Manual on Mangrove Nursery Raising Techniques

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Foreword

There is now much public awareness of the need to conserve the remaining mangrove forests and also to rehabilitate the degraded mangrove wetlands. This awareness is growing among coastal communities, particularly because of severe storms and also because of the linkages between exudates from mangrove roots and sustainable fisheries. So far the propagation and planting of mangrove trees have remained essentially a responsibility of Forest Departments. It is clear that unless local communities are also involved in the raising of nurseries and rehabilitation of damaged mangrove wetlands, the tasks of conservation and restoration will not be accomplished speedily and effectively.

It is in this context that this manual on Mangrove Nursery Raising Techniques assumes significance. I hope this Manual will help women and men living in coastal areas to raise nurseries and to raise mangrove forests along the coast. This will lead to a concurrent strengthening of the livelihood and ecological security of coastal areas. I thank Drs T Ravishankar and R Ramasubramanian for preparing this manual. I hope it will be widely used and will promote a community mangrove afforestation movement.

M. S. Swaminathan

M S Swaminathan

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Contents

Acronyms

AFBO	-	Assistant Forest Beat Officer
APFD	-	Andhra Pradesh Forest Department
EDC	-	Eco-Development Committee
ha	-	Hectare
IFS	-	Indian Forest Service
IUCN	-	International Union for the Consevation of nature and natural resources
MMU	-	Mangrove Management Unit
MSSRF	-	M.S. Swaminathan Research Foundation
NGO	-	Non-Government Organization
ppt	-	Parts per thousand
PRA	-	Participatory Rural Appraisal
RF	-	Reserve Forest
sq km	-	Square kilometres
VLI	-	Village level institution
VSS	-	Vana Samrakshana Samithi

Manual on Mangrove Nursery Raising Techniques

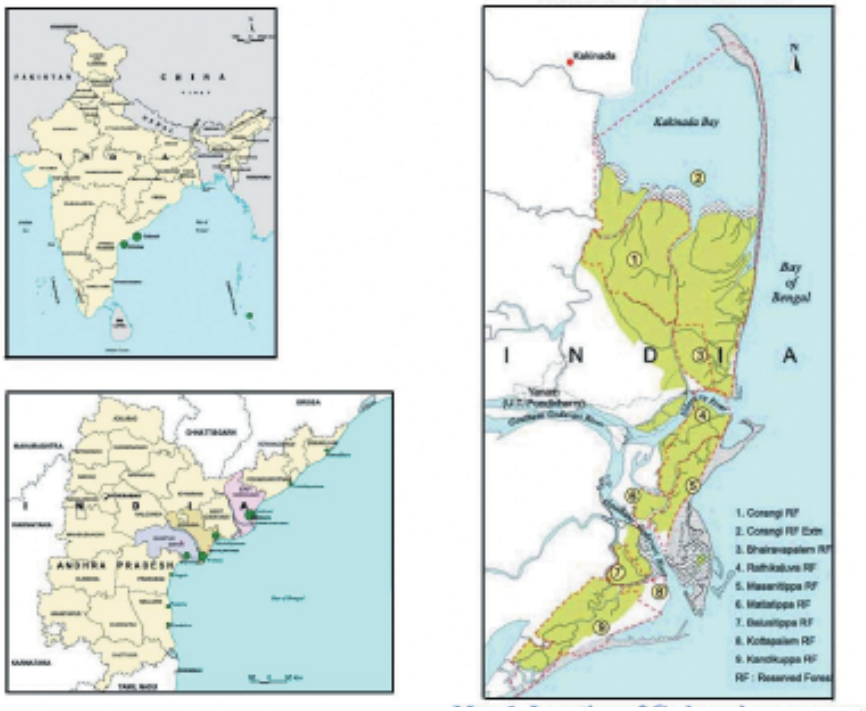
1. Introduction

Mangroves are known to provide shelter, act as nursery grounds and are also habitats for economically important fishes, prawns, crabs and molluscs. In addition to from providing nutrition in the form of detritus, mangroves also play an important role by improving water quality and controlling coastal erosion caused by flooding and storm surges. They also act as a barrier during cyclones and protect the coastline.

It is estimated that mangrove forests occupy 75% of the tropical coasts worldwide and are distributed in approximately 18.15 million ha. India's mangrove wetlands range from 6,81,000 ha. (Sidhu, 1963) to 5,00,000 ha. (FSI, 1999) (Map-1). The mangrove forests in Andhra Pradesh are located in the estuaries of the Godavari and Krishna rivers. The Godavari mangroves are located in the Godavari estuary of East Godavari district and the Krishna mangroves in the Krishna estuary of Krishna and Guntur districts (Maps 2 & 3). Apart from these estuaries, mangroves are also

