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A Guide to Community-Based Mangrove Reforestation and Management in WIO

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This is the 2nd part of the Report on *'Technical Support to NSA-CFP Projects Related to Mangroves in Kenya, Tanzania, and Somali'*. The conclusions and recommendations given are those considered appropriate at the time of its preparation. They may be modified in the light of further knowledge at subsequent stages of the project.

The opinions expressed in this document are those of the author and do not reflect whatsoever on the part of the RECOMAP, IOC or KMFRI

A. PREFACE

As terrestrial forest resources become further depleted in many tropical countries, mangrove forest management is likely to increase. Already mangroves are being managed for timber production in a number of countries in Asia and Latin America. In Africa however, there are very few examples of successful mangrove reforestation projects.

Major obstacles that have hitherto prevented rational uses of mangrove forests in the Western Indian Ocean (WIO) region have been the sectorial approach of mangrove resource management, lack of community inputs into management efforts, the poverty status of many indigenous coastal communities, and a lack of awareness amongst decision makers about the true values of mangroves. These management problems are compounded by inadequate knowledge of silviculture of mangroves, of multiple use potentials of resources, and of the techniques of natural regeneration and reforestation. Apart from plantation experiments for the rehabilitation of deforested mangrove areas at Gazi bay, Kenya, little effort has been made to restore degraded mangrove systems in Africa.

The current Guide targets communities involved in mangrove reforestation and management in the WIO region. The Guide provides background information on the nature of mangrove ecosystem, its attributes as well as the major problems affecting the mangroves – both human and natural pressure. Using long term experience in mangrove reforestation works at Gazi, the Guide analyses challenges facing community based mangrove reforestation projects; and provide possible solutions to these projects.

During the course of preparation of this document, the Consultants visited RECOMAP's funded mangrove projects in Lamu, Tana River, Ngomeni, Sabaki, Mida, Mombasa and Gazi. Additional information of these community projects were extracted from respective project documents.

The author wishes to thank the mangrove team at KMFRI – Dr Jared Bosire, Dr Benard Kirui, and Dr Joseph Langat- for their input into the document. Mr Alfred Obinga is thanked for his arranging field training with the communities.

I am grateful to RECOMAP for supporting mangrove reforestation in the region and do hope the communities will find this document helpful to their present and future endeavours.

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F. ACRONYMS

KMFRI	Kenya Marine and Fisheries Research Institute
EU	European Union
RECOMAP	Regional Programme for the Sustainable Management of the Coastal Zones of the Countries of the Indian Ocean
IOC	Indian Ocean Commission
ICZM	Integrated Coastal Zone Management
NGO	Non-Governmental Organization
RCU	Regional Coordination Unit, of RECOMAP
WIO	Western Indian Ocean
KWETU	An non-profit making organization registered under the Kenyan NGO Act
WCK	Wildlife Clubs of Kenya
NFDK	National Funds for the Disabled of Kenya

G. GLOSSARY

Deforestation: The clearing of forests, conversion of forest land to non-forest uses.

Forest degradation: Biotic or abiotic processes that result in the loss of productive potential of natural resources in areas that remain classified as forests. Degraded forest may take a long time to recover thus requiring human intervention.

Multiple uses: More than one use of a resource at one time. It is possible to practice fish culture (silvo-fishery) and bee farming (silvo-apiculture) in mangrove areas without necessarily affecting the functioning of mangrove ecosystem.

Poles: The merchantable part of the mangrove stem. In Kenya mangrove poles are categorized and marketed based on their butt diameter. The most marketable pole sizes are *Boriti* with butt diameter range of 11.5 – 13.5 cm.

Propagule: A dispersal unit in mangroves. In some mangrove literature a propagule is also referred to as a seed.

Reafforestation (*US*: Reforestation): Replant (an area of land) with forest trees.

Silviculture An area managed for the production of timber and other forest produce or maintained under woody vegetation for such indirect benefits as protection against flood or recreation.

