4.3 m. Higher GBH (41cm) and height (4.3 m) were recorded in older plantations raised during 2000-01 at Aghanashini-Masur-Lukkeri, Kumta Range. Lower height (0.8 m) and GBH (5 cm) was

recorded in younger plantations raised during 2005-06 at Kumta-Alwekodi-Kalbag, Kumta Range (**Table-4**).

4.2 Karwar Division

Karwar Division is situated within Northern latitude of $14^0 35'$ to $15^0 17'$ and Eastern longitude $74^0 5'$ to $74^0 42'$. Entire Karwar Division falls in North Kanara District. The Division is bounded by Haliyal Division in the north, Honnavar Division in the south, Yellapur and Sirsi Divisions in the east and Arabian sea in the West. Karwar Division has a total forest area of 144652 ha which include 143212 ha of Reserve Forests, 1204 ha of protected forests and 236 ha of Village Forests. Karwar Diivsion has Karwar, Gopshitta, Kadra, Joida, Ankola, Mastikatta and Ramanagulli ranges.

Mangrove plantations are raised in Karwar Division all along the gangavalli riverbed. All the mangrove restoration work was done by Karwar Territorial Forest Division. The total area of mangrove plantations raised by Karwar Territorial Division was 190.00 ha during 2002-03 and 2004-05 (**Table-5**).

4.2.1 Extent of mangrove plantations

In Karwar Division, totally 190.00 ha area has been planted under mangroves covering Karwar and Gopshitta Ranges (**Table-5**). In Ka rwar Range, the mangrove plantations taken up all along the gangavalli riverbed in 130.00 ha during 2002-03 and 2004-05. In Gopshitta Range, the total area under mangrove restoration during 2002-03 and 2004-05 was 60.00 ha (**Table-5**).

4.2.2 Species planted

There are about 10 species reported in the Karwar Division, *Rhizophora mucronata, Excoecaria agallocha, Avecinnia alba, Brugueira gymnorrhiza, B. cylindrica, Kandelia candel, Sonneratia alba* and *Rhizophora apiculata* are the chief mangrove species planted in Karwar Division. Among these species planted *Rhizophora mucronata* is the dominant species planted in both the ranges (Karwar and Gopshitta). More than 75 per cent of the area is planted with *Rhizophora mucronata, Sonneratia alba* and *Avecinnia alba* which are the major natural species found in Karwar Division.

4.2.3 Survival rate

In Karwar Division, most of the mangrove restoration work was done in Karwar Range (130 ha) during 2002-03 and 2004-05. Remaining 60 ha area of mangrove restoration was done in Gopshitta Range during 2002-03 and 2004-5 (**Table-5**). The survival rate of the mangrove plantations raised in Karwar Division ranged from 58-78 per cent. Higher survival rate of mangrove plantations (78 %) was recorded in Hotegali plantation site, Gopshitta Range raised during 2004-05. Lower survival rate (58 %) was recorded in Mavinahoel plantation site, Gopshitta Range raised during 2002-03 (**Table-5**).

4.2.4 Collar girth and Height

In Karwar Division, mangrove plants have recorded collar girth ranging from 10-15 cm and height ranging from 1.2 - 2.2m. Higher collar girth (15 cm) and higher height (2.2 m) were recorded in Mavinhole plantation site raised during 2002-03 at Gopshitta Range. Lower height (1.2m) and collar girth (10 cm) were recorded in younger plantations at Kanasgeri, Gopshitta Range raised during 2004-05 (**Table-6**).

4.3 Mangalore Division

Mangalore Division lies within $12^0$15' to $13^0$15' North latitude and $74^0$30' to $74^0$45' East longitude. Entire Mangalore Division falls in South Kanara District. The Division is bounded by Udupi District in the North, Kannur Division of Kerala in the South, Hassan and Chickmagalore Divisions in the East and Arabian sea in the west. The total forest area in Mangalore Division is 112816 ha. Mangalore Division comprises of eight ranges viz., Mangalore, Bantwal, Belthangadi, Puttur, Uppinangadi, Panja, Sullia and Subramanya ranges coming under Mangalore, Bantwal, Belthangadi, Puttur and Sullia revenue taluks of Mangalore District.

Mangrove restoration work was taken up in Mangalore Division in Nethravathi riverbed. All the mangrove restoration work was done by Mangalore Territorial Forest Division, Karnataka Forest Department. The total area of mangrove plantations raised by Mangalore Territorial Division is 227 ha during the years 1992-93, 1993-94 and 2002-03 (**Table-7**).

4.3.1 Extent of mangrove plantation

In Mangalore Division, totally 227 ha area has been restored under mangroves. Mangalore Range is the only coastal range in the Division. The plantations were raised in Mangalore Range during 1992-93, 1993-94 and 2002-03.

4.3.2 Species planted

There are about 5 species reported from natural mangrove forests in Mangalore Division, but the restoration work is done with *Rhizophora apiculata* and *Avecinnia alba*. These are the dominant species covered under restoration work in entire Mangalore Range. However, the major dominant natural species being *Sonneratia alba* and *Brugueria cylindrica*.

4.3.3 Survival rate

The survival rate of the mangrove plantations raised in Mangalore Division ranged from 50-72 per cent. Higher survival rate (72 %) was recorded in Thannirubhavi plantation site raised during 2002-03 in 10 ha. Lower survival rate (50 %) was recorded in older plantations raised in Ullala-I and Thannirubhavi-II during 1993-94 and 1992-93, respectively. However, these plantations have attained good growth (**Table-8**).

4.3.4 GBH / Collar Girth and Height

In Mangalore Division, mangrove species have recorded girth ranging from 9cm (collar girth) - 43cm (GBH) and height ranging from 2.1 – 7.1 m. Higher GBH (43 cm) and higher height (7.1 m) was recorded in Ullala-II (older plantation site) raised during 1993-94. Lower height (2.1 m) and collar girth (9cm) was recorded in younger plantations raised at Bengre during 2002-03 (**Table-8**).

4.4 Kundapur Division

Kundapur Division lies within $12^0 53'$ to 14^0 North latitude and $73^0 30'$ to $75^0 23'$ East longitude. Entire Kundapur Division falls in Udupi revenue district and parts of Belthangadi, Bantwal and Mangalore taluks of South Kanara district. The division is bounded by North Kanara district in the north, Mangalore Division in the South, Sagar,

Shimoga and Koppa forest divisions in the East and Arabian sea in the west. The total forest area in Kundapur Division is 114620 ha which include 55214 ha of reserve forest, 1873 ha of protected forest and 57533 ha of forests under wild life division. Kundapur division comprises of eight ranges viz., Byndoor, Kundapur, Shankaranarayana, Hebri, Karkala, Moodibidri, Udupi and Vencor Ranges.

In Kundapur Division, mangrove plantations are raised at Chakranadi, Kollurnadi, Haladynadi, Seethanadi and Swarnanadi riverbeds. The mangrove restoration work was done by Kundapur Territorial Forest Division, Karnataka Forest Department. The total area of mangrove plantations raised by Kundapur Territorial Division was 160 ha during the years 1995-96 and 2002-03 (**Table-9**).

4.4.1 Extent of mangrove plantation

In Kundapur Division, totally 160 ha area has been restored under mangrove plantations in Kundapur (115 ha), Byndoor (10 ha), Udupi (20 ha) and Moodibidri Ranges (15 ha) during 1995-96 and 2002-03 (**Table-9**).