Size of the circle indicates the extension of distribution

Map 1. Distribution of Mangroves in India



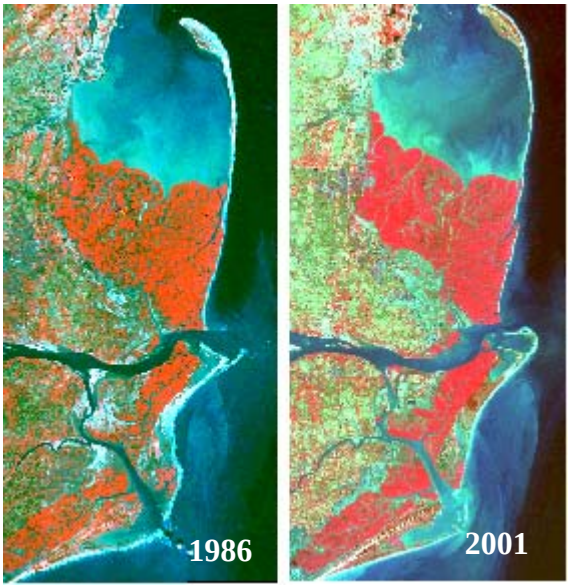
Map 2. Location of Godavari Mangroves

Map 3. Location of Krishna Mangroves

found in small patches along the coast of Visakhapatnam, West Godavari, Guntur and Prakasam districts. The total area under Godavari and Krishna mangrove wetlands is 58,263 ha of which 33,263.32 ha are under Godavari and 24,999.47 ha are in Krishna. However, the dense mangroves in Godavari and Krishna are only 17,000 ha and 7,347 ha respectively. The rest are distributed between mudflats, water bodies, sand bodies and casuarina plantations. Due to anthropogenic pressures and increased land use practices such as conversion of mangroves into agriculture and aquaculture ponds, the mangrove area has reduced to less than 50% of the original total cover. In addition to this, geomorphological changes, like elevated topography of the mangrove area, prevent free movement of tidal water and fresh water inflow into mangroves. This has resulted in increase in salinity and caused degradation of mangroves. Conversion of mangrove forests into aquaculture ponds has resulted in the exposure of acid-sulphate soils and increased the levels of salinity. As a result, the soils have become unsuitable for the natural regeneration of mangroves.

In order to overcome the issue of reduction in mangrove cover, attempts were made by government and non-government organizations to restore the mangroves wherever possible. In Andhra Pradesh, MSSRF, jointly with eight village level institutions (namely Sri Vigneswara EDC, Matlapalem, Sri Nookalamma EDC, Dindu, Sri Devi EDC, Kobbarichettupeta, Sri Kanakadurga EDC, Gadimoga, Dr. B.R. Ambedkar VSS, Bhairavalanka, Dheenadayaljee EDC,Dheenadayalapuram, Zinkapalem EDC, Zinkapalem and Sri Sita Rama Lakshmana EDC, Nali) and the Andhra Pradesh Forest Department, has restored 520 ha. The restoration has improved the mangrove forest cover (Remote sensing images of Godavari and Kridhna mangroves - 1986 & 2001). It has also arrested further degradation of mangroves adjoining the degraded patches and increased the fishery resources. The bio-diversity of the area has improved. The crab

population in the restored areas has increased due to the increased water regime. Since the work involves intensive labour, the



Godavari Mangroves

1986 2001

Krishna Mangroves

members of the village level institutions were benefitted by the employment opportunities generated. To restore the degraded areas, mangrove seedlings were raised in mangrove nurseries by developing nursery techniques. These techniques were developed by applying standard propagation and rearing methods followed in the project *"Coastal Wetlands: Mangrove Conservation and Management"*, which was implemented from 1996 to 2003 by M.S. Swaminathan Research Foundation with its regional centre at Kakinada. This project was supported by India Canada Environment Facility, New Delhi.

The techniques for mangrove nursery design, establishment and operation, and the use of nursery stock for mangrove restoration, which are described in this Manual will help in raising mangrove nurseries and in the restoration of degraded mangroves, involving local communities.

2. Natural regeneration of mangroves

Mangroves regenerate naturally when the conditions are suitable for their growth and establishment and also when the adjacent atmosphere suits the ecological niche. These conditions prevail in places where the natural course of tidal influx and river water flow occurs. Mangroves, like any other forest ecosystem, regenerate as a cyclic phenomenon. Each species has its distinguished character of regenerating: by seeds in the case of species such as *Excoecaria agallocha, Sonneratia apetala* and by viviparous germination through propagules in the case of *Rhizophora apiculata, R. mucronata* and *Bruguiera gymnorrhiza*. Natural regeneration occurs particularly in the accreted areas along the seaward side.

However, due to changes in geomorphological and hydrological conditions, the natural regeneration of mangroves is hindered. In the Godavari mangroves, the degraded areas near the old lighthouse near Gaderu River receive increased tidal flushing due to the breach in the sand spit of Hope Island during the 1996

cyclone. This increase in tidal flushing has resulted in the regeneration of mangrove species, namely *Avicennia marina* and *Excoecaria agallocha,* but only till the time the breach was opened. The mangroves are also establishing in the newly accreted mudflats near the river mouths which are inundated daily by the natural cycle of spring and neap tide.

3. Need for mangrove nurseries

The season for flowering, fruiting and production of seeds and propagules are not the same as the season of planting in degraded areas. The fruiting season of nursery raised saplings viz. *Avicennia marina* and *Avicennia officinalis,* which are mainly used in restoration, is October to November. However, the areas will be suitable for planting only during July to November. Hence, the seedlings raised during the first year will be used for planting in the second year, due to the mismatch of seasons between fruiting and planting. It was also seen during the implementation of the project from 1997 to 2003, that the rate of survival of nursery raised saplings is 50% greater when compared to direct dibbling of seeds. The casualty is due to the reason that the crabs damaged the sprouting seeds by eating the hypocotyle. The chemical reaction that takes place in the sprouting seeds emits a gaseous smell

that attracts the crabs. It has been observed by the mangrove project of IUCN, Bangladesh, that the seeds kept in running water had a better survival rate (personal communication of Mr. Junaid Chaudhary with Dr. T. Ravishankar).

The major requirements for a mangrove nursery site are

- areas with periodic inundation
- access to good quality salt and fresh water
- pumps for pumping saline water from the creeks for the saplings
- access to road/creek to mobilize transport and labour to the planting sites and
- good quality propagation stock.