Sustainable forest management: Utilization of forest resources without compromising their use by present and future generations.

Tree biomass: The biomass of vegetation classified as trees including foliage, trunk, roots and branches.

1.0. BACKGROUND TO THE CONSULTANCY

Mangrove forests in the Western Indian Ocean (WIO) region occupy approximately 10,000km^2 (Spalding *et al*, 1997), representing about 5.0% of the global mangrove coverage. These forests are valuable for their wood and non-wood products: timber, building poles, firewood, charcoal, fishing stakes, local medicines and as animal fodder and vegetables. They form a unique ecosystem encompassing terrestrial, freshwater, marine and estuarine systems. Mangroves are extremely important as feeding and nursery areas for prawns, fish, and shellfish. They prevent coastal erosion and protect coral reefs by preventing siltation. Mangroves also play a significant role in tourism, recreation and research. Moreover, being renewable resources, mangroves are capable of providing these goods and services indefinitely, only if they are sustainably-managed.

An initial consultancy (**Consultancy Report;** Dr. Kairo, J.G.; January 5, 2010) prioritized technical capability and the building of local capacity in rehabilitation, conservation, and sustainable utilization of mangrove resources in the pilot areas where RECOMAP is supporting community based mangrove management activities. During Phase 1, the Consultant assessed mangroves plantations component of projects implemented by non State actors in Kenya under ReCoMaP grant schemes (CFP 1 and CFP 2), namely:

- NFDK (CFP 1; started November 2008)
- TAFMEN (CFP 1; started November 2008)
- Kwetu Training Centre (CFP 1; started November 2008)
- WCK (CFP 2; started November 2009)
- Nature Kenya (CFP 2; started November 2009)
- COMRED (CFP 2; started November 2009)
- Nature Kenya and Kwetu Training Center (CFP 2; started November 2009)

Conclusions indicated major difficulties of implementation related to inadequate knowledge on:

- Species and Site matching
- Nursery and plantation establishment; out-planting
- Pest management
- Seasonality of mangrove forests leading to lack of (enough) propagules during planting time

Additionally, Consultant contributed to building a capacity for proponents through practical field training in;

- Mangrove nursery establishment and management
- Operating and managing the nursery
- Nursery techniques for different mangroves species
- Mangrove plantation establishment and management

The present consultancy aimed at establishing a monitoring and evaluation guidance for all proponents, leading to technical assistance for improving performances of mangrove plantation components of ongoing projects. The work entailed regular field visits to project sites and working with project technical teams, beneficiaries of reforestation and technical departments.

1.1 Terms of reference

According to the terms of reference (ToR) outlined by RECOMAP, the Consultant was to:

- Assess the appropriate mangrove reforestation approach considering projects locations;
- Brainstorm with proponents on possible solutions to their mangrove reforestation and conservation challenges; defining and providing technical assistance at project locations accordingly;
- Review project budgets of the mangrove component; in order to adjust to new approach and solutions;
- Develop a monitoring plan for the replanted mangroves;
- Train project proponents on data collection, analysis and reporting;
- Assist two proponents (NFDK-Lamu sites and COMRED-Kilifi sites) in the establishment of mangrove reforestation demonstration sites.

The total duration of the assignment was 90 days, spread over the period between December 2009 and October 2010. The Consultancy team visited field sites between 16 April and 20 October, 2010; in order to train and establish demonstration mangrove plantations. This report aims to serve as a concise guide for communities interested in engaging in mangrove activities in their area.

Plate 1: Mangrove stand with mature propagules of *Ceriops tagal*

2.0 MANGROVE ENVIRONMENT

Mangroves grow in the area between land and the sea. This area is referred to as intertidal area, and is flooded by spring high tides. Consequently, mangrove environment often experiences high salinity levels, and water logging conditions leading to insufficient oxygen in mangrove soils. Basic environmental requirements for growth and development of mangrove ecosystem include;

- Tropical temperature – minimum of 20^{o} C during the coldest month
- Protection from strong waves and storms
- Salinity
- Deep substratum allowing firm root establishment
- Tidal flooding – for moderating salinity levels and exchange of nutrients

Globally, mangrove covers 150,000-190,000 km^2 of land; represented by over 50 species. In the West Indian Ocean region (WIO), there are 11,000 km^2 of mangroves, which is about 5% of the world mangroves. Overall, there are 10 species of mangroves in WIO; distributed in 7 families (Table 1).