4.4.2 Species planted

There area about 6 species reported growing naturally in Kundapur Division. The restoration work has been done with *Rhizophora mucronata* and *Brugueira gymnorrhiza.* The major species planted was *Rhizophora mucronata* (> 75 %). The major dominant natural species found naturally regenerated are being *Sonneratia alba* and *Avecinnia alba.*

4.4.3 Survival rate

In Kundapur Division, most of the mangrove restoration work was done in Kundapur Range during the year 2002-03 (100 ha). Older plantations were raised during 1995-96 in 40 ha. Remaining 20 ha plantations were raised during 2002-03 in Udupi and Moodibidri Ranges (**Table-9**). The survival rate of the mangrove plantations raised in Kundapur Division was ranging from 45-80 per cent. Higher survival rate of mangrove plantations (80 %) was recorded in Halkady-I plantation site raised during 2003-04. Lower survival rate (45 %) was recorded in Kothathattu plantation site raised during 1995-96. However, these older plantations have attained good growth (**Table-10**).

4.4.4 GBH / Collar girth and Height

The girth and height of mangrove plants in Kundapur Division ranged from 14cm (collar girth) - 42 cm (GBH) and 1.9 to 7.8 m, respectively. Higher GBH (42 cm) and higher height (7.8 m) was recorded in Kothathattu plantation site of Udupi Range raised during 1995-96. Lower collar girth and height was recorded in Uppunda plantation site of Byndoor Range raised during 2002-03 (14 cm and 1.9 m, respectively) (**Table-10**).

4.5 Silvicultural operations

4.5.1 Nursery practices

In all the four divisions in Karnataka the mangrove nurseries are located in the creek beds where the availability of slushy silt is abundant and the survival of seedlings is more. Mangrove species being viviparous, germinated seedlings drop into the inundated muddy water. These seedlings float up and down during tidal currents. For raising nursery, the pregerminated seedlings are collected during low tides and they are transplanted into the polythene bags of 8" x 12" size. These polythene bags are filled with slushy silt collected from the adjacent creek beds at the time of low tides. The polybagged seedlings are maintained in the nurseries for 3-6 months.

The polybag seedlings are arranged in the sunken beds and water is pumped into these beds for a day or two and then drain out the water to facilitate the planting of mangrove seedlings. Later, the sunken beds are inundated by pumping tidal water to maintain water level of 2" to 3" above the top of the bags. Casualties are heavy in the nursery during early stages and these are replaced continuously. Simultaneously, in order to replace casualties seedling beds are formed separately by puddling the soil and collected seedlings are planted in these beds at 2" to 3" apart. These seedlings will be used to replace casualties in the polybags. The nursery will be maintained by pumping water daily once till planting i.e. up to October-November. The seedlings grow to a height of 50-60 cm with pencil thick stems by end of October-November and planting will be started during January.

4.5.2 Selection of site for mangrove restoration

In all the four Divisions of Karnataka State where sampling was done the mud flats formed along the estuaries are selected for mangrove restoration work. Mud flats which

are slushy are selected which were formed due to improper exchange of fresh water, insufficient tidal mixing in dry seasons and resulted in high salinity conditions. The mangrove species are planted in mud flats. The soil should be high saline in nature, sticky and coupled with regular flushing of tidal water. Regular flushing of tidal water is observed in all the plantation sites which results in regulating salinity of the terrain, to facilitate maintenance and improvement of true mangrove vegetation. The mangrove species thrive well in water of 20 ppt salinity that is in inter tidal regions including estuaries.

The site for mangrove restoration are usually devoid of trees and shrubs. In Honnavar and Kundapur Divisions, mangrove restoration was undertaken in the places where natural mangrove vegetation was not there.

4.5.3 Planting

The seedlings of 50-60 cm height with pencil thick stem are planted on the shoulders of the mud flats by the end of November/December. In Karnataka, the planting technique used was crowbar technique and in pits of 30 x 30 x 30 cm. In some cases the planting was done scooping the mud flats and planted the seedlings. In few cases the propagules collected from the older plantations or from natural mangrove forests are directly dibbled in the plantation areas. Where ever there is a more slope which is more than high tide area, the plantation area is leveled to facilitate the flushing of water during high tide for plantation.

4.5.4 Species used for planting•

Rhizophora mucronata is one dominant species used for mangroves restoration followed by *Avicennia alba, Kandelia candel.*

4.5.5 Espacement

The espacement followed raising mangrove plantations in Karnataka is highly varied. Closer espacements were followed in all the 4 Divisions. The closer espacements followed were 0.5m x 0.5m, 0.5m x 1m and 1m x 1m. The closer espacement is followed to avoid continuous casuality replacement. In Kerala, the mangrove seedlings are given support with bamboo stick to get higher survival rate. Whereas in Karnataka, no such method is followed and hence, closer espacement is followed to avoid higher mortality.

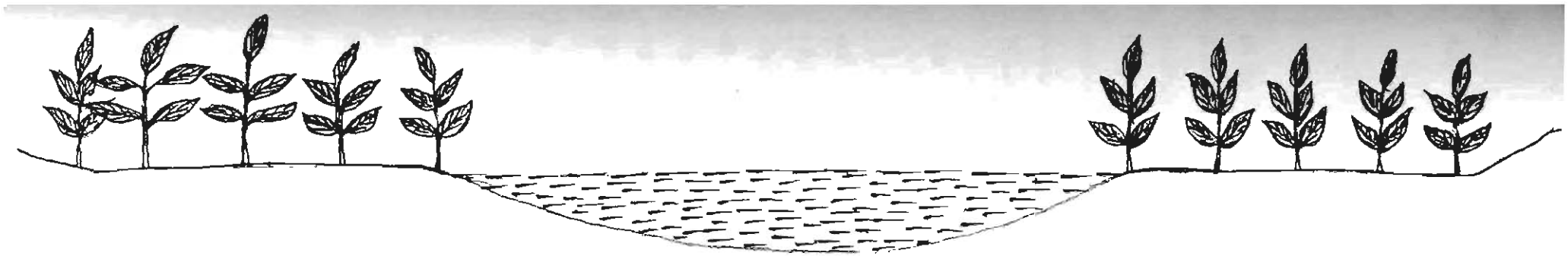

Fig-1 : Shoulder planting of mangroves in the mud flats as it looks during low tide

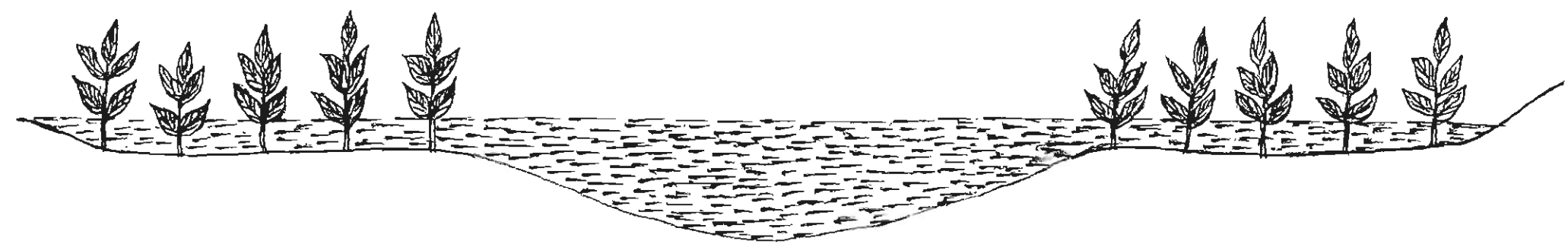

Fig-2 : Shoulder planting of mangroves in the mud flats as it looks during high tide

4.5.6 Age of the seedlings

Age of the seedlings planted varied from 3 months - 6 months. When six months old seedlings were used for planting it resulted in better survival rate.

