Mangrove planting and sustainability

Action sheet 89

Mangroves are woody trees or shrubs that grow on sheltered, low-lying shorelines in the tropics, subtropics and warm temperate areas. Mangrove species are unique. They have evolved to grow in these hot, humid coastal sites. They can survive the muddy, salty, oxygen-poor soil in the inter-tidal zones (between high and low tide) where other species would quickly die. The wood is often termite resistant, leaves are thick and fleshy, and roots often extraordinary shapes,

The word Mangrove also refers to the type of forest they form.

Why are mangroves important?

Mangrove forest is a unique, complex and biodiverse ecosystem. Many coastal communities in Africa depend on mangrove for the products and ecosystem services it provide. Mangroves are critical habitats for a wide range of wildlife species, and for commercial species of fish, shrimp, lobsters and crabs. Mangroves provide a buffer protecting the coast from ocean storms, and rising sea level. There is more information on this in the PACE Mangroves booklet and film.

What is this action sheet about?

This Action sheet is for people interested in small scale practical mangrove conservation, who want to know how to 'plant' and grow mangroves in areas that are degrading or have limited natural regeneration. It contains information on mangroves and mangrove species, and issues to consider when planning, implementing and following up on mangrove conservation and sustainability projects: how to choose where to plant, who to consult and involve, how to select which species to plant, why choosing carefully is important, how to collect 'seeds' or propagules, how to nurse and plant them and how to care for your trees and the habitat they create in the long term.

Why plant mangroves?

Overharvesting, agriculture, industrialization, coastal development and pollution are causing many mangrove forests to degrade, shrink, and in some places to disappear completely. They can self-repair and regenerate naturally, but sometimes they need help, especially where use by or damage from humans is heavy.

Mangrove distribution in Africa

On the West, Atlantic coast of Africa, mangroves can be found from Mauritania in the north to Angola in the south. On the Indian ocean coast they grow on suitable sites from north to south.

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Types of Mangrove forest

There are different types of mangrove forest. The type of forest that grows depends on the geography of the site. The structure varies, from shrubs no more than 1m high, to trees up to 40m. Some is dense and inpenetrable, elsewhere it is more open. The number of species also varies. Nigerian mangrove contains up to eight tree species, but in Equatorial Guinea there are only two. Angola, Mauritania and Togo have three species. Gabon, Guinea, Senegal, Gambia and other West & Central African countries have seven mangrove species each, but they don't all have the same seven.

Factors that influence the type of mangrove forest

Topography. Topography has various influences. It affects the intertidal range, the distance between high and low tide. A gentle slope on the shore creates a larger intertidal zone than a steep slope. Unless there are strong currents a shallow slope generally causes water to move up and down the shore more gently, meaning that there is less erosion of soil and less force exerted on plants as tides move in and out. On steeper slopes it is the opposite,

A large intertidal range is associated with larger number of mangrove species. A gentle gradient from inland towards the coast, over a wider area, usually means the influence of tides extends further inland. This greater 'tidal penetration' of tides and salt water up rivers and estuaries allows mangroves to grow far inland – up to 100 km inland on some West & Central African rivers.

Hydrology. Mangrove forest grows best in places with ample freshwater. Mangrove forest is taller and denser, up to 40 m tall, in areas of high rainfall. On semi-arid sites (with low precipitation) mangrove grows as shrubs and thickets less than 1m tall. Freshwater from rivers and runoff is also important as it carries the nutrients and soil that mangroves need to grow, and reduces salinity.

Substrate. Mangrove forest grows on different substrates: rocks, sand, stones, soil, etc. The most extensive are on the silty soils common in deltas, lagoons, bays and estuaries.

Nutrients. Some mangrove species can establish and thrive on rocky or stony ground that has few nutrients. As these pioneer colonizing species establish, their roots trap organic matter creating a nutritious substrate suitable for secondary species that need more nutrients.