Table 1. Species of mangroves in WIO

Species name	**Family***
Avicennia marina	Acanthaceae
Bruguiera gymnorrhiza	Rhizophoraceae
Ceriops tagal	Rhizophoraceae
Heritiera littoralis	Malvaceae
Rhizophora mucronata	Rhizophoraceae
Lumnitzera racemosa	Combretaceae
Sonneratia alba	Lythraceae
Xylocarpus granatum	Meliaceae
Xylocarpus moluccensis	Meliaceae

*For a detailed taxonomic classification and distribution of mangrove species in WIO readers are encouraged to refer to the revised edition of Richmond (1997).

2.1 Adaptations in mangroves

Mangroves have evolved structural and physiological adaptations that help them to survive and reproduce in their habitat. Several of the recognized adaptations exhibited by various mangroves are:

a) Structural adaptations of seeds (propagules): majority of mangrove trees produce **viviparous seed**s, meaning that the seed germinate while still attached to the parent.
b) Presence of specialized **prop roots** in *Rhizophora*, for anchorage and aeration (Fig. 3).
c) Possession of **pneumatophores** in the genus *Sonneratia* and *Avicennia* extending vertically above the substrate along the cable roots (Fig. 2).
d) Some mangrove trees cope with the salinity problem by (a) excreting excess salts (*Avicennia*), (b) Excluding salt uptake (*Rhizophora, Ceriops, Sonneratia),* and (c) accumulating salts (*Sonneratia, Lumnitzera,* and *Xylocarpus*).
e) Most mangrove species have got thick leaves, with a thick waxy cuticle to reduce loss of water. The stomata are sunken and mostly situated on the underside of leaves.