Neither fertilizer application nor soil working was done for mangrove plantations in all the four Divisions of Karnataka state. However, in few plantations sites weeding was done to remove algae to facilitate good growth. No irrigation was given in any of the plantation sites. But during high tides, the water level rises there by water is coming into the plantations. Generally mangrove species are relatively free from pests. However, mulluscan snails build their shells on the stems of growing seedlings that is believed to hamper the growth of the seedlings. Casuality replacement of 10 – 20 was done twice in 1st and 2nd year after planting in all the four Divisions.

4.6 Protection

In Karnataka, barbed wire fencing was done in few plantations sites namely, Katgal and Hiregutti ranges of Honnavar Division. This fencing was provided to prevent the cattle and fisherman's boats. In addition to these, strict monitoring and supervision by the departmental staff has resulted in better restoration of mangrove plantations. Generally, all plantations are protected by appointing full time watchers. In Karnataka, the full time watchers were paid with a monthly salary of Rs.2,600/-. This provision of appointing watchers is there up to 3 years after planting. During this maintenance period the plantations were protected well and resulted in adequate survival rate.

4.7 JFM activities

No Village Forest Committees (VFCs) are formed for protection and restoration of mangroves in Karnataka. In most of the sites, there was a non-cooperation from the local people or local fishermen. They were thinking that the restoration work hampers their fishing activities. Karnataka Forest Department has to motivate the local people about the importance of mangroves and form Village Forest Committees (VFCs) for future management and protection of mangrove plantations.

Table - 3 : Mangrove plantations raised in Honnavar Division during 2000-01 to 2005-06

Year of Planting	Range	Location	Area (ha)	Species
2000-01	Kumta	Masur	12.50	*Rhizophora mucronata*
		Lukkeri	12.50	- do -
		Baad	12.50	- do -
		Kaagal	12.50	- do -
		Aghanashini	22.00	- do -
		Subtotal	72.00	
2001-02	Bhatkal	Venkatapur Riverbed	9.00	- do -
	Honnavar	Kasarkod	18.50	*Avicennia alba, Kandelia candel*
	Kumta	Masur-Lukkeri	16.00	- do -
		Baad-Kagal	11.00	- do -
	Hiregutti	Gangavalli Riverbed	21.00	- do -
	Kumta	Aghanashini Riverbed	41.00	- do -
	Hiregutti	Gangavalli Riverbed	23.00	- do -
		Subtotal	139.50	
2002 -03	Kumta	Masur-lukkeri	68.00	- do -
	Hiregutti	Bargi - gund	11.25	- do -
		Gund - Betkuli	11.25	- do -
	Bhatkal	Alwekodi (Shirali Section)	6.75	- do -
		Subtotal	97.25	
2003-04	Bhatkal	Alwekodi	5.00	- do -
	Kumta	Alwekodi	6.50	- do -
		Kagal-Baad	15.00	- do -
		Kagal-Masur	15.00	- do -
		Masur-Lukkeri	15.00	- do -
		Lukkeri-Hegde	15.00	- do -
		Kumta-Alwekodi	15.00	- do -
	Katgal	Paduvani	17.00	- do -
		Subtotal	103.50	

Table - 3: Contd...

Year of Planting	Range	Location	Area (ha)	Species
2003-04	Hiregutti	Bargi gazni land-Morba	15.00	*Rhizophora mucronata*
		Moralli-Mogta-Andle	15.00	- do -
		Juga-Ulware	15.00	- do -
		Subtotal	**45.00**	
2004-05	Kumta	Masur-Lukkeri	15.00	- do -
		Lukkeri-Hegde	3.75	- do -
		Lukker – Baad	3.75	- do -
		Kalbag-Alwekodi	2.50	- do -
	Hiregutti	Nushikote gazniland	35.00	- do -
		Subtotal	**60.00**	
2005 -06	Honnavar	Kasarkod(Sharavathi Riverbed)	22.50	- do -
	Kumta	Lukkeri-Hegde	3.75	- do -
		Alwekodi-Kalbag	3.75	- do -
		Alwekodi-Kumta	2.50	- do -
		Kumta -Alwekodi	3.75	- do -
	Katgal	Mirjan (Paduvani)	22.00	- do -
	Hiregutti	Nushikote-gazniland	90.00	*Avicennia alba, Rhizophora mucronata, Kandelia candel*
		Subtotal	148.25	
		Grand Total	665.50	

Table-4 : Growth Parameters and survival rate of Mangrove Plantations sampled in Honnavar Division

Sl. No.	Range	Year of planting	Area (ha)	Location	Av. height (m)	Av. GBH/Collar girth (cm)	Survival rate (%)
1.	Honnavar	2001-02	18.50	Kasarkod	3.1	33 (gbh)	63%
		2005-06	22.50	Kasarkod	1.1	6 (cg)	80%
2.	Kumta	2000-01	30.00	Aghanashini – Masur - Lukkeri	4.3	41 (gbh)	65%
		2001-02	27.00	Masur - Lukkeri -Baad- Kagal	2.8	32 (gbh)	70%
		2002-03	68.00	Masur - Lukkeri	2.6	30 (gbh)	65%
		2003-04	6.50	Alwekodi	2.4	26 (gbh)	70%
		2003-04	60.00	Kagal-Lukkeri -Masur-Hegde	1.8	28 (gbh)	72%
		2003-04	17.50	Kumta-Alwekodi -Kalbag	1.9	27 (gbh)	73%
		2004-05	25.00	Masur - Lukkeri -Baad	1.5	12 (cg)	80%
		2005-06	10.00	Kumta-Alwekodi -Kalbag	0.8	6 (cg)	85%
3.	Hiregutti	2001-02	23.00	Gangavalli Riverbed	2.5	18 (gbh)	70%
		2003-04	15.00	Bargigudi-Morba	1.6	12 (cg)	75%
		2003-04	15.00	Juga-Ulware	1.5	10 (cg)	76%
		2003-04	15.00	Moralli-Mogta- -Andle	1.20	8 (cg)	80%
		2004-05	35.00	Nurhikote	1.00	7 (cg)	83%
		2005-06	90.00	Morba-Nushikote	1.00	6 (cg)	85%
4.	Katgal	2003-04	17.00	Pudvani riverbed	1.25	6 (cg)	90%
		2005-06	22.00	Mirjan	1.00	6 (cg)	95%
5.	Bhatkal	2001-02	9.00	Shirali	2.6	16 (gbh)	50%

Table - 5 : Mangrove plantations raised in Karwar Division during 2002-03 to 2004-05

Year of Planting	Range	Location	Area (ha)	Species
2002-03	Karwar	Kodibag	20.00	*Rhizophora mucronata, Excoecaria agallocha, Avecinnia alba, Brugueira gymnorrhiza, Kandelia candel, Sonneratia alba, Rhizophora apiculata, Brugueira cylindrica*
		Sunkeri	20.00	- do -
		Halgejug	20.00	- do -
	Gopshitta	Devbag	20.00	- do -
		Kanasgeri	20.00	- do -
		Mavinhole	10.00	- do -
		Subtotal	110.00	
2004-05	Karwar	Kadwada	8.00	- do -
		Boviwada	7.00	- do -
		Railway bridge	10.00	- do -
		Kinnar Baat	12.00	- do -
		Kharge jug	8.00	- do -
		Amdalli	25.00	- do -
	Gopshitta	Saverpai	4.00	- do -
		Kanasgeri	2.00	- do -
		Hotegali	2.00	- do -
		Honkonjug	2.00	- do -
		Subtotal	**80.00**	
		Grand Total	**190.00**	-