3.1. Advantages of mangrove nurseries

The establishment of a nursery has several advantages. The survival rate of nursery raised seedlings in restoration areas is high (90%) when compared to the direct dibbling of seeds / propagules. This is due to the fact that nursery-raised saplings have a well established root system, as they are maintained for 8-9 months in the nursery (from October to July) under simulated conditions, before being transplanted in the degraded areas, which were under high saline conditions for long periods.

4. Selection of site for the mangrove nursery

The mangrove nursery site should be selected in the inter-tidal area, in close proximity to creeks with drainage into canals. The water quality should be good and the area should be fenced with barbed wire, to prevent grazing by feral cattle inhabiting the mangrove forests. It should be connected by road and waterways, to reduce the cost of transportation of seedlings from the nursery to the restoration site. It should be provided with water pumping facility by the Forest Department, especially during summer.

Channels for inflow and outflow of tidal water should be dug to facilitate natural inundation as shown in chart 1.

5. Selection of mangrove species

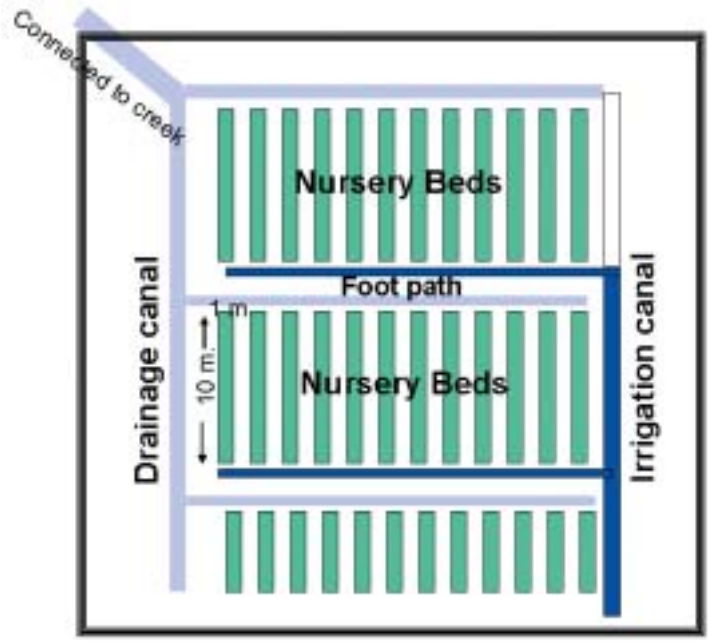


Chart 1. Mangrove Nursery Layout

Mangrove species should be selected, based on the salinity of the degraded area or the area chosen for afforestation. Nine mangrove species were selected for raising in the mangrove nursery (Table-1). The first three species were raised for planting in the degraded area to increase forest cover, bring back the greenery and enable the bird species to come back. The other six mangrove species were raised for planting in the degraded area in order to maintain genetic diversity.

5.1. Collection of seed material and planting in the nursery

Mature and healthy fruits / propagules were collected from the forest in the morning, involving locally trained villagers and kept in the shade. The fruiting season for a majority of the mangrove

species in Godavari is between September and December. Except *Sonneratia apetala* and *Aegiceras corniculatum* all other species were gathered from good quality fallen propagules. The collected seeds were examined for incidence of diseases or pests.

Seeds of *Avicennia marina* and *Avicennia officinalis* were collected from the ground beneath the trees during low tide.They were stored in separate bags and labeled. Floating propagules of *Rhizophora apiculata, Rhizophora mucronata, Bruguiera gymnorrhiza* and *Xylocarpus moluccensis* were collected from

Table 1. Details of mangrove species and the planting material

S.No	Mangrove Species	Planting material	Purpose
1.	*Avicennia marina* (Forsk.) Vierh.	Fruits	Planting in degraded areas
2.	*A. officinalis* L.	Fruits	Planting in degraded areas
3.	*Excoecaria agallocha* L.	Young seedlings	Planting in degraded areas
4.	*Aegiceras corniculatum* (L.) Blanto	Propagules	Planting for genetic diversity
5.	*Bruguiera gymnorrhiza* (L.) Savigny	Propagules	Planting for genetic diversity
6.	*Rhizophora apiculata* Bl.	Propagules	Planting for genetic diversity
7.	*R. mucronata* Lamk.	Propagules	Planting for genetic diversity
8.	*Sonneratia apetala* Buch.-Ham.	Seeds	Planting for genetic diversity
9.	*Xylocarpus* moluccensis (Lamk.) M.Roem.	Seeds	Planting for genetic diversity

the creeks using hand nets. Mature seeds of *Aegiceras corniculatum* were collected from the trees. The collected seeds and propagules were kept in either polythene bags or in jute sacks and transported to the nursery.

5.2. Identification of mature propagules

Rhizophora mucronata can be easily identified from *R. apiculata* by its larger size and green colour. The seeds were planted within a day or two of collection, as delay in planting reduces the rate of germination. Young seedlings of *Excoecaria agallocha* (about 2" height) were collected locally in the morning and planted directly in the bags in the evening. The mature fruits of *Sonneratia apetala* can be easily identified by change in the colour from pale green to deep green. The taste of the fruit becomes sour as it matures.

5.3. Fruiting season

Field observations in Coringa Wildlife Sanctuary in Godavari mangroves indicated that the ideal season for collecting the propagules is from September to December. However, *Bruguiera gymnorrhiza, Rhizophora apiculata* and *R. mucronata* bear fruits throughout the year, though the peak fruiting season is during August – November. The viability of the seeds depends on the age of the tree. For eg. *Rhizophora* is able to produce fruits from the age of four years, but the propagule should be collected from the trees older than 5 years i.e. trees which are taller than 5-6 m.