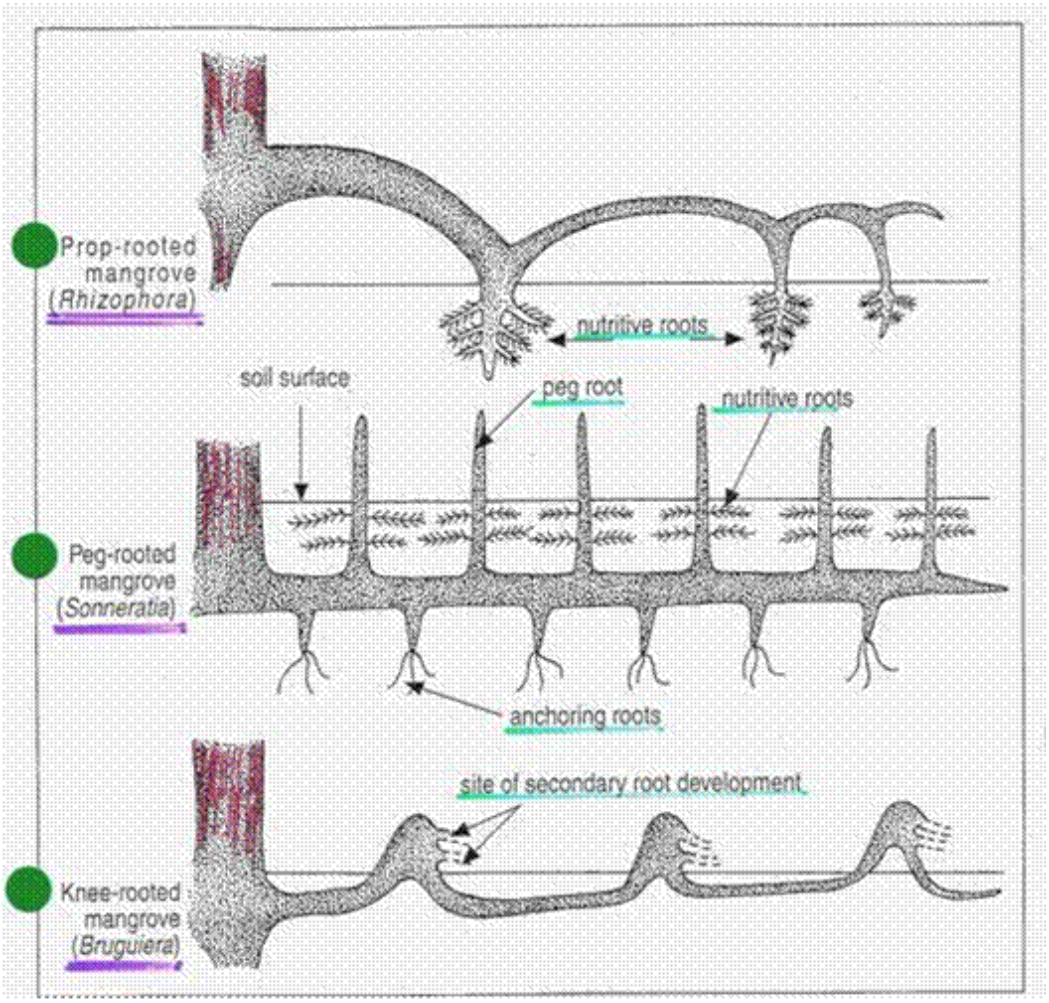

Fig 1. Types of aerial root in mangrove plants

2.2 Mangrove zonation

A conspicuous feature of most mangrove environment is the horizontal distribution of species across the interidal area (or zonation) – Fig. 2. Zonation occurs because different species of mangrove need particular conditions to grow. Some species require more water than others. Some species are able to tolerate more saline soils than others. The species occurring in a zone depends on:

a) depth, duration and frequency of tidal inundation
b) soil salinity
c) amount of fresh water available

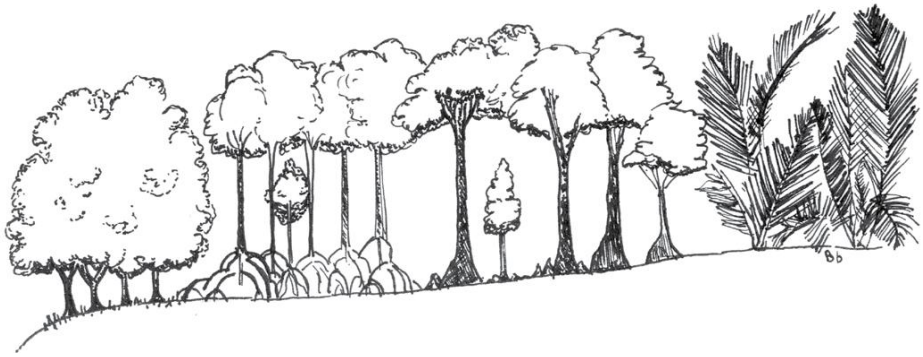

Fig. 2. A generalized scheme of mangrove zonation across intertidal area

2.3 Importance of mangroves

Mangrove ecosystems have a wide range of ecological, socio-economic and environmental values which could be viewed at local, national and global levels (Table 2). They provide home to many animals such as crabs, molluscs, prawns, birds and insects, all of which directly or indirectly are beneficial to man. Mangroves also form nursery and refuge areas for juvenile fish. They provide forest products such as timber for construction, firewood, fish traps and stakes among others. In addition, mangroves stabilize shoreline and control water quality. Because, they are very productive ecosystems, mangroves capture and store carbon, thereby, helping in reducing carbon dioxide concentration in the atmosphere. This is very crucial in mitigating global climate change.