Table-6 : Growth Parameters and survival rate of Mangrove Plantations sampled in Karwar Division

Sl. No.	Range	Year of planting	Area (ha)	Location	Av. height (m)	Av. GBH/Collar girth (cm)	Survival rate (%)
1.	Karwar	2002-03	20.00	Kodibag	1.9	12 (gbh)	60%
			20.00	Sunkeri	2.1	13 (gbh)	62%
			20.00	Halgejug	1.9	12 (gbh)	65%
		2004-05	8.00	Kadawada	1.4	10 (cg)	72%
			7.00	Boviwada	1.5	11 (cg)	74%
			25.00	Amdalli	1.5	12 (cg)	75%
2.	Gopshitta	2002-03	20.00	Devbag	2.1	14 (gbh)	60%
			10.00	Mavinhole	2.2	15 (gbh)	58%
		2004-05	2.00	Kanasgeri	1.2	10 (cg)	75%
			2.00	Hotegali	1.3	10 (cg)	78%

Table - 7 : Mangrove plantations raised in Mangalore Division during 1992-93, 1993-94 and 2002-03

Year of Planting	Range	Location	Area (ha)	Species
1992-93	Mangalore	Joppinamogru-I	10.00	*Avecinnia alba, Rhizophora apiculata,*
		Joppinamogru-II	10.00	- do -
		Sasihithlu-I	10.00	- do -
		Sasihithlu-II	15.00	- do -
		Thanniru Bhavi-I	10.00	- do -
		Thanniru Bhavi-II	15.00	- do -
		Bangra Kuluru-I	15.00	- do -
		Bangra Kuluru-II	10.00	- do -
		Subtotal	**95.00**	
1993-94	Mangalore	Bangra Kuluru-Kudru	11.00	- do -
		Nearseashore	12.00	- do -
		Ullala-I	12.00	- do -
		Ullala-II	12.00	- do -
		Ullala-III	13.00	- do -
		Joppinamorgru	5.00	- do -
		Celavuru-Padukodi	7.00	- do -
		Pavanje-Sasihithlu	10.00	- do -
		Sasihithlu	10.00	- do -
		Celavuru	5.00	- do -
		Surathkal	5.00	- do -
2002-03	Mangalore	Sampukuduru	10.00	- do -
		Bengare	10.00	- do -
		Thanniru Bhavi	10.00	- do -
		Subtotal	**132.00**	
		Grand Total	**227.00**	-

Table-8 : Growth Parameters and survival rate of Mangrove Plantations sampled in Mangalore Division

Sl. No.	Range	Year of planting	Area (ha)	Location	Av. height (m)	Av. GBH/Collar girth (cm)	Survival rate (%)
1.	Mangalore	1992-93	10.00	Joppinamogru-I	6.5	40 (gbh)	55%
			10.00	Joppinamogru-II	6.8	42 (gbh)	58%
			10.00	Thannirubhavi-I	6.6	40 (gbh)	52%
			15.00	Thannirubhavi-II	6.9	41 (gbh)	50%
			15.00	Bangrakuluru-I	6.5	38 (gbh)	52%
			10.00	Bangrakuluru-II	6.6	37 (gbh)	53%
		1993-94	12.00	Ullala I	7.0	42 (gbh)	50%
			13.00	Ullala II	7.1	43 (gbh)	51%
			5.00	Joppinamogru	6.5	38 (gbh)	54%
		2002-03	10.00	Sampukuduru	2.2	9 (cg)	68%
			10.00	Bengre	2.1	10 (cg)	70%
			10.00	Thannirubhavi	2.3	9 (cg)	72%

Table - 9 : Mangrove plantations raised in Kundapur Division during 1995-96, and 2002-03

Year of Planting	Range	Location	Area (ha)	Species
1995-96	Kundapura	Kodi-I & II	15.00	*Rhizophora mucronata*
	Byndoor	Paduvary-uppunda	10.00	*Brugueira gymnorrhiza*
	Udupi	Kothathattu	10.00	*Rhzophora mucronata*
	Moodbidri	Bappandu-Pavanje	5.00	- do -
		Subtotal	**40.00**	
2002-03	Kundapura	Uppina kuduru-I	10.00	- do -
		Haklady-Kalbelthuru-I	10.00	- do -
		Gujjady-Gangoli	10.00	- do -
		Hosadu	5.00	- do -
		Haklady-Katbel-Thuru-II	10.00	- do -
		Hemmadi-I	10.00	- do -
		Hemmadi-II	10.00	- do -
		Tallur	10.00	- do -
		Uppina Kudure-II	10.00	- do -
		Tarapathi	5.00	*Brugueira gymnorrhiza*
		Kambadakone	5.00	- do -
		Uppunda	5.00	- do -
	Udupi	Udyavara	10.00	*Rhizophora mucronata*
	Moodibidri	Pavanje	5.00	- do -
		Surathkal	5.00	- do -
		Subtotal	**120.00**	
		Grand Total	**160.00**	-

Table-10 : Growth Parameters and survival rate of Mangrove Plantations sampled in Kundapur Division

Sl. No.	Range	Year of planting	Area (ha)	Location	Av. height (m)	Av. GBH/Collar girth (cm)	Survival rate (%)
1.	Kundapur	1995-96	15.00	*Kodi*	7.2	40 (gbh)	60%
		2002-03	10.00	Uppinakuduru	2.8	18 (cg)	70%
			10.00	*Halkady I*	2.6	20 (cg)	80%
			10.00	Halkady II	2.6	19 (cg)	76%
			10.00	*Hemmadi I*	2.5	20 (cg)	78%
			10.00	Hemmadi II	2.6	21 (cg)	76%
			5.00	*Hosadu*	2.9	20 (cg)	74%
			10.00	Tallur	3.0	22 (cg)	73%
2.	Byndoor	1995-06	10.00	Paduvary	6.9	36 (gbh)	55%
		2002-03	10.00	Uppunda	1.9	14 (cg)	60%
3.	Udupi	1995-96	10.00	*Kothathattu*	7.8	42 (gbh)	45%
		2002-03	10.00	Udyavara	2.2	16 (cg)	62%

V. IMPACT OF MANGROVE PLANTATIONS IN KARNATAKA AND KERALA

The opinion gathered from the local people and the Forest Departments on the impact of mangrove plantations in Karnataka and Kerala is presented here under.

5.1 Reduction of wind velocity

As per the information gathered, successful mangrove plantations established in Karnataka and Kerala have reduced the wind damage by which it has benefited the easy movement of fishermen's boats.

5.2 Reduction of sand drift

The mangrove restoration work in Kerala and Karnataka have resulted in the reduced sand drift which was severe before the restoration work. This has resulted in creating more area of slushy nature for raising mangroves plantations which could be used. Sand drift areas are not suitable for mangrove plantations.

5.3 Reduction in salt spray on field crops

As per the information collected, successful mangrove plantations have reduced the salt spray on field crops which are nearby the mangrove plantation sites. This is an indirect benefit the local farmers have obtained from the mangrove plantations.

5.4 Reduction in the sea erosion of sea bank

The mangrove plantations have reduced the erosion of sea bank where severe back water flows. During heavy rains the base water causes severe sea erosion, but mangrove plantations have checked this erosion.