5.4. Identification of mangrove species

The species can be identified with the help of *Flora of the Presidency of Madras* by Gamble (1915-38), *Mangroves in India – Identification of Mangroves* by Banerjee *et al.* (1989) and *Mangroves of Andhra Pradesh - Identification and Conservation Manual* by Ramasubramanian *et al.* (2003).

6. Techniques in preparing the nursery

6.1 Soil

Only muddy soil which is clayey should be used for preparing the nursery bags. The soft clayey mud available in the mud flats during low tide should be collected. Any debris or hard material should be removed before filling the bags with mud.

6.2 Nursery bags

Polythene bags of 5"x8" should be used to raise the mangrove saplings in the nursery. Mud from nearby creeks should be collected

and used to fill the polythene bags. Small perforations should be made at the bottom of the bag in order to drain excess water. The filled bags should be kept in the shade to harden.

6.3 Preparation of nursery beds

The mangrove nursery which was raised jointly by Andhra

Pradesh Forest Department and MSSRF for restoring about 1,500 ha has the capacity to raise 1,20,000 saplings per year. It has 80 sunken beds of 10 x 1 x 0.3 m (LBH respectively). Each bed can hold 1500 bags. Bamboo poles were placed horizontally at both the ends and also in the middle to keep the bags intact. The nursery

bags were placed inside the beds, which were then flooded to a depth of about 10 cm. The nursery sites and beds may be prepared according to the number of seedings.

6.4 Sowing

Viviparous seeds of *Rhizophora apiculata, R. mucronata* and *Bruguiera gymnorrhiza* were planted directly in the bags placed in the beds. Similarly, young seedlings (about 2" height) of *Excoecaria agallocha* collected from the forest and *Sonneratia apetala* from the primary bed were planted directly in the bags. However the seeds of *Avicennia marina*, *A. officinalis* and *Xylocarpus moluccensis* were sown in bags kept outside and were transported to the nursery bed after germination.

6.5 Application of Fertilizers

Inorganic fertilizers like N:P:K 17:17:17, Di-Ammonium Phosphate and Urea were added after 60 days for better growth of the mangrove seedlings, so as to ensure root establishment. A micronutrient mixture may also be added to enhance the growth of the saplings.

6.6 Grading

The sapling bags were shifted periodically and the empty bags were separated. Shifting of bags with seedlings helps in preventing rooting into the soil.

6.7 Pest control

The seedlings were periodically checked for pest or wood borer damage as the sprouting seeds / propagules are susceptible to caterpillar damage. Pesticide was sprayed when pest attack was severe. The water from the beds was drained completely before applying the pesticide in order to avoid the spread of pesticide residue to other areas.

7. Nursery techniques for different species

Nursery techniques differ from one species to another, depending on the salt tolerance level and the ecological zone. In the following pages, guidelines that should be followed for each species are described. Comprehensive details are given in Tables 2 & 3 and Chart 2.

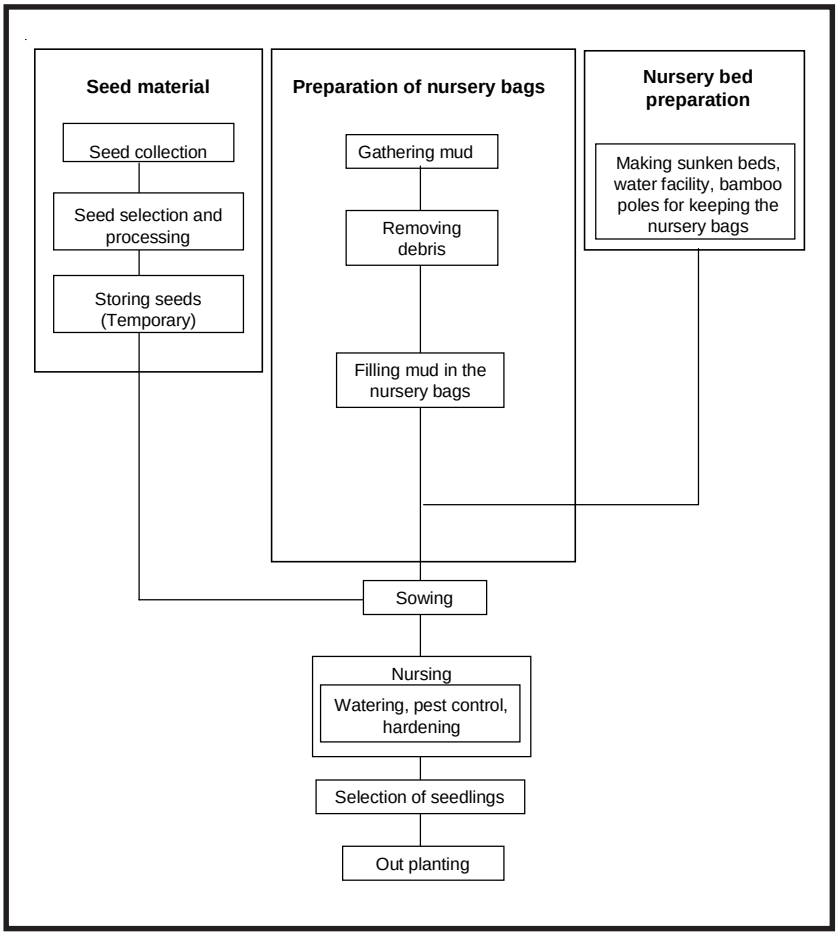
Table 2. Details of mangrove species, sowing and maintenance in the nursery