Salinity. Most mangrove species can grow in freshwater, and they grow better and faster in less saline conditions. Sea water is salty, and only a few mangroves can survive the low tide zone that is covered by salty sea water most of the time. Salinity varies between seasons, when there is a lot of rainfall salt water is diluted. In dry seasons, with no rain and high evaporation, salinity is greater.

The amount of freshwater entering a mangrove from rivers or in surface runoff from the land depends on local hydrology, as well as the amount of precipitation.

Exposure. Hot winds and sun are desiccating, drying. Some species are adapted to the harsh, drying conditions on the very edge of the ocean, others need some shade and protection.

African Mangrove species

Each mangrove species is adapted to slightly different conditions, its niche or favoured microhabitat. Each different type of forest tends to contain a particular group of species, adapted to the conditions or geography where it occurs.

There are nine mangrove species on the Indian Ocean coast of Africa and eight on the Atlantic coast. It is important to understand the differences between species. *Rhizophora mucronata* and *Sonneratia alba* for example are very tolerant of high salinity and being inundated by water. They grow on the seaward side of the shore where salinity is high, varies little, and the ground is rarely exposed. *Heritier litoralis* and *Avicennia germinans* grow on the landward shore, where there is more freshwater, and seawater only reaches at high tides.

Species found on Africa's eastern, Indian Ocean coast

Name **Scientific, English & Swahili**	**Characteristics**
Rhizophora mucronata Red mangrove Mkoko	Usually on the seaward side of mangrove forest. Tolerates high salt levels and being inundated by water.
Sonneratia alba Apple mangrove Mlilana	Grows in low muddy areas close to the ocean edge where there is little fluctuation in salt levels and little freshwater influence. Tolerates high salt. One of the first colonisers: mud accumulates around its roots creating conditions that suit *Ceriops tagal* & *Rhizophora mucronata.*
Ceriops tagal Yellow mangroves Mkandaa	Grows in the intermediate zone, between the ocean edge and landward side of mangrove forest.
Avicennia marina Grey mangroves Mchu	Grows in lower and intermediate zones on the sea shore, lower than *Lumnitzera racemosa* and higher up the shore than *Ceriops tagal.* Adapted to frequent inundation, deeper water, less frequent root exposure to wind and sun. One of the first colonisers.
Lumnitzera racemosa White-flowered black mangrove Kikandaa	Grows on the highest, landward side of mangrove forest, behind *Avicennia marina.*
Brugeria gymnorrhizah Black mamngrove Muia	Frequently grows just above Avicenna, in the second zone back from areas most frequently and deeply inundated by water.

Species found on Africa's eastern, Indian Ocean coast – continued

Xylocarpus granatum Mahogany mangrove Mkomafi	Grows higher up the shore, where inundation occurs only during higher tides, and exposure is greater. Grows 5-15 sometimes 20m, with poor trunk, many spreading above ground roots. A round, hard, cannonball fruit.
Xylocarpus moluccensis Mahaogany /Cedar mangrove Mkomafi dume	Grows 3-10 sometimes 20m tall. Fruit is globular, woody, orange-sized (5 to 10 cm), containing 4 to 16 tightly packed seeds,
Heritiera litoralis Glass mangrove Msindikundazi	Prefers higher parts of the shore where it's only covered by seawater at highest tides. Spends most of the time exposed.

Species found on Africa's western, Atlantic Coast

Name **Scientific, English & Swahili**	**Characteristics**
Avicennia germinans Black mangrove Palétuvier blanc/gris, mang blanc,	Most common on the landward side of mangroves and grows quite far up estuaries and creeks where there is strong freshwater influence. Roots have many pneumatophores. A shrub or tree, usually 3-12m tall, occasionally 25m. The stem is often crooked and may be 30-60cm diameter.
Conocarpus erectus Buttonwood mangrove Mangrove à boutons	Usually on landward side, often forms an inland zone above high tide level. Grows well on dry land where it is drought tolerant. Sometimes called a 'Mangrove associate'. Usually dense many-trunked shrub 1–4 m tall, may be 20m, with trunk up to 1m diam.
Laguncularia racemosa White mangrove	Grows on higher areas of mangrove forest, away from the sea.
Rhizophora mangle Red mangrove	Grows on the edge of the water, the seaward side. Tolerant of salt water and being often and much covered by water. Reaches 40 m tall, 70 cm diameter.
Rhizophora racemosa Red mangrove, Palétuvier	Prefers landward side because it is less tolerant of salt water. Grows in a salt water environment but needs plenty of fresh water, likes estuaries and open waterways.