5.5 Effect on micro-climate

Due to mangrove restoration work in Karnataka and Kerala, the micro-climate of the areas have improved and helped in reducing the temperatures around the plantation areas. Mangrove plantations have made the environment fresh and oxygen rich.

5.6 Shelter for fishes and birds

The mangrove restoration work in Karnataka and Kerala have markedly attracted the bird population and have made the mangrove plantations convenient nesting places. The water sources around the mangrove plantations have also provided the birds for easy access of food (like fish and water insects). The mangrove plantations have also acted as breeding places for fishes and provided shelter thus improving the fish population and which is an indirect benefit for the fishermen.

5.7 Reduces damages during severe cyclonic storms

It is a known fact that mangroves reduce damages caused during severe cyclonic storms. As a live example, 2 km stretch of mangroves in Nagapattinam district has caused no life and property damage during Tsunami which hit the coastal Tamil Nadu in December 2004. Like wise in Karnataka and Kerala also, the mangroves have reduced the damages during severe cyclonic storms.

5.8 Benefits obtained by local people

The major benefits obtained by local people from these mangrove plantations are fodder for their cattle and firewood. The leaves of *Avicennia* species are highly palatable for cattle and local people have been benefited from these plantations. The dried twigs of mangroves are used as fuelwood by the local people and thus solved their fuel wood problem.

5.9 Employment generation

People in and around the mangrove restored areas in Karnataka are involving themselves in nursery raising and plantation work. So more employment has been generated for the people who are living in and around the mangroves restored areas/ mangrove plantation sites.

VI. OVERVIEW AND RECOMMENDATIONS

The mangroves are coastal tropical plant formations found along the border of the sea and lagoons, reaching up to the edge of the rivers to the point where the water is saline, growing in swampy saline soils frequently in undated during high tides. As per the Forest Survey of India (2003), the natural mangrove cover in Karnataka is 3 sq.km which is confined to North Canara district (2 sq.km) and Udupi district (1 sq. km). In Kerala, the natural mangrove cover is 8 sq. km which is confined to Kannur district (7 sq. km) and Ernakulam district (1 sq. km). In Karnataka, the change with respect to 2001 assessment, there is an increase in the mangrove cover by 1 sq. km. The natural mangrove cover in Kerala consisting of small and scattered patches, has been assessed for the first time by Forest Survey of India.

The livelihood security of major coastal communities in terms of food, fuel wood and shelter is traditionally derived from this ecosystem. As a consequence of anthropogenic pressure, huge blanks are formed in mangrove forests along the coastal areas of Kerala and Karnataka States. The Forest Departments of both states have taken up restoration works including afforestation, protection and conservation. Mangrove restoration work has been done very well in Andhra Pradesh and Tamil Nadu also and this Centre conducted a detailed survey and already documented its findings [Mangrove restoration work in Tamil Nadu State (RC, NAEB, Publ. 90) and Afforestation of mangrove blanks in East Godavari and Krishna Districts of Andhra Pradesh (RC, NAEB Publ. 108)]. Subsequently, it was thought desirable to study and document on the various afforestation and restoration techniques adopted in Kerala and Karnataka states and thus RC, NAEB, Bangalore undertook a study on "Restoration of Mangroves in Kerala and Karnataka States" during 2005-06.

The summarized information of mangroves restoration work carried out in Karnataka and Kerala is given below.

1) The total area restored under mangroves in Karnataka and Kerala is 1,242.50 ha and 134.78 ha, respectively. In Karnataka mangrove restoration work has been taken up in all the 4 coastal Territorial Forests Divisions namely Honnavar,

Karwar, Mangalore and Kundapur Divisions. Where as in Kerala, the major restoration work has been taken up in Kannur division (134.78 ha).

2) The major species used for plantation in Karnataka are *Rhizophora mucronata, R. apiculata, Avicennia alba, A. oflicinalis, Kandelia candel, Brugueira cylindrica, B. gymnorrhiza, Avicennia marina* and *Sonneratia alba*. Among these, *Rhizophora mucronata*, and *R. apiculata*, are the major species used under for raising plantations (> 75% of the area planted with these species).

3) The major species used for plantation in Kerala are *Rhizophora apiculata, Kandeila candel, Avecinnaia officinalis, Sonneratia alba* and *Aeqiceras corniculatum*. Among these *Rhizophora apiculata* and *Kandelia candel* are the major species used for raising plantations (>80 % of the area planted with these species).

4) Raising of tall seedlings (50 cm – 1m) and planting directly in the mud flats / slushy soils is the type of technique followed in and Karnataka and Kerala.

5) The planting techniques adopted in Karnataka are crowbar technique and planting in 30cm x 30cm x 30cm pits. Planting is also done by scooping the mud flats and planting seedlings. In few cases the propagules are collected from the older plantations or from natural mangrove forests and are directly dibbled in the plantation areas. In Kerala, the main planting method followed was by pit planting method in pits of 30cm x 30cm x 30cm size. The planted seedlings were tied to the bamboo stick which were inserted in the mud flats. Even though the mangrove restoration work has been a success in Karnataka and Kerala, improved planting methods can be adopted for better drainage of tidal water and further better survival rate mangrove plantations. Such improved methods of planting were not followed in Karnataka and Kerala States as compared to Andhra Pradesh and Tamil Nadu where improved methods of planting like trench method and herring bone channel method were followed which enabled flushing of water in and out of the trenches and thereby avoiding stagnation of tidal water or drying up of mud blanks and also resulting in better growth of mangroves.

6) The mangrove plantations are protected with bamboo fencing in Kerala and barbed wire fencing in some plantation sites of Karnataka. Full time watchers are appointed to protect the plantations in both the states. This has helped in better restoration of mangroves from biotic interference.

7) No JFMCs are formed in both Kerala and Karnataka to protect the mangrove plantations. However, the staff of both the states have convinced the people about the importance of mangrove forests. On the contrary, in Andhra Pradesh, Forest Department adopted Joint Forest Management concept to reduce the local people's dependency on mangroves. They have taken up welfare measures along with alternate income generating activities in the fringe villages. Vana Samrakshana Samithies and Mangrove Management units have been formed to ensure people's participation which has led to the successful restoration of mangroves. In Tamil Nadu, Forest Department and M.S. Swaminathan Research Foundation (MSSRF) have implemented Joint Mangrove Management (JMM) programme in the villages located around Picahavaram and Muthupet.

8) Forest Department staff of both Karnataka and Kerala have no doubt put their sincere efforts in monitoring and supervising the mangrove plantations. Thus, it has resulted in successful mangrove restoration and conservation.

RECOMMENDATIONS

1) In all the plantation sites, JFMCs are not formed. So JFMCs under JFM concept are to be formed and involve them in restoration and protection of mangroves.

2) Even though the mangrove restoration work had been a success in Karnataka and Kerala, no improved planting methods like one-sided fish bone method and one sided herring bone pattern of planting were not practiced in both the states. But these techniques have been successfully adopted in Andhra Pradesh and Tamil Nadu for mangrove restoration. Hence these methods can be adopted for better drainage of tidal water and further better survival of mangrove plantations.

3) Regenerating and afforested mangroves should be protected from encroachment, grazing and felling through fencing, patrolling and provision should be made for extending maintenance period for watch and ward. Boats should be given to the patrolling staff for strict protection, watch and ward.

4) In most of the areas, monoculture of *Rhizophora* species was found, but mixed species should be tried.