Species	Seed characteristics				Sowing	Nursing	
	Seed collection (months)	Indicators of maturity	Seed collection (criteria)	Seeds storage (Max. Days)		Watering	Pests
Avicennia officinalis	Oct – Nov	Yellowish fruit skin	Weight of seeds > 5g	7	On top of soil	Fully once a day	Crabs caterpillars
Avicennia marina	Oct – Nov	Yellowish fruit skin	Weight of seeds > 1.5g.	10	On top of soil	Fully once a day	Crabs caterpillars
Excoecaria agallocha	Sep – Oct	Dark brown fruits	< 100 mg.	10	On top of soil	Fully once a day	Crabs caterpillars
Aegiceras corniculatum	Aug – Oct	Yellow Epicarp	5 to 6 cm long	15	Push calyx portion 1cm deep	Fully once a day	Crabs caterpillars
Sonneratia apetala	Jul – Sep	Floats in water	Fruit >15mm. diameter	5	Push radicle of seed into soil	Twice a day	Rats, Crabs, caterpillars
Xylocarpus moluccensis	Sep – Nov	Yellow to brown fruit Floats in water	Weight of seeds > 30g.	10	On top of soil	Fully once a day	Crabs
Bruguiera gymnorrhiza	Jul – Sep	Reddish brown or greenish red hypocotyls	>10 cm. long	10	Push hypocotyle 5 – 8 cm	At neap tide	-

Table 3. Action plan for the preparation of the nursery

Species / Item	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avicennia officinalis												
Collection & Sowing										↔	↔	
Raising period	←	—	—	—	—	—	—	→				↔
Planting in degraded area									↔	↔		
Avicennia marina												
Collection & Sowing										↔	↔	
Raising period	←	—	—	—	—	—	—	→			↔	
Planting in degraded area												
Excoecaria agallocha												
Collection & Sowing	↔								↔	↔		
Raising period	←	—	—	—	—	—	—	→				
Planting in degraded area									↔	↔		
Aegiceras corniculatum												
Collection & Sowing								↔	—	→		
Raising period	←	—	—	—	—	—	—	→			↔	↔
Planting in degraded area									↔	↔		
Sonneratia apetala												
Collection & Sowing							↔	—	→			
Raising period	←	—	—	—	—	—	—	→			↔	↔
Planting in degraded area									↔	↔		
Xylocarpus moluccensis												
Collection & Sowing									↔	—	→	
Raising period	←	—	—	—	—	—	—	→				↔
Planting in degraded area									↔	↔		
Bruguiera gymnorrhiza												
Collection & Sowing							↔	—	→			
Raising period	←	—	—	—	—	—	—	→			↔	↔
Planting in degraded area									↔	↔		
Rhizophora apiculata												
Collection & Sowing							↔	—	→			
Raising period	←	—	—	—	—	—	—	→			↔	↔
Planting in degraded area									↔	↔		
Rhizophora mucronata												
Collection & Sowing							↔	—	→			
Raising period	←	—	—	—	—	—	—	→			↔	↔
Planting in degraded area									↔	↔		
Gathering soil									↔	↔		

Chart 2. Procedure for preparation of Nursery



7.1 *Avicennia marina* (Forsk.) Vierh.

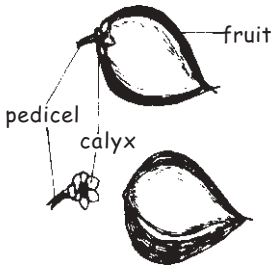
Local Name: *Tella Mada* (Telugu), *Singal Bani* (Oriya), *Venkandal* (Tamil), *Peyara-ban, bain, bani* (Bengali)

Avicennia officinalis L.

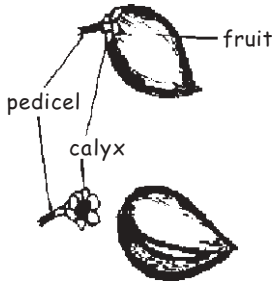
Local Name: *Nalla Mada* (Telugu), *Bani* (Oriya), *Karukandal* (Tamil), *Jat-ban, bain, bani* (Bengali)

Collection and treatment of *Avicennia* seeds

Healthy and mature seeds of *Avicennia marina* and *A. officinalis* should be collected separately. The mature seeds can be easily distinguished by observing the light yellowish colour of the seed coat with cracks on it. The seeds can be collected from October to December.



Avicennia officinalis



Avicennia marina

Avicennia officinalis

Selection and processing of the seeds

Mature fruits should be selected and checked for insect borers. Seeds should be soaked in brackish water overnight to remove the seed coats. This treatment reduces the establishment time by two to three days. Only seeds without seed coats should be used for planting in the polythene bags. Normally the seeds must be planted in the polythene bags immediately. In case of storing, the seeds should be kept in the shade for one or two days.

Young seedling of *Avicennia marina*

Sowing into nursery bags

The polythene bags with soil must be allowed to harden by placing them outside the beds. After hardening, the polythene bags containing mud should be watered, using sprinklers. The radicle part of the seeds must be gently pushed (1/3 of the seed) inside the soft mud. Deeply buried seeds will not germinate and will rot.

Watering

During the initial stages, water should be sprinkled twice, using rose-water cans. After germination, the polythene bags should be transported to the beds and watered through canals.