Species found on Africa's eastern, Indian Ocean coast	
Rhizophora harrisonii Red mangrove	A hybrid between *R. mangle* and *R. racemosa*.
Acrostichum aureum Golden leather/Swamp fern	A fern species, that is common in mangrove habitats around the globe.
Nypa fruticans Mangrove/ Nypa palm	In Nigeria and Cameroon mangroves. A shrubby palm 5 x 5m, the stem (up to 45cm diameter) grows underground and branches above. Likes deep mud, no shade and happy to grow in water. Invasive.

Why plant mangroves?

Mangroves are planted for different reasons, including -

- To enhance natural regeneration, biodiversity and ecological restoration;
- To sustain yield of wood and non-wood forest products – poles, timber and charcoal;
- Coastal protection, erosion control and channel stabilization in lagoons and estuaries;
- To support and protect fisheries;
- To establish new mangrove locations;
- Adapting to climate change;
- Coastal landscaping and ecotourism;
- Social enrichment;
- Legislative compliance – your local government may have a requirement to maintain the mangroves and have asked you to help.

Planting is mainly done in places with degradation, losses and habitat alteration, that may have been caused by human or by natural factors.

Planting is usually only done when there are no signs of natural recovery within 6 to 12 months after disturbance – for example if trees are cut, or died due to drought, flooding, storms, or pollution.

Getting started with planting mangroves

An adaptive mangrove restoration cycle is often recommended. It uses the following steps, which are a good framework to use even if you are planning very small scale. It is wise to think through each step for a range of different scenarios, for example using different sites, buying or growing seedlings, before you decide on a final plan.

1. Planning phase

A. Know your problem. Who are the stakeholders, what resources and expertise are needed for the actions you're considering?

B. Define and clarify the purpose of your project. Do you plan to plant trees and harvest them, keep bees in them, allow the community to use them? Are you assisting the forestry dept, or local council with their bigger plan? Are you helping to create a reserve?

C. Understand governance. Who owns the land? Who has rights to access or use it? Does government, local or national, and what departments have a say on it's use? What role do traditional administration have?

D. Community engagement. Learn, inform and involve your stakeholders.

2. Implementation phase

A. Site assessment and preparation.

B. Establish a nursery (or get saplings from elsewhere).

C. Planting out.

3. Monitoring, evaluation and learning phase

A. Monitor, feedback and adjust.

Where to plant. Site assessment and preparation

Once you have planting sites in mind, do a site assessment for each, and be sure to include the questions below.

- What caused the loss and/or degradation of mangroves?
- What is preventing natural regeneration from occurring in the area?

Will answers to the above questions prevent replanting from succeeding? For example, if pollution caused trees to die, has it now cleared? If mangroves were lost because people felled the trees, you will need to be sure that interventions are made to ensure any trees you plant will be used sustainably.

- Why should we plant mangroves in the degraded site?
- Who owns the site we plan to plant?
- Who should be involved in your project?

It is important to identify and consult as many different stakeholders as possible. If anyone has concerns or objections that you cannot resolve then it may be worth choosing another site to avoid problems and conflict as you move forward. You will need access to the site for your project duration and perhaps afterwards if there are long-term plans to use and manage the site, so it is important to find out who the responsible regulatory agencies and landowners are, explain your plans and obtain any necessary permission and authorisation.

Which species to grow?