5) In Karnataka, at the time of planting out, the seedlings are not tied with the bamboo stick which has resulted in more casualties. Whereas in Kerala the casualties were less as the seedlings are given stacking with bamboo stick and the seedlings are intact with slushy mud which has resulted in better survival rate. Hence, in Karnataka this method can be adopted to reduce the casuality. In Karnataka, the survival rate is ranged from 45 - 95 per cent. In Kerala, the survival rate of mangrove plantation ranged from 52-85 per cent. Lower survival rate recorded in older plantations and higher survival rate was recorded in younger plantations.

6) The mangrove restoration work should be undertaken based on the soil analysis of mud flat and soil suitability. In some areas the mangrove soils do not have sufficient clay content but rather have more sand content. In such places where sufficient clay content is not there, different techniques and species have to be adopted which requires further research.

7) The problem of high salinity in the mud flat can be reduced by preparing the land well in advance before the onset of monsoon. This also promotes good establishment and growth of the seedlings or propagules planted.

8) Delay in funding for mangrove afforestation work has often resulted in postponement of land preparation and planting activities which resulting in poor survival rate.

9) In most of the areas there was no cooperation from the local people and local fishermen were thinking that the restoration work hampers their fishing activities.

In such areas, local people or fishermen should be convinced about the importance of mangrove restoration.

10) In some of the areas, there was a too much slope in the mangrove plantation sites which hampers the flushing of tidal water to the uplands. Hence, before taking planting in such areas the areas are to be leveled for free flushing of tidal water.

11) Less degraded mangrove forest areas should be declared as preservation plots to allow natural regeneration and to restore them to their prime status by isolating them from biotic pressures.

12) Afforestation / mangrove restoration work should be carried out in existing blank areas by digging continuous field channels which help in promotion of natural regeneration and also success of transplanted seedlings due to frequent inundation of tidal water. For the enrichment of estuaries or riverbeds, mangrove afforestation should be done in collaboration with Fisheries Department.

13) Research has to be done pertaining to pests and diseases of mangroves by developing of advanced restoration techniques including propagation methods, planting, techniques etc. to standardize suitable techniques to a given situation.

14) The wood of mangrove species has high calorific value and high oil content. The bark has high tannin content. A study on the economic importance has to be done and these benefits are to be made known to the local people.

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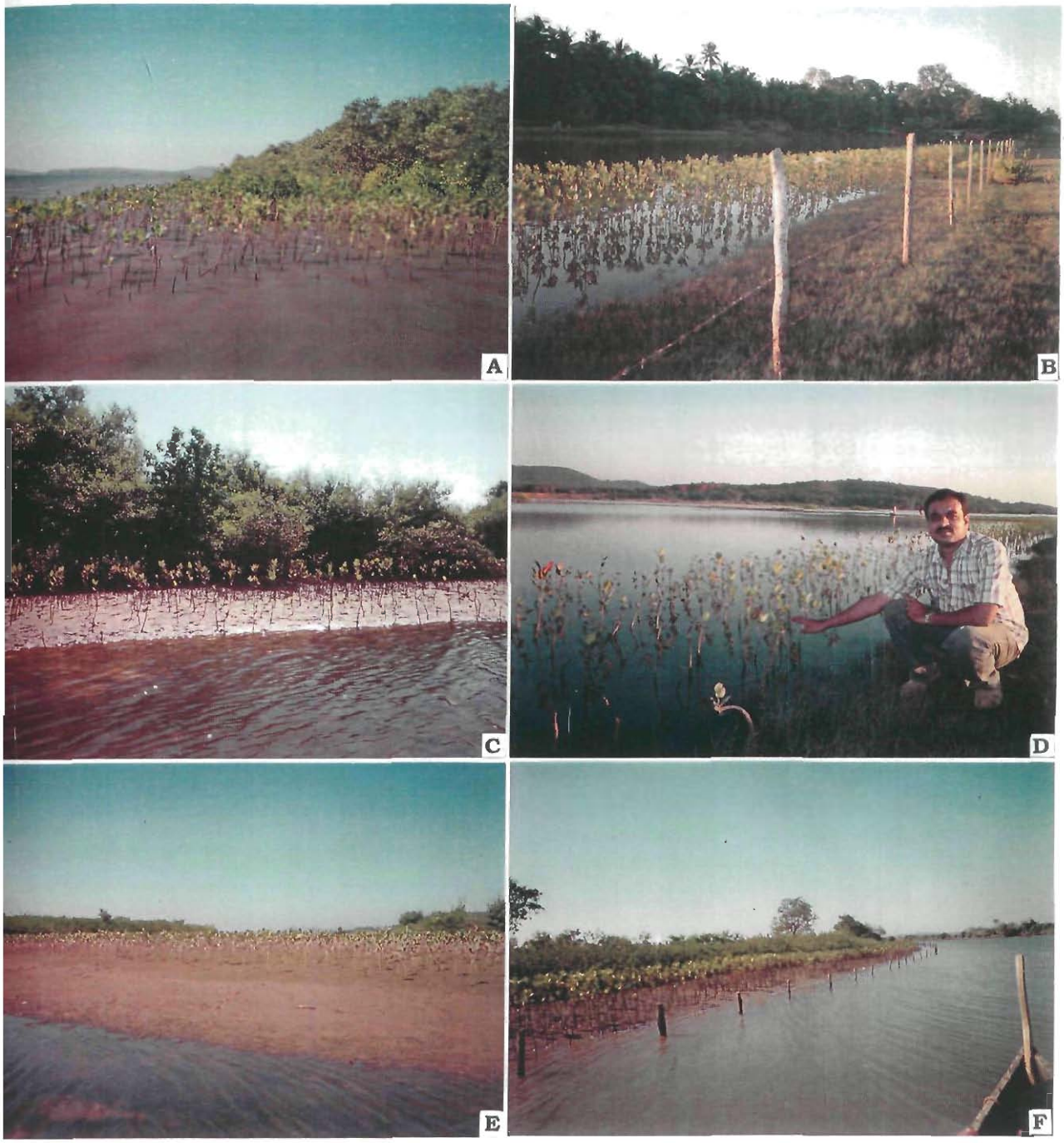
PHOTOGRAPHS


23 JAN 2007
Rpt. 15542

PLATE – I

(A) *Rhizophora mucronata* seedlings raised at Mavinhole nursery, Gopshitta Range, Karwar Division ; (B) *Rhizophora mucronata* seedlings raised at Hotegali nursery, Gopshitta Range Karwar Division ; (C) *Sonneratia caseolaris* seedlings raised at Kadawad nursery, Karwar Range and Division ; (D) *Sonneratia caseolaris* plantations raised during 2004-05 at Amdalli, Karwar Range and Division ; (E) *Rhizophora mucronata* plantations raised during 2003-04 at Kundapur Kasaba, Kundapur Range and Division ; (F) *Rhizophora apiculata* plantations raised during 2005-06 at Kasarkod, Honnavar Range and Division.

PLATE – II



(A) *Rhizophora apiculata* plantations raised during 2005-06 at Bergigundi, Hiregutti Range, Honnavar Division ; (B) & (C) *Rhizophora apiculata* plantations raised during 2004-05 at Nushikote, Hiregutti Range, Honnavar Division ; (D) *Rhizophora apiculata* plantation raised during 2003-04 at Paduvani, Katgal Range, Honnavar Division ; (E) *Rhizophora apiculata* plantations raised during 2005-06 at Paduvani, Katgal Range, Honnavar Division ; (F) *Rhizophora apiculata* plantations raised during 2005-06 at Bergigundi, Hiregutti Range, Honnavar Division.