Pest control

During the sprouting stages, crabs damage young seedlings. These damaged seedlings should be replaced with fresh seed / seedlings. Caterpillars are the major pests for *Avicennia* and when the attack is severe, pesticides like *Monochrotophos* and *Ekalux* may be used. Water from the beds should be drained before pesticide application.

Grading

For the purpose of grading and to ensure raising healthy seedlings, casualties should be replaced with seeds / seedlings. The seedlings from the beds must be shifted periodically for three months after sowing.

Selection of seedlings from the nursery beds

The recommended specifications of the seedlings are as follows:

Height	:	50 cm
No. of leaves	:	at least 12
Period	:	8 months

7.2 *Excoecaria agallocha* L.

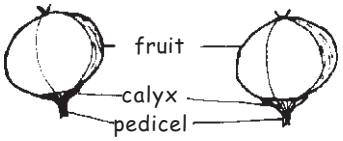
Local Name: *Thilla* (Telugu), *Guan* (Oriya), *Tillai* (Tamil), *Gneoa* (Bengali)

Collection of young seedlings

Juvenile seedlings collected from the mangrove forest can be used as planting material. The seedlings should be collected in the morning and planted on the same day, as early as possible.

Sowing into nursery bags

The young seedlings collected from the forests should be transplanted into the bags. Polythene bags filled with mud should be kept ready.



Excoecaria agallocha

Watering

Watering is to be done daily through the canals.

Grading

The casualties need to be replaced with young seedlings that are collected from the forests. The seedlings from the beds should be shifted periodically for three months after sowing.

Selection of seedlings

The recommended specifications of the seedlings are as follows:

Height	:	40 cm
No. of leaves	:	at least 12 to 14
Period	:	8 months

Vegetative propagation of *Excoecaria* through stem cuttings

Healthy plants should be chosen as mother plants. Branches of 1 cm diameter, should be cut to a size of 20 cm length and planted in the nursery. Polythene bags filled with mangrove soil should be kept ready and the cuttings planted in them. Watering should be done regularly for six months if the nursery is maintained in the houses of fishermen as a livelihood alternative. If maintained in regular nursery with tidal inundation facility, the watering is to be done for the first fifteen days.

Juvenile leaves start appearing from the nodes after 10 to 15 days, from which time manual watering can be stopped in the nurseries. However watering should be continued in the homestead nurseries. Roots will develop after 40 days. Polythene bags with rooted saplings need to be rotated within the beds after two months, at an interval of 30 days,until planting in the degraded areas.

7.3 *Sonneratia apetala* Buch. - Ham

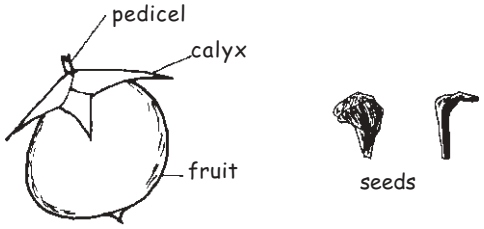
Local Name: *Kalinga* (Telugu), *Keruan* (Oriya), *Marama maram* (Tamil), *Keora* (Bengali)

Collection of fruits

Healthy and mature fruits should be collected from the trees. The characteristic indicators of mature fruits are deep green colour and souro taste of the mesocarp.

Collection of seeds from fruits and sowing

Mature fruits of *Sonneratia apetala* can be easily identified by the change in their colour from pale green to deep green. The taste of the fruit becomes sour as it matures. The mature, healthy



Sonneratia apetala

fruits can be collected during September and October from the forest near the creeks and river mouth. The fruits should be kept in polythene bags for 15 days, to allow the fleshy mesocarp of the fruits to rot in order to collect the seeds. The fruits should then be gently crushed and the seeds, along with debris, sown in a primary bed. Periodical watering through canals is necessary. After 20 to 30 days, the seeds will start sprouting. The young seedlings of about 30 days old should then be transplanted into the polythene bags.

Transplanting of young seedlings

Young seedlings of 30 days old should be transplanted from the primary bed to the polythene bags and kept in beds. Polythene bags filled with mud should be kept ready.

Watering

Watering is to done daily through the canals.

Grading

The casualties need to be replaced with young seedlings that are collected from the mangrove forests, in order to raise healthy seedlings. The seedlings from the beds should be shifted periodically for three months after sowing.

Selection of seedlings

The recommended specifications of the seedlings are as follows:

Height : 50 cm

No. of leaves : at least 6

Period : 8 months

7.4 *Xylocarpus moluccensis* (Lamk.) M. Roem.

Local Name: *Senuga* (Telugu), *Pitamari* (Oriya), *Komandry* (Tamil), *Pasur* (Bengali)

Collection of fruits

Healthy and mature fruits should be collected from the creeks using fishing nets;they can also be collected from the trees. The characteristic indicators of mature fruits are yellow colour and a cracked pericarp.

Collection of seeds

The seeds should be removed from the fruits. The seeds available in the creeks can be harvested with fishing nets. The seeds should be checked for insect / pest attack before planting.

Sowing into nursery bags

Polythene bags containing hardened mud should be sprinkled with water. The radicle side of the seeds should be placed gently in the polythene bags, ensuring that the mud is soft. Polythene bags filled with mud should be kept ready.

Transporting of young seedlings to beds

Young seedlings of about ten days old should then be transferred to the nursery beds.

Watering

Watering is to be done daily through the canals.

Grading

The casualties need to be replaced with seeds. The seedlings from the beds should be shifted periodically for three months after sowing.