Table 2. Valuation of mangroves

Community level	National level	Global level
Timber and firewood	Timber production	Conservation
Fodder for animals	Charcoal production	Education
Traditional medicine	Shrimp & crab industries	Preservation of biodiversity
Food	Mangrove silviculture	Indicator of climate change
Local employment	Trade	
Recreation	Ecotourism	
Shell collection	Water quality management	
Erosion control	Education	
Protection from storm damage	Coastal & estuary protection	

2.4 Human induced pressures on mangroves

Despite providing important ecological, socio-economic and environmental values, mangrove forests have been subjected to destruction and removal. Continued degradation of mangroves has far reaching consequences. Major factors that have led to losses and degradation of mangrove forests in WIO have been identified as:

- Over-exploitation of resources
- Conversion of mangrove area for saltworks and pond aquaculture
- Coastal development – e.g. road construction
- Oil spills
- Diversions of freshwater flows
- Sedimentation – e.g. from inappropriate agricultural activities in the hinterlands
- Municipal wastes – leading to massive growth of algae

In addition, sea level rise due to climate change poses another threat to the survival of mangroves.

3.0 MANGROVE REFORESTATATION AND MANAGEMENT

Mangrove reforestation and management has a long history in South East Asia. Among the countries with the longest history of mangrove management for timber are India, Bangladesh, Malaysia and Indonesia. The objective of mangrove reforestation in these countries has been to produce timber, protect shoreline from erosion, and enhance fish production. Beginning with the realization of ecological roles of mangroves and the passage of laws protecting them from destruction, many small plantings for mitigating environmental damage have occurred for example in Hawaii, Burma, Florida, and Fiji. Mangroves have also been planted to restore forests killed as a result of oil spills in Panama.

In WIO region information on earlier mangrove plantation practices is scanty. Few references exist for mangrove planting in Lamu, Kenya, after the trees were clear-felled during the First World War (1914 - 1918) by Smith and McKenzie Company (Kairo et al., 2001). In Tanzania, attempts to replant mangroves in the abandoned saltpans of Tanga district failed probably because of environmental factors (e.g. soil salinity and acidification) as well as poor species selection (Semesi and Howell, 1992).

Factors, which lead to failures in mangrove reforestation projects include:

- Extreme changes in site conditions – e.g. soil factors (especially salinity), hydrology (relating to water movement), sedimentation
- Inappropriate restoration techniques – species-site mismatch, poor quality seeds/propagules, poor nursery establishment and management, poor site preparation, inappropriate transplantation
- Failure to involve all stakeholders, especially local communities and relevant government institutions.

3.1 How to achieve a successful mangrove reforestation

Important steps to ensure successful mangrove reforestation can be summarised as follows:

1. Understand both the individual and community species ecology of the naturally occurring mangrove species at the site
2. Understand the normal water regime in the reforestation site
3. Assess the modifications of the mangrove environment that occurred and that currently prevent natural regeneration to occur.
4. Design a restoration program of the reforestation site; always choosing to start with the easiest sites first.
5. Utilize actual mangrove reforestation only after determining that natural recruitment will restock the degraded site

3.2 Species selection

It is important to select the right mangrove species to use during reforestation. Species selection is based on the prevailing site conditions after the damage has occurred. If the site conditions have been drastically changed, restoration may be initiated with mangrove plant species, e.g. *Avicennia*, that are tolerant to harsh conditions. Assessment of the adjacent mangrove communities helps in determining the species distribution in the tidal range, and

hence the species to be used for restoration. After identifying the appropriate mangrove species, planting can be done either by direct planting of propagules and seedlings collected from the forest or planting nursery raised stocks.

3.3 Direct planting of propagules vs transplanting of saplings

Direct installation of propagules is usually used while replanting mangroves belonging to Rhizophoraceae family (*Rhizophora*, *Ceriops* and *Bruguiera* species). These species produce large and pointed propagules that could be installed directly into the mud. Experience has shown that mature propagules picked from mother trees or those recently fallen have a higher survival than transplanting of saplings. This is because transplanting of saplings leads to disturbance of root-balls when removing and transporting them. Further, transplanting of saplings is three times more expensive than use of propagules (Kairo et al., 2001). Wildlings (i.e. seedlings that have germinated naturally within the mangrove forests) can also be dug out and be used as planting materials.