Choose species that occur naturally in your area. Mangrove species should be planted in the particular microhabitat, on the substrate and position up the shore, that suits them. So only choose the species when you know where you will plant. Don't plant a *Rhizophora* species that needs muddy soil, on a rocky or sandy place.

- In east Africa *Sonneratia alba* and *Rhizophoa mucronata* should be planted in low, muddy areas closer to the ocean that are inundated for long periods.
- *Brugueira gynorhiza* is suited to an intermediate zone, higher up than *Sonneratia alba*.
- *Ceriops tagal* and then *Avicennia marina* are planted higher up the shore.
- *Lumnitzera racemosa* can be planted closest to the highest landward side, which is covered with sea water for shorter periods, just at high tide.

Check the information on species on pages 3-5.

Planting material

You may be able to get seedlings or saplings from the forestry department or private nurseries. If this is an option then you will not need your own nursery.

If they are available you can collect and re-plant wildlings. See below. Propagules can also be planted directly where they are to grow.

Alternatively make a nursery and grow saplings yourselves.

Your mangrove nursery

You will need committed and enthusiastic people, and basic equipment: ideally, a shovel, spade, wheelbarrow, safety gumboots, thatch and poles for shading, and potting bags or wraps made of organic material that can hold the propagule or seeds.

To ease transportation of seedlings from nursery, locate your nursery at or close to the planting site. If you have a large planting area consider having a nursery at each corner and one in the centre.

The site should be free from strong waves.

It should be located in the intertidal area (between low and high tide) and in close proximity to creeks with draining channels so that the potting bags containing soil and seedlings are always touched by sea water.

Water quality should be good and the site fenced if keeping animals or people out may be an issue.

Open sites may need shading. It can be created using thatch materials and branches laid over a simple frame. This gives workers protection from rain and sun. You can also use the the shade of a large tree.

Artificial shade needs to be removed one month before planting out young trees, this acclimatises seedlings – prepares them for exposure to sun when they are planted out.

Germination bed

A germination bed can be made by digging a trough 1 - 1.5m wide and 2 - 10m long. It must be narrow enough to allow pots in the middle to be handled from the outside. Instead of digging, you may use planks of wood on their side and pegged in place, to create a 10-12cm high barrier around the edge of the area you will use. Pots are then laid on the soil surface, contained by the edging. The seed pots are arranged in the germination bed. The depth should be ¾ the height of your seedling pots or bags.
It secures seedling roots, preserves moisture, protects soil from movement, and prevents pots from toppling over.

Soil potting material

Use muddy soil that is clayey for filling the potting bags. The soft clayey mud available in the mud flats during low tide should be collected and debris removed before using it to fill the bags.

Filling pots

Most species can be raised in potting bags. Different species need different size bags:12.5 x 20cm suits small sized seedlings like *Avicennia marina.* Large seedlings like *Rhizophora* need at least 15 x 30cm.

Seeds and propagules

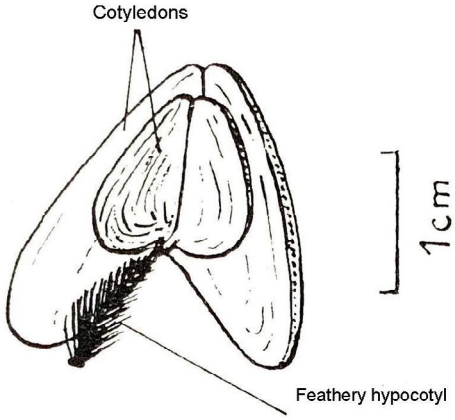
Many mangrove trees are viviparous, which means that the seeds germinate and start to develop into seedlings while still on the parent plant. Some may produce the first leaves and roots before they drop. These propagules, from species like Rhizophora and Avicennia can be collected and planted directly where you want them to grow. You can also put them in pots and grow them on in a nursery before planting out when they are bigger and stronger.