Selection of seedlings

The recommended specifications of the seedlings are as follows:

Height : 50 cm

No. of leaves : at least 12 to 14

Period : 8 months

7.5 *Aegiceras corniculatum* (L.) Blanto

Local Name: *Guggilam* (Telugu), *Khrasi* (Oriya), *Narikandal* (Tamil), *Khalsi* (Bengali)

Collection of seeds

Healthy and mature seeds should be collected from the trees. The mature seeds can be easily identified by the yellow or greenish-yellow colour of the seed coat.

Propagule selection and processing

The selected seeds should be checked for insect borers.As in the case of *Avicennia*, the seeds should be planted in polythene

bags directly. While storing the seeds, they should be kept in the shade for two to five days.

Sowing into nursery bags

The calyx region of the fruit should be inserted to a depth of about two to three cm. After the germination of the seedlings, they should be transported to the beds and watered. Polythene bags filled with mud should be kept ready.

Watering

Watering is to be done daily through the canals.

Pest control

Caterpillars are the major pests and in case of a severe attack, pesticides like *Monochrotophos* and *Ekalux* may be applied. However, as a precaution, water from the beds should be drained before applying the pesticide.

Grading

Initially the casualties should be replaced with seeds / seedlings. The seedlings from the beds should be shifted periodically for three months after sowing.

Selection of seedlings

The recommended specifications of the seedlings are as follows:

Height : 50 cm

No. of leaves : at least 10

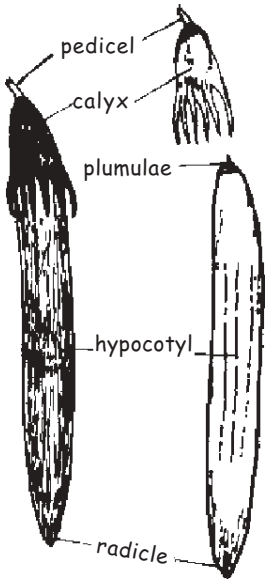
Period : 8 months

7.6 *Bruguiera gymnorrhiza* (L.) Savigny

Local Name: *Kandriga* (Telugu), *Bandari* (Oriya), *Kakra* (Bengali)

Collection of propagules

Healthy and mature propagules should be collected in the creeks with the help of fishing nets. The characteristic and visible indicator of mature propagules of *Bruguiera gymnorrhiza* is the reddish brown or greenish red colour of the hypocotyle.



Bruguiera gymnorrhiza

propagule

Selection and processing of propagules

Mature propagules should be selected and checked for insect borers. The propagules should then be planted in the polythene bags placed in the beds. In case the propagules have to be stored, they should be kept in the shade for one or two days, without exposing them to direct sunlight.

Sowing into nursery bags

The hypocotyl of the propagules should be inserted to a depth of about 4 to 5 cm. Polythene bags filled with mud should be kept ready.

Watering

Watering is to be done daily through the canals.

Grading

Initially the casualties should be replaced with propagules. The seedlings from the beds should be shifted periodically for three months after sowing.

Selection of seedlings

The recommended specifications of the seedlings are as follows:

Height : 50 cm

No. of leaves : at least 6

Period : 8 months

7.7 *Rhizophora apiculata* Bl. and *Rhizophora mucronata* Lamk.

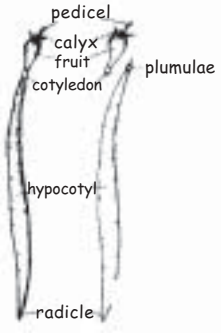
Local Name: *Ponna* (Telugu), Raai (*Oriya*), *Surapunnai* (Tamil), *Garjan* (Bengali)

Collection of propagules

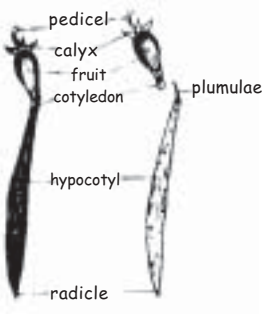
Healthy and mature propagules should be collected from the tidal creeks, using fishing nets. Characteristic indicators of mature propagules of *Rhizophora mucronata* are pale green or yellow

***Rhizophora mucronata* propagule**

***Rhizophora apiculata* propagule**



Rhizophora mucronata



Rhizophora apiculata

cotyledon and green hypocotyle. Propagules of *Rhizophora apiculata* have red or yellow cotyledons. Propagules of *Rhizophora mucronata* are bigger than *R. apiculata.*

Selection and processing of propagules

Healthy propagules should be selected and checked for insect borers. The propagules should then be planted immediately in the polythene bags placed in the beds. In case of storing, the seeds should be kept in the shade for one or two days, without being exposed to direct sunlight.

Sowing into nursery bags

The hypocotyl of the propagule should be inserted to a depth of about 7 to 8 cm. Small sticks are to be tied to the hypocotyl for providing support. Polythene bags filled with mud should be kept ready .

Watering

Watering is to be done daily through the canals.

Grading

Initially, the casualties should be replaced with propagules. The seedlings from the beds should be shifted periodically for three months after sowing.

Selection of seedlings

The recommended specifications of the seedlings are as follows:

Height : 60 cm.