3.4 Nursery establishment and management

Raising seedlings in nurseries have some advantages, over relying on propagules and wildings. Apart from providing healthy saplings, raising seedlings in nursery ensure that the saplings are available all year round. At transplanting age, nursery raised saplings have a well developed root system.

Sites for setting up mangrove nurseries should be selected based on the following criteria:

- Suitability to allow tidal flooding
- Accessibility – for effective nursery monitoring and proximity to intended reforestation site
- Shade regulation – ease to construct nursery shed

To ensure maximum germination percentage and survival of saplings, the following factors should be taken into considerations:

- Fill potting bags with soft clayey soil
- Avoid water stagnating on the top of the pot by filling the soil to the top
- The pots should be arranged in a dug-trough such that at least ¾ of the height of the bags is below the ground level. This ensures that moisture is preserved
- Proper drainage to ensure no water stagnation within the nursery
- Raising seedling in screen house protects saplings from insect pests in the early part of their growth

3.5 Preparation of a community reforestation plan

Most mangrove species have specific fruiting seasons; hence, propagule/seed production may not be available throughout the year. It is essential to understand the seasonality of your mangrove forest before embarking on reforestation activities. In order to ensure maximum survival of saplings and save money, reforestation should be scheduled during the **peak** fall of propagules (Tables 4). Mature propagules should be collected from forest that is near the selected planting site to ease transport. General indicators of maturity and quality

of propagules for different mangrove species are given in Table 4. Some mangrove seeds/fruits will require treatment in order to enhance germination. *Sonneratia* and *Avicennia* seeds need to be pre-soaked overnight in fresh/sea water to hasten the opening of fruit and the splitting of seed coat respectively (Plate 2). *Heritiera* fruits can be soaked in fresh water for 1-2 weeks and the husk split by hand prior to planting.

When planting mangroves with pointed propagules, the hypocotyl should be inserted to a depth of ~ 4-5 cm (*Ceriops* and *Bruguiera*) and 7-8 cm (*Rhizophora*). For *Avicennia* and *Xylocarpus* seeds, the radical part must be pushed gently (<1/3 of the seed) into the sediment. A screen house can be used to raise the seedlings as this reduces incidences of insect pests. Table 5 summarises nursery and plantation technique appropriate for different mangrove species in WIO.

Plate 2. Pre-sorted *Rhizophora* and *Avicennia* propagules ready for planting

Table 3. Propagule/seedling availability for mangroves species in WIO

Species	Planting material	Peak availability of propagules*	Indicator of maturity	Size at maturity	Storage (max days)	Treatment
Avicennia marina	Seedling	April-May	Seed coat turns light yellow, wrinkly	weight of 100seeds>150g	5	Soak in freshwater (> 12 hrs)
Bruguiera gymnorrhiza	Propagule	April-July	Reddish brown body	Propagule length >15cm	10	Cool wet conditions
Ceriops tagal	Propagule	February-March	Light yellow collar, brown/green body	Propagule length > 20cm	15	Cool wet conditions
Rhizophora mucronata	Propagule	March-June	Yellow collar, green body	Propagule length >40cm	30	Cool wet conditions
Sonneratia alba	Fruit	September-November	Dark green, float in water	Fruit diameter >4cm	5	Soak in fresh/sea water (>12 hrs)
Xylocarpus granatum	Fruit	May-July	Dark brown, float in water	Weight of individual seed inside fruit > 30g	30	Store in dry cool conditions until it open
Lumnitzera racemosa	Seed	May-July	Dark green, dry style	Dark green, dry style	20	Store in moist conditions
Heritiera littoralis	Fruit	May-July	Dark brown	Seed intact inside the fruit, no sign of insect attack	>30	Soak in fresh water (1-2 weeks)
Xylocarpus moluccensis	Fruit	May-July	Dark green	Weight of individual seed inside fruit > 10g	20	Store in dry cool conditions until it open