Collecting and sorting seeds and propagules for your nursery

Most mangrove species fruit in specific seasons, so propagules and seeds may not be available throughout the year, You need to learn propagule/ seed production seasons for the species you've chosen to grow. The timing and seasons of flowering, seed and fruit development is called phenology, *Avicennia marina* for example usually has a single flowering period, producing propagules only once during the year, in April – May. Some species flower and produce propagules throughout the year, with certain peak periods. Peak fall for mangrove propagules tends to coincide with the wet period.

It is best to collect mature seeds, fruits and propagules from forest close to your nursery and planting site. After collection they should be sorted to ensure you have and only use good quality planting material.

Type of planting material, signs of maturity, and treatments to use before sowing



Avicennia germinans seed, that has started germinating.
Drawing from Letouzey, Manual of forest botany, tropical Africa.

Avicennia germinans seedlings in nursery.

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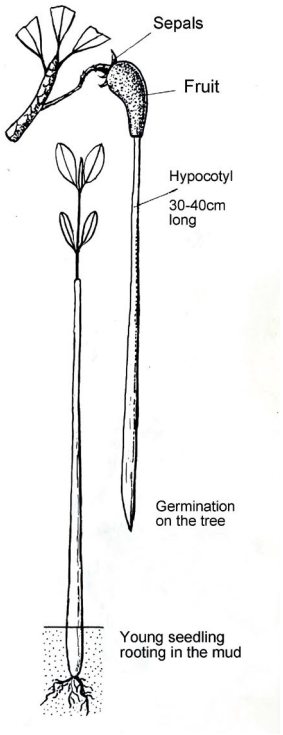
Propagules

Propagules are young plants, that have germinated and started developing on the parent tree. Only certain species produce propagules. They are collected and used for direct planting, or growing on in a nursery.

A distinct cotyledon colour in the hypocotyls of *R. mucronata* and *C. tagal* are good indicators of the maturity of propagules. They both have a yellow collar when mature, and green or brown/green body, respectively. Collection period for *Ceriops* is Feb – Mar and for *Rhizophora mucronate* is March – June.

Avicennia marina propagules have a dark-blue seed coat when mature and will dislocate from the parent plant without the calyx with a slight twist.

The propagule of *Brugeria gymnorrhiza* has a reddish brown body when it is matures (in April – July). It should be kept in cool, wet conditions prior to sowing.



Rhizophora propagule and seedling.
Picture from Letouzey 1970.

Collecting propagules, Kenya © LaMCoT.

Mangrove propagules in nursery pots.

Fruits and seeds

Xylocarpus species. Use the fruit and seeds to propagate. The fruit is a ball or globe 5-10cm diam. It is woody, dark brown and floats in water when mature. Keep it cool and dry until it opens, exposing 4 to 16 tightly packed seeds, then the seeds can each be planted.

Avicennia germinans. Use the fruit/seeds. The seed is best sown fresh. Young seedlings grow best when in contact with fresh water. Older seedlings need contact with sea water. For reference, in Ghana, seedlings grew up to 26cm in 4 months after planting, and trees grew 60cm/year in height.

Conocarpus erectus. Use the fruit/seeds. The Fruit is a cluster of red-brown, small, scaly, two-winged cone like seeds 5-15mm long. Sow seed in a sunny position in a nursery seedbed.

Sonneratia alba. Use the fruit/seeds, which in east Africa can be collected Sept - Nov. The fruit is dark green and floats in water when it is mature. Seeds should be soaked overnight with either sea or fresh water to hasten the opening of fruits and splitting of their seed coat.

Lumnitzera racemosa. Seed, is dark green when mature, picking period is May-July. It should be kept moist before sowing.

Xylocarpus moluccensis. Fruit is dark green when it is mature, in May – July period. It should be kept cool until it opens, then the seeds can be sown.

Heritiera littoralis. Fruits are dark brown when mature (May-July). They should be soaked in fresh water for 1-2 weeks after which the husk can be split by hand prior to sowing the seeds.