PLATE – III

(A) *Rhizophora apiculata* plantations raised during 2001-02 at Kasarkod, Honnavar Range and Division ; (B) *Rhizophora mucronata* plantations raised during 2001-2002 at Shirali-Venkatapur riverbed, Bhatkal Range, Honnavar Division ; (C) *Rhizophara apiculata* plantations raised during 2003-04 at Paduvani, Katgal Range, Honnavar Division ; (D) *Rhizophora mucronata* plantations raised during 2003-04 at Hosadu, Kundapur Range and Division ; (E) *Rhizophora mucronata* plantations raised during 2002-03 at Thannirubhavi, Mangalore Range and Division ; (F) *Rhizophora mucronata* plantations raised during 2002-03 at Koderi, Byndoor Range, Kundapur Division.

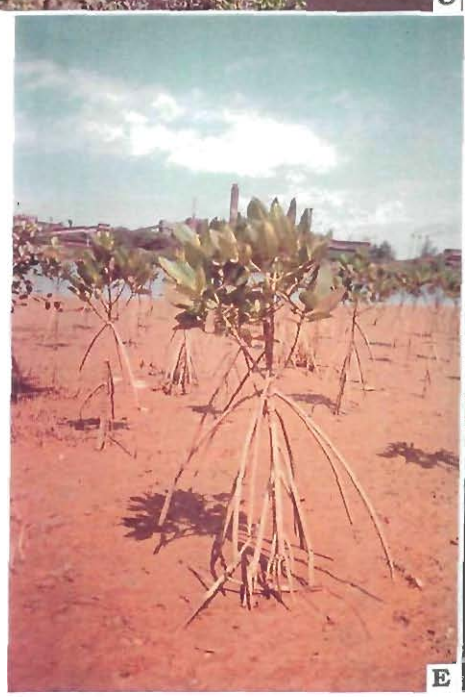
PLATE – IV


A


B


C


D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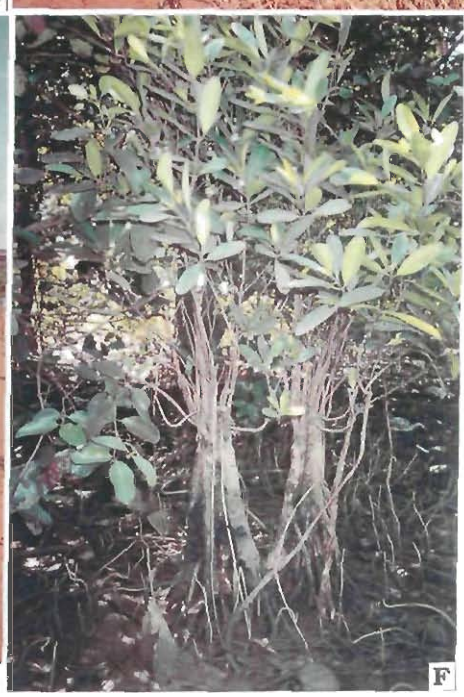

F

(A) *Rhizophora apiculata* plantations raised during 2001-2002 at Masur-Lukkeri, Kumta Range, Honnavar Division ; (B) *Rhizophora apiculata* plantations raised during 2001-02 at Kasarkod, Honnavar Range and Division ; (C) *Rhizophora apiculata* plantation raised during 2003-04 at Alwekodi, Kumta Range, Honnavar Division ; (D) *Rhizophora mucronata* plantations raised during 2002-03 at Thannirubhavi, Mangalore Range and Division ; (E) *Rhizophora mucronata* plantations raised during 2002-03 at Bengre, Mangalore Range and Division ; (F) *Avicennia officinalis* plantations raised during 1992-93 at Joppinamogaru, Mangalore Range and Division.

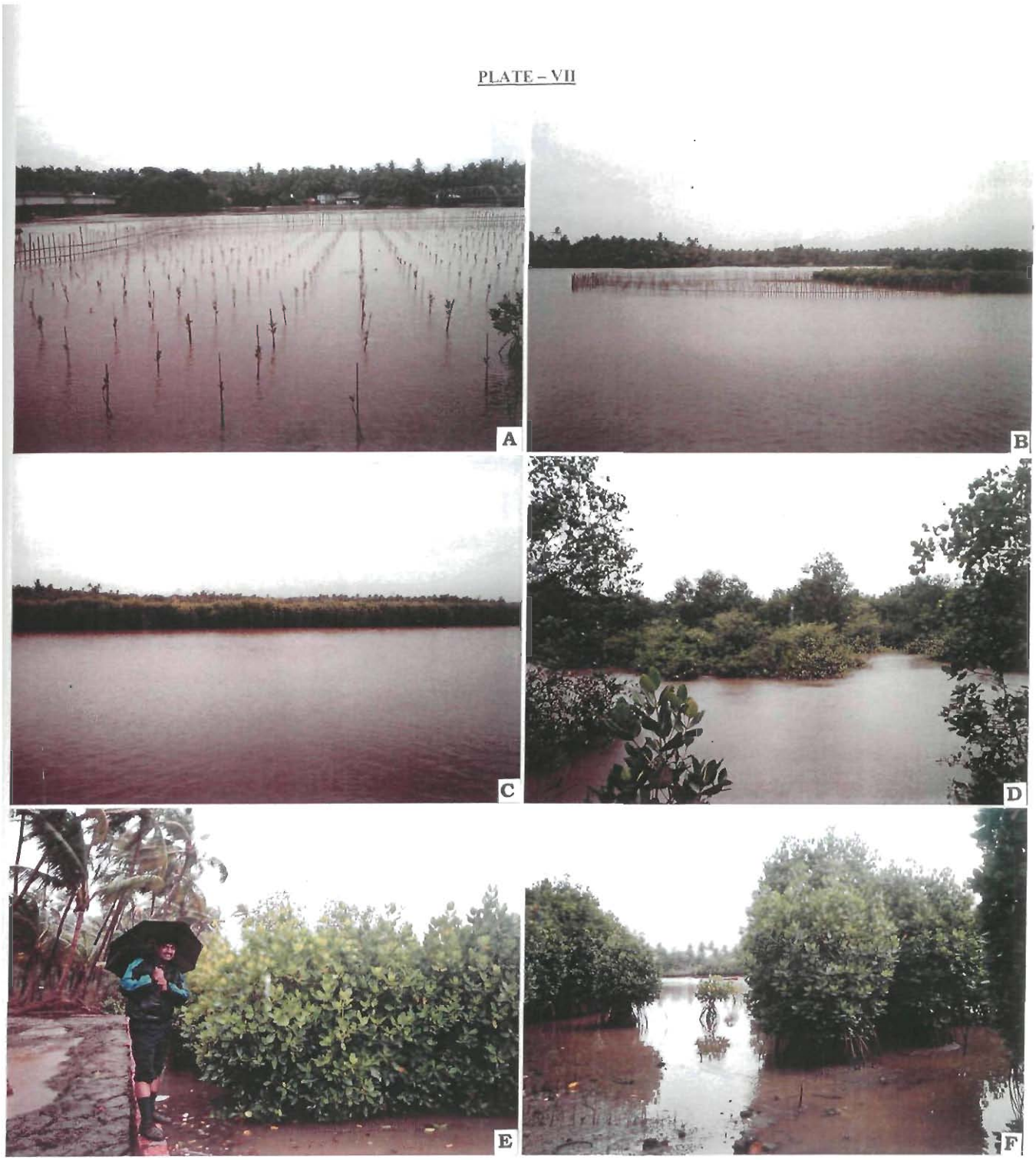
PLATE – V

(A) *Rhizophora mucronata* plantations raised during 2002-2003 at Tarapathi, Udupi Range, Kundapur Division ; (B) *Avicinia officinalis* and *Rhizophora mucronata* plantations raised during 1993-94 at Ullala, Mangalore Range and Division ; (C) *Rhizophora mucronata* plantations raised during 1992-93 at Thannirubhavi, Mangalore Range and Division ; (D) *Rhizophora mucronata* plantations raised during 1992-93 at Tallur, Kundapur Range and Division ; (E) *Rhizophora mucronata* plantations raised during 1995-96 at Udyavara, Udupi Range, Kundapur Division ; (F) *Rhizophora apiculata* plantations raised during 2001-2002 at Masur-Lukkeri, Kumta Range, Honnavar Division.