**Peak fruiting period given here may vary from site to site; Project Developers must understand seasonality of the trees prior to initiating reforestation project in your area*

Table 4. Propagation methods for different mangrove species

Species	Mode of propagation	Sowing depth	Germination period*	Height/age for out planting
Avicennia marina	- Nursery - Broadcast - Wildings	On surface of potted soil	Within 10 days	Ht ~ 50 cm No. of leaves 12 Age 6-8 months
Bruguiera gymnorrhiza	- Direct planting - Nursery	Push ~ 5 cm into the soil	10-20 days	Ht ~ 50 cm No. of leaves ≥ 6 Age 8 months
Ceriops tagal	- Direct planting - Nursery	Push ~ 5 cm into the soil	10-20 days	Ht ~ 30 cm No. of leaves ≥ 6 Age 8 months
Rhizophora mucronata	- Direct planting - Nursery	Push ~ 10 cm into the soil	10-20 days	Ht ≥ 80 cm No. of leaves ≥ 8 Age 8 months
Sonneratia alba	- Nursery - wildings - cuttings	Broadcast seed on nursery bed Push the radical gently into the soil	Within a week	Ht ~ 50 cm No. of leaves ≥10 Age 6-8 months
Xylocarpus granatum	- Direct planting - Nursery	Lay on surface with radical downward	1- 3 months	Ht ~ 80 cm No. of leaves 12-14 Age 8 months
Lumnitzera racemosa	- Nursery - wildings - cuttings	Spread the seeds in moisten soil	1 - 2 months	Ht ~ 30 cm No. of leaves ≥10 Age 8 months
Heritiera littoralis	- Direct planting - Nursery	Lay on surface with radical downward	1-2 months	Ht ~ 30 cm No. of leaves ≥ 6 Age 8 months
Xylocarpus moluccensis	- Direct planting - Nursery	Lay on surface with radical downward	1-2 months	Ht ~ 50 cm No. of leaves 12-14 Age 8 months

**germination period may vary with the maturity and quality of seed.*

4.0 ESTABLISHMENT OF DEMOSTRATION MANGROVE PLANTATIONS

One of the objectives of the present Consultancy was to set up large scale mangrove plantations in Kilifi and Lamu pilot areas. These plantations will serve as demonstration farms for communities engaged in mangrove reforestation in the north coast of Kenya and Lamu. Unlike Lamu where contiguous blank mangrove areas exist, it was not possible during this period to indentify clear felled areas in Kilifi. Instead, the Consultant in collaboration with students from Pwani University and the Project Proponents carried out gap filling in degraded mangrove forests in Maya, Kilifi. The forests in Kilifi have been degraded through selective removal of merchantable poles.

In Lamu a large scale mangrove plantation was established in Manda Island close to Lamu Airport. The mangroves of Manda are seriously impacted by wood removal for traditional lime making (Plate 3). The process involves arranging mangrove billets in a 5m diameter circular kiln of 1.0m height (Plate 3b). Once this is done coral rags are arranged on top of the wood before fire is set. Because of the high heat capacity associated with mangroves wood, the coral rags are converted through heating to quick lime that is later mixed with sand and water to make mortar for house construction. Traditional lime making, as carried out in Pate and Manda Islands, is quite destructive to mangrove forests as it is non-selective. A single kiln consumes up-to 8.0m^3 of wood.

A 3.0 ha plot of degraded mangroves in Manda was used in setting up a demonstration plantation. Site preparations involved cutting of crooked tree remnants and removing debris that could otherwise dislodge replanted propagules. Planting was carried out in 1.0 x 10 m matrix giving a stand density of 10,000 trees/ha. Survival rate 4 months after planting was estimated at 70% (Plate 3c). KMFRI will work with the local community in monitoring the plantation.

a

b

c

Plate 3. (a). A degraded mangrove stand in Lamu, Kenya; (**b**). Open kiln for traditional lime making; (**c**), a large scale mangrove reforestation project in Manda.