Your forestry department, and local people who use the mangroves, fishers and crab collectors, will advise you on flower and fruiting periods.

Direct planting propagules on Kenya coast. © LaMCoT.

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Direct planting of propagules is good for *Rhizophora, Ceriops* and *Bruguiera (*all in the Rhizophoraceae family). Species in this family produce large, pointed propagules that can be planted directly into the mud. Mature propagules picked from mother trees or those recently fallen have a higher survival rate than transplanted saplings. When direct planting propagules use the same rules for seasons and spacing as when planting out seedlings.

Vegetative propagation *Conocarpus erectus,* grows on the landward side of mangrove forest, on Africa's Atlantic coast, often above the high tide mark. It grows from cuttings, even large cuttings will form roots, especially if planted in wet soil. It can also be propagated by layering.

Sowing seeds and propagules in potting bags

Put a mangrove propagule 7-8 cm into the soil for large propagules like *Rhizophora,* 4-5cm for smaller ones like *Ceriops tagal* and *Bruguiera gymnorrhiza.*

For *Avicennia* and *Xylocarpus* seeds, the radicle must be gently pushed, 1/3 of the seed, into the soft mud.

Sonneratia doesn't not do well in a nursery. It is best to soak seeds in water overnight or for 12 hours, then scatter directly on the field site, which you use as a 'wild' nursery. Monitor for 5-6 months or longer and when seedlings have at least 4-10 leaves they can be uprooted and transplanted where you want them to grow. Transplant in a wet season.

Wildings are seedlings that started growing naturally, but are uprooted and moved to the desired location. Transplanted *Sonneratia alba* wildings do particularly well, better than when raised in a nursery, unless it is a 'Wild nursery' as described above. Natural regeneration of *Avicennia germinans* is often abundant, and wildlings can be collected to transplant to new sites.

When scooping wildlings from the field, it is important to ensure that the root-ball diameter is half the height of the sapling.

Community mangrove nurseries in Kiongwe BMU creeks, Kenya coast. © LaMCoT.

Golden rules for a successful nursery

Beware that nurseries can be infested with diseases if not properly done.

- Use soil from the mangrove forest.
- Avoid water stagnating on the top of the pot by filling the soil firmly to the brim.
- Allow the pots to harden – the pots should be arranged in a secured trough, with at least ¾ of the height of the bags below ground level. This preserves moisture.
- Good drainage prevents water stagnating.

Planting out

1. Planting should be in vegetated areas where the forest has been degraded or lost.
2. Do not plant mangroves too densely – leave 1.5m between plants.
3. Plant in a hole 1 ½ times the size of the root ball.
4. If the plant is in a bag, slit the bag and insert the seedling in its bag, into the hole. The bag can then be pulled upwards and the hole filled in around the plant.
5. Don't plant too many of a single species at one time as this may attract pests.
6. Start with a small test planting, as a pilot, a mass trial could be setting up for a big failure.
7. Do not plant in any water channels, sand flats or mudflats.
8. Young trees must be protected from livestock, if there is livestock in the area.

When to plant

It is best to plant mangrove seedlings in the season that their fruits mature in your area. Rainy seasons are usually best. Most mangrove species grow fastest when there is high rainfall, so it's best to plant out your seedlings or propagules at the start or early part of the wet season, then they can get established and build reserves to survive the dry season.

Project monitoring and evaluation

Monitor your site for 5 years. Observe what works and what doesn't work so well, making adjustments all the time to correct and improve.

Assessment during the first 3 months will include: recording survival data, gap filling schedules, pest control and debris removal. The next 4-6 months assess seedling survival and growth and note disturbances to growth. This should continue for 9 months and after one year, survival data, height and number of leaves and any emerging challenges need to be noted. Producing an annual report will help you know what worked, what didn't and so best plan your next projects.

Education and awareness raising on the value of our mangrove ecosystems and the need to conserve and use sustainably will help us all.

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Credits

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