No. of leaves : at least 8

Period : 8 months

8. Seed Germination and growth of seedling

The germination period, percentage of germination and average height of mangrove saplings raised in the mangrove nursery are given in Table 4. *Avicennia officinalis* and *Avicennia marina* germinate within 6 days when compared to other mangrove species, which take nearly 20 days. The percentage of germination of these two species is also high. As these species have a wide range of tolerance to salinity, they were raised in large numbers compared to other species for planting in the degraded areas for the restoration of mangroves. Some mangrove species, namely *Excoecaria agallocha, Rhizophora apiculata, R. mucronata, Bruguiera gymnorrhiza, Xylocarpus moluccensis* and *Sonneratia apetala,* take more than 20 days to germinate. The nursery saplings should be fed with saline water (5 to 30 ppt) collected from the mangrove creeks. The salinity levels will be 5 ppt during October (germination period) and will be 30 ppt after March. The initial growth of *Xylocarpus moluccensis* was found to be rapid and the colour of the shoot was brown. The germination percentage of the propagules of *Rhizophora apiculata, R. mucronata* and *Bruguiera gymnorrhiza* was observed to be high - above 90%. Nevertheless, their establishment time is longer.

8.1. Viability of seed material

The viability of the seeds depends on the age of the tree. For eg. *Rhizophora spp.* is able to produce fruits between the third and fourth years, but the propagules should be collected from trees at least 5 years old (Wirjodarmodjo and Hamzah, 1984). In the present study, the age of the tree was determined with the help of elderly local villagers and by measuring the girth at breast height (GBH). The mangrove seeds / propagules were collected from mature stands (10-15 years old). The viability period of the mangrove seeds is very short and hence they are to be planted immediately after collection (within 24 h). Siddiqui and Islam (1988) observed that *Sonneratia apetala* seeds loose their viability after

Table 4. Details of Mangrove species to be followed for better survival

Plant species	Seed material	Germination period	Germination percentage	Average height after 8 months (cm.)
Avicennia officinalis	Fruit	6 days	95	75
Avicennia marina	Fruit	6 days	95	75
Excoecaria agallocha	Young seedlings	-	60	60
Aegiceras corniculatum	Fruit	35 days	80	70
Sonneratia apetala	Seed	30 days	20	80
Xylocarpus molluccensis	Seed	20 days	90	80
Bruguiera gymnorrhiza	Propagule	35 days	100	60
Rhizophora apiculata	Propagule	40 days	100	70
Rhizophora mucronata	Propagule	40 days	100	80

60 days of collection of fruits. The salinity levels of the water that is used also plays an important role in the germination and survival of mangrove saplings. The saplings were raised in low salinity initially (10 ppt during October); the salinity was increased gradually and saline water with 30 ppt was used in the later stages. Siddiqi *et al.* (1989) found that 10 ppt salinity is optimum for *Sonneratia apetala* and no germination of seeds was observed over 40 ppt. Mortality of the propagules can be avoided by selecting healthy propagules.

9. Role of nurseries in participatory management

In participatory management, the local community should be sufficiently involved and made to own the resources, in the management of which, they are involved as partners for sustainable management. In this regard, the community mangrove nurseries helped in the movement of mangrove forest restoration and management in Godavari and Krishna mangrove wetlands. At present, fisherwomen and men living in Godavari and Krishna mangroves are trained in nursery raising techniques. Seedlings of *Avicennia marina, A. officinalis* and *Excoecaria agallocha* were raised by the members of women self-help groups. The saplings thus grown by the women were purchased and planted in the degraded areas thus helping the women in providing alternative employment and income generation.

Similarly, if the FD and NGOs involved in mangrove restoration and conservation include the community in raising the mangrove nursery in their backyards and buy the saplings from the community, it will help them to earn additional income and also increase the responsibility of owning the mangrove resources and paving the way for sustainable mangrove forest management.

10. Mangrove nurseries as livelihood alternative for women

Community mangrove nurseries were started in the villages of Matlapalem and Bhairavalanka. The nursery techniques were discussed with the villagers. Necessary materials like polythene bags, seeds / propagules were provided to the community. The community members were involved in the collection of seeds and propagules, using nets in the creeks. The saplings were raised in the backyard of the houses in Bhairavalanka and Matlapalem. In Dheenadayalapuram, the mangrove nursery established by the project was used to raise the mangrove saplings. Mostly women were involved in raising the saplings and in maintaining the nursery by periodical removal of algae and other materials. The mangrove saplings were bought from the community @ Rs.1/- after 6-8 months. By raising mangrove saplings in their respective villages the fisherwomen earned an income of Rs. 2,15,000/-. The women have to work for four to five days in the initial stages. Later on they have to spend an hour a day for watering the nursery saplings in their backyards. Table 5 provides the details of saplings raised by the village level institutions and Table 6 provides details of the wages and the labour absorption for raising 30,000 mangrove saplings.

Table - 5. Details of mangrove saplings raised by VLIs

Name of the VLI and Village	Species raised	No. of saplings	Income for community
Sri Vigneswara EDC, Matlapalem	*Excoecaria agallocha*	12,000	Rs. 12,000
Dr. B.R. Ambedkar VSS, Bhairavalanka	*Avicennia officinalis* *Avicennia marina*	1,000 2,000	Rs. 3,000
Dheenadayaljee EDC, Dheenadayalapuram	*Avicennia officinalis* *Avicennia marina*	60,000 1,40,000	Rs. 2,00,000
Total		**2,15,000**	**Rs. 2,15,000**

Table 6. Labour absorption for nursery for raising 30,000 mangrove salings

Task	Persons		Hours of work	Wages		Amount
	Men	Women		Men	Women	
Clearing the area & Clearing Bushes	7		6	60		420
Bed preparation	70		6	60		4200
Fencing	40		6	60		2400
Filling bags	28	98	6	60	40	5600
Seed collection		42	6		40	1680
Bag transfer to beds		16	6		40	640
Planting seeds in bags		108	6		40	4320
Maintenance		96	6		40	3840
Total	145	360				23100

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