4.1 Monitoring of replanted mangroves

Regular assessment of seedling performance should be made right from nursery to post planting period. Monitoring is very essential for any mangrove reforestation project for several reasons;

- Assess survival and growth performance of seedlings
- Enables to assess whether the project is achieving its restoration goals and objectives
- Document challenges encountered and if possible identify ways of addressing them
- Making replacement – gap filling
- Pest control
- Debris removal – algal growth, solid debris brought by tides
- Surveillance to assess damages e.g. by waves, crabs, vandalism

In order to monitor reforestation projects, establish permanent plots of manageable size (usually 10 x 10 m). The following parameters should be considered during monitoring:

i. Mortality/survival, germination percentage (for the whole sample)
ii. Average height increment (m), number of internodes, number of leaves, number of lateral branches (for a sample size of 20 – 30)
iii. Diameter of stem (in cm) at 2nd internode. For *Avicennia,* stem diameter is taken at **50%** of total plant height (n = 20 -30.
iv. Measure length and width of leaves (n = 20 -30)

A general monitoring schedule for mangrove reforestation is provided in Table 6.

Table 5. Monitoring schedule in mangrove reforestation

Time (months)	Activity	Remarks/parameters to measure
0+3 months	a) Preparing report of nursery and out planting phases b) Survival assessment c) Gap filling d) pest control e) debris removal	- survival % - if survival is low attempt to identify cause of problem - note source of debris - Note any form of disturbance, damages
6	a) Assessment – seedling survival and growth performance b) Surveillance	- Survival % - Height (from the ground to the base of top-most leaves) , no. of leaves for randomly selected individuals (tag them for subsequent monitoring) - Note any form of disturbance, damages
9	a) Assessment – seedling survival and growth performance, recruitment of wildlings b) Surveillance	- Survival (%) - Height, diameter (between **1st & 2nd internode** for *Rhizophora*, *Bruguiera* & *Ceriops*; at **30 cm from ground** for other species) , no. of leaves for tagged individuals - Note No. & species of natural recruitments - Note any disturbance
12	a) Assessment – seedling survival and growth performance, recruitment of wildlings b) Assessment for animal types and abundance c) Surveillance d) Annual report	- Survival (%) - Height, diameter, no. of leaves for tagged individuals - Note no. & species of natural recruitments - Note emerging challenges & propose appropriate plan of action to address them - Make a report of all activities done during the first year
18	a) Assessment – growth performance, recruitment of wildlings b) Assessment of animal types & abundance c) Surveillance	- Height, diameter, no. of leaves for tagged individuals - Note no. & species of natural recruitments - Note any form of disturbance, damages
24	a) Growth performance, wildings, animals b) Environmental factors c) Annual report d) Surveillance	- Same growth parameters as in previous measurements (but may need to revise point of diameter measurements as seedlings grow older, if internodes are no longer visible, take measurements at ~ ½ the tree ht) - Note also survival of wildings - Note changes in soils
36	a) Growth performance, wildings b) Surveillance c) Annual report	
48	a) Growth performance b) Surveillance c) Annual report	
60	a) Growth performance - General forest assessment, including natural regeneration b) Pruning/or thinning c) Detailed report – baseline for subsequent assessment (e.g. every 5 years) Detailed financial report – documenting the cost of planting and other operations	- Forest assessment using standard techniques – measure diameter at breast height (DBH; at 130 cm above the ground. ***See appendix***) - Natural regeneration – seedlings/saplings grouped into 3 regeneration classes – class 1; < 40 cm ht, class 2; 40-150 cm & class 3; >150 cm - Pruning & thinning depend on the objective of planting i.e. preferably for replanting for wood production. Determine appropriate spacing – usually between 1 to 2 m

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