PLATE – VI

(A) *Rhizophora apiculata* plantations raised during 2004-05 at Palayad East, Kottiyoor Range, Kannur Division ; (B) & (C) *Rhizophora apiculata* plantations raised during 2004-05 at Thalangara, Kasaragod Range, Kannur Division ; (D) *Rhizophora apiculata* plantations raised during 2004-05 at Mogral, Kasaragod Range, Kannur Division ; (E) *Rhizophora apiculata* plantations raised during 1998-99 at Palayad Diet, Kottiyoor Range, Kannur Division ; (F) *Rhizophora apiculata* plantations raised during 1999-2000 at Palayad University, Kottiyoor Range, Kannur Division.

PLATE – VII



(A) *Rhizophora apiculata* plantations raised during 2005-06 at Maidupalem, Kottiyoor Range, Kannur Division ; Seedlings planted with bamboo sticks for support and fenced with bamboo stakes all along the boundary ; (B) *Rhizophora apiculata* plantations raised during 2005-06 at Koduvally, Kottiyoor Range, Kannur Division, Also observe bamboo fencing all along the boundary of the plantation ; (C) *Rhizophora apiculata* plantations raised during 1999-2000 at Maidupalem, Kottiyoor Range, Kannur Division ; (D) & (E) *Rhizophora apiculata* plantations raised during 2000-2001 at Madakkara South, Thaliparamba Range, Kannur Division ; (F) *Rhizophora apiculata* plantations raised during 1997-98 at Koduvally, Kottiyoor Range, Kannur Division.

PLATE VIII

Trench method of planting and restoration of mangrove as followed in Andhra Pradesh and Tamil Nadu

A. One year old *Rhizophora mucronata* planted in dugout artificial creeks at Pichavaram, Tamil Nadu.

B. Desilting and planting operations being carried out to provide free flow of sea water in the feeder cannels at Nagapattinam, Tamil Nadu.

C. Trenches being dugout for mangrove plantation by M.S. Swaminathan Research Foundation (MSSRF) at Krishna Wildlife Sanctuary, Sorlagundi, Andhra Pradesh.

D. *Rhizophora mucronata* and *Avicennia marina* raised in trench method of planting system at Maravakadu, Muhupet, Tamil Nadu.

ANNEXURE

REGIONAL CENTRE
NATIONAL AFFORESTATION AND ECO-DEVELOPMENT BOARD
(Ministry of Environment and Forests, Govt. of India)
UNIVERSITY OF AGRICULTURAL SCIENCES,
GKVK, BANGALORE - 560 065

Restoration of Mangroves in Kerala and Karnataka

SCHEDULE
(General Information from Kerala and Karnataka Forest Departments)

1. **Location details**

   a. Circle :

   b. Division :

   c. Range :

   d. Name of the village :

   e. Distance from seashore :

2. **Category of land** : Area (ha)

   a. *Forest land* : .....

   b. Community land : .....

   c. PWD land : .....

   d. Government Revenue land : .....

   e. Any other land : .....

3. **Mangrove forest details** :

   A. Length of the mangrove : .....

   B. Width of the mangrove : .....

   C. Area of the mangrove : .....

   D. Impact of mangrove restoration work

      i) Total mangrove blanks ..... (ha)

      ii) Mangrove blanks covered under restoration ..... (ha)

      iii) Left over mangrove blank ..... (ha)

E. Name of the species

i) Year of planting : .....

ii) Age : .....

iii) Density : ...../ha

iv) Spacing : .....

F. Major dominant natural species

G. i) Type of plantation : (a) Block
(b) Strip
(c) Mixed
(d) Mono species

ii) Restoration may be by : (a) Raising plantations
(b) Aided natural regeneration -
- Seeding
- Protection
- Special technique

H. Survival percentage and growth observations :

Species	I	II	III	IV	V	Total	Mean	Survival %	Effectiveness of techniques adopted	Crown cover
Plant height (m) 1. 2. 3. 4. 5.										
GBH / collar girth (cm) 1. 2. 3. 4. 5.										

I. If mangrove restoration work adopted :

Types of restoration works

(a) Nursery techniques and materials

i) Viviparously / pre germinated seeds sown in poly bags

ii) Wildings / nematophores collected from sea and transplanted in polybag

iii) Tissue cultured seedlings

iv) Height of the seedlings when planted - < 45 cm / < 1 mt / > 1 mt

v) Dibbling of seeds

(b) Planting season and size of pit or trench adopted for better survival

(c) Fertilizer application, Yes/ No

If yes, mention the quantity and time of application

(d) Soil working and weeding Yes/No

If yes, mention the stage and time of weeding (no. of weedings)

(e) Irrigation If Yes

i) Mention the number of irrigations and method of irrigation

ii) If trench method of irrigation and mention the size of trench

(f) Pest, disease and weed management, if any Yes/No

(i) If yes, mention name of chemical, time of application and quantity of chemical.

(ii) Social fencing through EDC/JFM

(iii) Fencing : Charges .....:...../ha

(iv) Watch and ward : Labor charges/month/.....ha

(g) Extent of participation by local people

J. Any benefits or material obtained by people from mangrove forest - Food / Fuel wood / Fodder / Any others

4. Impact of mangrove restoration in mitigating harsh effect of cyclone

- Reduces wind velocity	Yes/No
- Reduces sand drift	Yes/No
- Stabilizes sand	Yes/No
- Reduces salt spray on field crops	Yes/No
- Reduces erosion of sea bank	Yes/No
- Reduces damages during severe cyclonic storms with hurricane winds	
- Fully	Yes/No
- Partially	Yes/No
- Not effective	Yes/No
- Reduces damages during normal cyclonic storms	
- Fully	Yes/No
- Partially	Yes/No
- Not effective	Yes/No
- Need of shelterbelt in without shelterbelt area	Yes/No

5. Factors responsible for success for mangrove restoration and conservation

i) Timely planting
ii) Planting of tall seedlings
iii) Application of soil amendments
iv) Providing irrigation through feeder channels
v) Social fencing through EDC/JFM
vi) Fencing
vii) Watch and ward
viii) Any others

6. **Problems in establishment of mangroves :**

(a) Sand dunes
(b) Alkaline soils
(c) Increase in salinity
(d) Poor moisture retention
(e) Sea weeds
(f) Molluscan shells
(g) Lack of aeration and oxygenation
(h) Full submergence
(i) Other causes

7. **Technologies adopted to increase the survival per cent**

(a) Deep pit
(b) Planting of tall seedlings
(c) Timely planting
(d) Any others

Discussed with DCF/ACF/RFO : .....

Signature with seal

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